THE WEST COAST OIL THREAT IN PERSPECTIVE

An Assessment of the Natural Resource,

Social and Economic Impacts of Marine Oil Transport

In Southwest B.C. Coastal Waters

Volume II

Main Report

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PREFACE

This second volume of the study report "The West Coast Oil Threat in Perspective" is the main body of the report and includes both conclusions and recommendations.

Volume III contains the maps we refer to in this volume.

We recognize that this volume is a lengthy document and refer those interested in a summarized form to Volume I.

FOREWORD

As the final sections of this report are being written - in mid-March, 1972 - a Panamanian freighter bound for Vancouver with a load of Japanese automobiles is aground on the rocky shoreline of Austin Island adjacent to the newly established Pacific Rim National Park (Refer to Map 1). The vessel ran aground in typical weather for this time of year late on the evening of March 14. It was badly holed and approximately 450 tons of bunker fuel and unknown quantities of diesel and lubricating oil were released. Some of this oil has already ended up on the rocky shorelines of Austin and adjacent islands. Attempts are being made to contain and remove the oil slicks that are still on the water as a result of that wreck.

This 450 ton spill, which has already prompted widespread attention on the west coast and has proved to be the first real testing ground for oil spill contingency planning on this coast, represents less than a two hundred and fiftieth part of the total cargo of one of the supertankers that will start to operate on the Cherry Point tanker route at a rate of one per month in 1972. Regardless of Alaska crude, which would not be shipped to Cherry Point before 1975, one and a half million tons of crude oil will come to the Cherry Point refinery in foreign flag tankers in 1972, 1973, and 1974. From then on, shipments of Alaska crude would lead to an average one 120,000 ton capacity American flag tanker coming to Cherry Point every five days.

Four hundred and fifty tons of oil represent a fraction of the spill that can be anticipated through a tanker grounding or through a collision between a tanker and one of the 7,500 major ocean-going vessels that enter the Puget Sound/Strait of Georgia area via the Strait of Juan de Fuca every year.

The grounding of the Vanlene is the fourth incident that we have had a chance to observe within our West Coast/Juan de Fuca/Strait of Georgia study area during the short time that this study has been underway.

On December 14, 1971, a self-admitted human error during the course of pumping operations from a half million gallon capacity barge to shore-side tanks at Lang Bay near Powell River resulted in the accidental spillage of nearly 9,000 gallons of gasoline.

On March 10, 1972, 1,000 gallons - less than 5 tons - of bunker oil was spilled from a Canadian forces vessel at Nanoose Bay on Vancouver Island. A lucky combination of tidal conditions and the presence of a readily available clean-up force of 300 servicemen made a quick clean-up possible. However, even that comparatively tiny spill took two days to clean up and has resulted in the closure of commercial oyster harvesting.

Only a few days later, on March 18, an unknown amount of oil going through refinery operations spilled from the Standard Oil refinery on Burrard Inlet. The spokesman for the oil company was quoted as saying: "We know the cause; it's one of these things you can't do anything about - it was a mechanical failure, not a case of carelessness."

Four incidents within four months, and each a question of human error or mechanical failure.

Each of these spills represents but a minute fraction of the amount of oil that will actually be spilled in a tanker collision or grounding along the supertanker route from the open Pacific to Cherry Point.

This comment on four incidents that have occurred while we have been undertaking a predictive study on an oil transportation system that is yet to go into operation, provides the very real day-by-day backdrop to the report that follows.

CHAPTER I - INTRODUCTION

A. THE CONTEXT OF THE PROBLEM

Man has been transporting crude oil and petroleum products by sea for over fifty years, yet only in the past five has he really become conscious of the actual and potential impact of oil spills on the marine environment.

Obviously, one of the key factors in this awareness of the environmental dangers of oil spills is the growing world-wide concern for the impact of man's activity on his environment. Coincidental with this growing concern, and part of its cause, is the technological change that is taking place in oil transportation. For years we have been transporting oil cargoes in relatively small tankers with capacities in the 10,000 to 20,000 ton range. However, during the past ten years, we have seen the emergence of the supertankers - vessels with capacities measured in hundred thousands of tons - and a consequent drastic increase in the potential damage from spillage, yet with relatively few technological advances in operational capability to offset the potential dangers that spillage of these immense cargoes poses.

1. Torrey Canyon

Against this general background of increased environmental awareness and advances in the economically expedient facets of tanker technology, the Torrey Canyon went aground on the southwest shores of the British

Isles in 1967. This one incident, more than anything else, focussed world attention on the dangers inherent in large-scale ocean transportation of oil and petroleum products. Although spills had occurred prior to the Torrey Canyon, this one, the largest in history, happened on the shorelines of a major maritime nation and affected both British and French coastlines. Perhaps most significant, it occurred on the shores of an advanced modern country with alert news media able to focus attention on the problem, a well-established scientific community able to document the immediate and long-term impacts of the spill, and a technological strength capable of responding to the urgency of the problem.

2. Chedabucto

This broad world-wide concern was brought home to Canada in February, 1970, when the Arrow, a relatively small tanker of 18,000 tons, grounded and broke in two off Chedabucto Bay in Nova Scotia, spilling some 10,000 tons of heavy bunker oil on adjacent shorelines. After a slow start, a major, well-documented clean-up operation was initiated by the Canadian Ministry of Transport in close cooperation with other Canadian government departments, resulting in a report entitled, "Operation Oil". We have found it of invaluable guidance for our study but have deliberately attempted to avoid duplication.

The Arrow incident coincided closely with the voyage of the Manhattan through arctic waters to evaluate the feasibility of transporting oil through arctic waters and had a significant impact on regulations to protect Canada's shorelines, particularly in the arctic, from the dangers of oil spillage.

3. Alaska Oil

Late in 1970, government officials and conservation groups in British Columbia rather suddenly became aware of the potential threat to marine and shoreline resources on the west coast from plans to ship Alaska oil by tanker from Valdez to a refinery at Cherry Point, near Bellingham. It became apparent later that regardless of Alaska oil, crude would be coming to Cherry Point by supertanker. The route for this trans-shipment would run adjacent to Canadian territorial waters in an area where arbitrary straight-line international boundaries are unrelated to natural marine environments. Canadians realized that a large oil spill anywhere along the tanker route from S. W. Vancouver Island to Cherry Point, regardless of its position in relation to the international boundary, had major implications for Canadian marine resources and shorelines, as tidal currents and winds have no regard for international boundaries.

Probably because of the major concentration of interest by American officials on the pipeline route across Alaska and the fact that a route across Canada was also being suggested as a possible oil pipeline location, Canadians had at first concentrated most of their interest on the overland implications of oil transportation. However, some of this concern soon shifted to the tanker route as the public became more conscious of the hazards of marine oil transportation.

B. THE LIMITS OF THE STUDY

It is within this context, then, that this study began.

In its very simplest terms, the study sets out "to assess and evaluate the socio-economic implications on the marine environment of oil transportation and possible oil spills in the S.W. Vancouver Island / Juan de Fuca / Strait of Georgia region."

The term, "socio-economic" is a jargon way of asking, "What would be the effects on people?" So much of the work on oil studies to date has concentrated solely on the physical effects of oil spills on marine resources and on the clean-up measures that could be undertaken. In almost all of the literature on oil spills apart from the Chedabucto report, the implications for people from both an economic and life-style standpoint, have been dealt with almost incidentally. Of course, any valid assessment of the impact of oil spills on people must be predicated on sound basic knowledge of the physical and biological implications of those spills.

Because of the relatively recent interest in the hazards of marine oil transportation, virtually no studies have set out to determine beforehand what the site specific implications of oil transportation might be in a given area (apart from work undertaken concurrently with this study on Puget Sound, and released too late to be of significant help to us).

The main thrust of this study has been to examine the information that has been obtained on oil spills and oil transportation elsewhere in the world and to relate it to the Strait of Juan de Fuca and the Strait of

Georgia.

To do this properly, it has been necessary to examine the actual oil transportation plans, vessel limitations, traffic patterns in the area, water conditions, weather and known navigational hazards. This physical information in turn has had to be related to an understanding of what would likely happen to oil should a spill occur, the influence of tidal and wind movements on an oil slick, and finally and most significantly, the impact that all of this would have on the marine and shoreline resources of the region. Although obviously a complex undertaking, it is a very necessary one if Canada is either to make a strong case against the planned tanker route or if she is to be in a good state of preparedness should any oil spill occur within the region.

Right from the outset of the study we were aware that oil products had been moving through Juan de Fuca and the entire Strait of Georgia for many years. Marine transportation has played a key role in the development of the region and the transport of petroleum products by sea has been a part of this development. Spills that have occurred within the study region have, of course, all been part of this existing transportation pattern and regardless of plans for shipment of crude oil to Cherry Point, the concern for the dangers inherent in marine oil transportation demands a better understanding of oil transportation and its implications within the study region.

Current and potential oil spill hazards within the study area fall into three main categories:

i) <u>Harbour Problems</u>

These include the numerous relatively minor spills that have always been occurring in harbours, at storage facilities and at any points where oil is being transferred either from vessel to vessel or from vessel to shore installation.

The oil spills that frequently take place in Vancouver harbour and other harbours throughout the study region fall into this category. Spills of this type can be prevented in large measure by far more stringent control over the actual manner in which oil is moved from vessel to vessel or to shore. Coastguard monitoring of such operations in Puget Sound, for example, has resulted in a dramatic decrease in the number of unidentified slicks in the area. Furthermore, spills of this type are usually small and can be far more readily cleaned up. Most of the contingency planning for controlling oil spills to date on the west coast has concentrated on this type of spill.

Within the terms of reference of this study, relatively little attention has been given to the smaller type of spill within harbours and at shoreline installations, though naturally the baseline information on marine resources, their susceptibility to oil spill damage and methods of clean-up are directly applicable to any spill.

ii) A Legacy Problem

A second level of oil spill threat is that posed by the existing transportation of petroleum products in the study area. While the bulk of crude oil used in B.C.'s coastal region is brought to refineries by pipeline, the refined products are distributed to all the coastal distribution points, including many remote logging camps and marinas, by barge or small tanker. In addition, all of the vessels coming into the study region carry their own fuel cargo - some of the larger vessels coming into the Port of Vancouver and Roberts Bank have a fuel capacity, for their own purposes, in excess of the total capacity of smaller tankers and barges operating within the region.

For the most part, it is within Canada's power to control spill dangers from this local transportation. However, although such dangers are important, we have been moving oil within the region for a considerable period of time without a serious accident and also this area of concern lacks the time urgency and magnitude posed by the transportation of Alaska crude to Cherry Point. Nevertheless, the general information on marine resources and their susceptibility to damage and clean-up methods is directly applicable to this internal movement of oil within the study region.

iii) The New Threat

A third and major area of concern is, of course, the transportation of crude oil to Cherry Point - a new threat that is governed by factors over which Canada may have no control, and one with a serious sense of time urgency. This facet of the study has obviously received the heaviest emphasis.

C. LIMITS OF THE STUDY REGION

In order to obtain information on both the likely impact of existing oil transportation and the Cherry Point tanker route, the study region has included the Strait of Georgia from Johnstone Strait to the international boundary, the Strait of Juan de Fuca and territorial waters of southwestern Vancouver Island to a point opposite Tofino.

Within this much broader study region, the highest hazard zones in relation to the shipment of Alaska crude have been identified and the heaviest emphasis has been placed on the likely impact of a spill within those hazard zones.

D. STUDY CONSTRAINTS

All of the published material that we have dealt with on oil spills has been "after the case" information. To apply this to the study area on a predictive basis demands as thorough a knowledge as possible of the region and its resources in relation to the likely impact of an oil spill. Limited general background data on the Strait of Georgia have been brought together only recently in connection with marine park studies, and we have taken these and similar information and examined them in the light of potential oil spills, recognizing that the information is still far from complete. If a meaningful assessment of the social and economic impacts of a spill on these resources is then to be made, obviously that assessment must be made on the best possible understanding of what the actual physical impact is likely to be.

It would be very misleading, for example, to simply deal with the economic values associated with the marine resources of the study region as a whole on the assumption that all these resources would be affected by a spill. It is true that the total resource complex of the region is at risk, but it is a serious over-simplification to assume that total risks would be involved in even the most serious spill that could occur within the region. There are just too many variables operating, as this study will indicate. Even assuming that we are dealing with a spill of crude oil of a given size, the time of year at which the spill occurs and the meteorological and oceanographic conditions at the time of the spill are three major variables that automatically introduce a very wide range of potential impacts, and equally important, a wide range of effective clean-up actions that could be undertaken.

Superimposed on this complexity of interactions that revealed themselves in more detail as the study progressed, is the fact that the study deals in future possibilities which are in many instances based on dynamic living resources, about which scientific knowledge is still seriously lacking, and on the new and still nebulous area of assessing recreational values.

E. OUR APPROACH

In the light of the foregoing constraints, the approach that has been taken falls into three main categories, each of which represents an increasing level of reliability within which interpretations could be made.

1. First we have dealt with the resources and oil transportation patterns of the study region at a macro-level. Obviously one oil spill is not going to affect the entire area, but since one main thrust of the study is to provide information to assist in the clean-up of a spill should one occur, information on the total regional resource complex is important. At a region-wide level, however, resource abundance, economics and other values must be interpreted with extreme caution. They simply give an indication of the total values within the study region, not the total values that would be affected by an oil spill.

2. Within this broad regional context, the study area has been broken into a grid pattern, and an assessment has been made of the full range of resource values - commercial, recreational and aesthetic-intangible value judgements - lying within each square of the grid. The system used in the assessment is explained in more detail in the report. It has enabled us to identify shoreline and marine areas where the impact of oil spills would be greatest in terms of resource values affected. In addition, of course, it gives an indication of resource values throughout the study region to help assess priorities

for clean-up operations should a spill occur. These higher potential resource damage zones can then be combined with higher spill probability zones based on transportation patterns and navigation considerations to identify hazard zones. It is within the hazard zones that quantitative and qualitative information takes on even more meaning.

3. The third stage of the study has involved the simulation of oil spills of different types at different seasons of the year within selected hazard zones. At this level, it is possible to be more precise in dealing with the impacts on a known set of resources within a known region under given meteorological and oceanographic conditions. Within the context of these scenarios, potential resource damage information becomes more realistic yet.

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Again, two major constraints must be borne in mind. First, detailed knowledge of the abundance, distribution and consequently, the economic or other values of some of the resources that would be affected by an oil spill within the study region, is far from complete. This is particularly true of recreational resources.

The second constraint is that in the light of the relative newness of research on the impact of oil spills on living resources, our knowledge of the long-range and sublethal impacts of oil on marine resources is by no means complete.

The major significance of these constraints is to point out, as is the case with almost every environmental argument, that a major cause for concern should be those facets of the problem in which our knowledge is far from complete, and that this lack of knowledge in itself forces us to be extremely cautious in any decisions that we make. On the one hand, predictions on the demand for petroleum products and on the economics of transporting those products can be based on plenty of prior experience, and more important, they are subject to man-made decisions and manipulation. On the other hand, in dealing with the impact of those same petroleum product demands on the environment, be it through extraction or transportation, we have no background pool of knowledge to fall back on.

Equally significant, the problems associated with those demands are not simply technological and economic, but may involve ecological imperatives to which man will have to adapt his demands, not vice versa. Until we know precisely whether or not we are dealing with solvable problems that technology can overcome, or with imperatives to which we must adapt our demands, then we should move with extreme caution. To date our track record in exercising caution and restraint has been poor.

This study does not try to deal with the international implications of the problem other than to point out the obvious artificiality of international boundaries in dealing with marine pollution problems. We do, however, touch briefly on international implications by determining which kind of action Canada can take on her own, what kind of action she could take in cooperation with the U.S., and in understanding what the problem demands on a broader level of international cooperation.

Another consideration that must be borne in mind is the fact that this study has been undertaken in a relatively new area of work. Some major facets of the oil spill problem that could not be anticipated at the outset emerged during the course of the study. This of necessity has made time constraints difficult, because it was also essential to recognize the time urgency of the study. As the work progressed, new information from other sources published during the course of the study came to hand, some of it unfortunately too late for incorporation in this report. In addition, policy moves relating directly to the study were taking place and, as we have indicated in the foreword, oil spill incidents also were occurring while the study was underway. Of necessity, for the study to be really meaningful and not simply an academic exercise, the objectives in themselves became something of a moving target, since there was little point in our preparing a report in a dynamic field to reach a completely static goal. We looked upon these difficulties as challenges rather than insurmountable obstacles. They do, however, point out how much more very basic information we have yet to obtain if we are to manage even our own territorial waters wisely.

Finally, we are well aware that this particular study is only one component of a total analysis of the problem of transporting oil from the arctic to U.S. markets. Much that has been written and said recently about west coast oil transportation has involved a comparison of coastal and overland transportation routes. We hope that this report will contribute to that comparative analysis. However, we must caution against an over-simplified "either - or" approach to the problem of oil transportation and the Pacific Coast.

Cherry Point refinery is built and operating, and will be served by tanker supplies of crude oil, starting this year, quite independently of crude supplies from Alaska.

CHAPTER II - REGIONAL PHYSICAL CHARACTERISTICS

The limits of the study region have been established on the basis of both physiographic units and transport patterns. The northern islands in the Strait of Georgia define the northeastern extent, while heavy local marine traffic and the potential supertanker route demark the southern and western limits. Major water bodies included are the open Pacific, Juan de Fuca Strait, Rosario Strait, Haro Strait, Strait of Georgia and Johnstone Strait. (Refer to Map 1.)

Overall length of the region is about 200 nautical miles with a width varying from 10 to 30 nautical miles. Some of the larger coastal inlets are more than 40 nautical miles in length. There are three significant groupings of islands in the region - all within the Inland Sea: the Gulf Islands; Texada, Lasqueti, Hornby and Denman Islands; and the northern islands. Through Juan de Fuca Strait to the open Pacific, waters are much more exposed as no archipelago is found within them.

One outstanding characteristic of the study region is the number of shoreline miles relative to the area of marine waters. Numerous islands, reefs and inlets make for an abundance of protected waterways for both recreational and commercial activities.

Extreme variations in submarine and terrestrial topography create complex patterns of oceanography and meteorology, particularly in the Strait of Georgia. The many archipelagos and mountain ranges produce a diversity and intensification of surface water currents and winds, the two main factors determining transport and dispersion of oil spills. Following is a summary of oceanographic and meteorologic factors which will include a brief consideration of their relevance to oil transportation.

A. Oceanographic Conditions

1. Wave Heights

Throughout the study region there are a number of sheltered coves which are relatively calm for most of the year, but in area these are insignificant to the rest of the region. Within some of the narrow inlets, wave heights occasionally reach 5 feet when strong gales occur. This is more common in the Straits of Juan de Fuca and Georgia, while off the west coast of Vancouver Island maximum wave heights of 58 feet have been observed (Drilling Rig SEDCO 135). There, where there is open exposure to the Pacific, mean wave height in summer is approximately 5 feet, and in winter, 11 feet.

Although much of the region is an inland sea, its overall size is of significant enough proportions to permit the formation of waves of such height as to prohibit viable boom or even slick-licker clean-up operations. In terms of safety of transport, even supertankers may be threatened off the southwest part of Vancouver Island.

2. Water Temperatures

Variations in surface temperature are greatest in the Strait of Georgia and least on the west coast of Vancouver Island and in tidal passes. They reach a maximum in summer in the open coastal Strait of Georgia and in secluded coves such as Pendrell Sound in the northern archipelago where highs in the 70's have been recorded. In most of the main body of the Strait, summer water temperatures in the mid-60's prevail, while those in the mid 50's are common in Juan de Fuca Strait and off southwest Vancouver Island.

In winter months, these lower to approximately 45° throughout the study region, with the exception of the somewhat colder Fraser River area of influence and in secluded coves during very cold winters when water temperatures may drop to the low 30's.

Summer surface water temperatures, even off the southwest part of Vancouver Island, are well above the pour point of most crudes being transported in the world. Alternatively, winter temperatures are low enough to minimize the effectiveness of dispersants which might be used in the event of a spill.

3. Tides

Although on a large scale, tides and tide currents are caused by gravitational attraction by the moon and the sun, tides in such restricted marine areas as Juan de Fuca and Georgia Straits have their source mostly from ocean tides. There is, therefore, a co-oscillation of tides of the open Pacific and the two Straits. Generally, the progressive tide wave moves from the ocean into Juan de Fuca Strait and thence into the Strait of Georgia. However, there is also a tide wave which comes in through the northern archipelago; the two meet in the general vicinity of Comox. The study region's smallest tide range is near Victoria; this increases to the north through the region. Ranges in excess of 15 feet are common. As tides on the Pacific coast of Canada have both diurnal and semi-diurnal components, they are characterized by a large difference between high and low water heights. These changes in sea level, determined primarily by phases of the moon, may also be reduced or exaggerated by meteorological conditions such as atmospheric pressure or winds and cause an average change in range of 2 to 5 feet above or below the normal predicted heights.

Because significantly large portions of coastline are very gently sloped (these often in recreational or high biological productivity areas such as Boundary Bay which can least withstand the impacts of any oil spill), tide ranges of 15 feet can cover large portions of intertidal zone.

4. Currents

In most of the study region, surface currents are mainly of tidal, wind and freshwater origin. Water circulation is relatively rapid along the west coast of Vancouver Island, while in the Strait of Georgia there is believed to be a net circulation which is counter-clockwise, although this has not been fully substantiated by large scale current studies.

Deep waters require about one year for exchange. Surface layers are likely to be replaced more frequently, but time scales are not known definitely.

With reference to Map 2, it can be observed that tidal current speeds vary from several knots in narrow passages to a fraction of a knot in the central Strait of Georgia. In Juan de Fuca Strait, tide currents attain 1-3 knots on both ebb and flood, in Rosario Strait and Boundary Pass they can be as high as 5 knots, but in narrower passages such as Active Pass, they may even reach 8 knots. Although in the open area of the southern Strait of Georgia, current speeds may be as large as 2 knots, they get progressively smaller with distance to the north, so that in the vicinity of Texada Island, only a maximum of 1/2 knot occurs. However, in the constricted northern channels such as Seymour Narrows, there is a dramatic change to current speeds as high as 14 knots.

Current directions through tidal passages vary considerably; those through Rosario Strait are of longer duration in the flood than the ebb; the reverse is sometimes true in Haro Strait. In most tidal areas, net excursion is seaward.

The most notable influence to circulation in the study region in terms of river discharge is the

Fraser River. Although in winter months this influence is probably small except after periods of heavy rainfall, during late spring and early summer it can have an effect reaching as far as Porlier Pass to the west with speeds in excess of 4 knots having been recorded. The secondary influence of this river flow is the creation of a convergence area between fresh water and sea water often marked by a collection of floating debris or foam. Internal waves occur fairly commonly during summer months when brackish water lies over denser sea water. Such waves can disrupt regular surface flows as they may travel with, against, or even perpendicular to the direction of tidal currents.

Tidal current conditions in many of the passes in the Strait of Georgia can be a significant threat to safe transport, particularly for any vessel not under full power or manoueverability. In terms of clean-up, booming methods which have frequently proved viable elsewhere may possibly be useless even in sheltered areas of the study region because of the intensity of tidal currents. (Several experts contend that booms lose their effectiveness in current speeds above 2 knots in shallow waters.) Furthermore, as current patterns for the area can be made even more complex because of such factors as the Fraser River influence, predictability of spill direction and rate can not often be assumed.

B. Meteorologic Conditions

The most reliable meteorologic data available for use in this section were from well-established terrestrial stations and reflect conditions only close to shore as modified by topography. It should not be assumed that similar conditions might prevail over open waters.

1. Fogs

The greatest frequency of fog on the B.C. coast occurs in the vicinity of Juan de Fuca Strait northwards to Barkley Sound with a tendency to persist on the Washington side of Juan de Fuca. It reaches a maximum at Pachena in August with 20 days per month and somewhat later, in October, around Victoria with 15 days per month, when visibility of 1,000 feet or less is normal. In both these places, a minimum occurs in winter of 1 to 2 days. In the Strait of Georgia, as recorded at Vancouver Airport, fog is at a maximum of about 13 days in October and December, and at a minimum of about 1 day in May, June and July. In general, the further north along the outer coast, the fewer days of fog per month, while in many areas such as fiords, intermittent local fog situations result from cold snow meltwater moving out of estuaries into the moist coastal environment. There are other areas with frequent early morning fog which burns off by afternoon. Smoke from forest fires can also be found any time during summer months, while that from slash burning by the logging industry is frequent in late September, continuing into November.

In late summer and early fall when most other meteorologic and oceanographic conditions are least hazardous, fog frequency approaches its maximum and is followed shortly thereafter by smoke from slash burning in some areas. Although normally not considered a hazard to navigation, smoke must be taken into account for supertankers because of their long stopping distance. Low visibility hampers not only safe transportation as evidenced by shipwreck accident records for the mouth of Juan de Fuca but also both aerial and surface spill clean-up coordination and operations.

2. Winds

The general wind system in the northeast Pacific Ocean is as follows: In winter the Aleutian low is strongly developed in the Gulf of Alaska directing the mean airflow northward almost parallel to the coast, a time when southeasterly to southwesterly winds dominate B.C.'s coastal areas. During the summer, the North Pacific high controls the entire eastern half of the North Pacific so that northwest and westerly winds become most characteristic for the region.

Modifications to these patterns are frequent. For example, summer winds in Juan de Fuca Strait may be modified by topography so that they become southwesterly, while in marine channels and fiords, winds tend to funnel up and down their axes. Diurnal winds prevail in most areas of the coast due to land mass heating, although this is not as evident in winter. On the other hand, a situation occurs in winter where migrating low pressure pockets create highly variable pressure conditions which can result in marked day to day changes in wind velocity from calm to gale force.

Recent studies have indicated that wind will move a surface oil spill with a velocity about 3% of wind speed in the direction of the wind. Such a figure suggests that within tidal passages and off the southwest part of Vancouver Island where current speeds are relatively high, winds, although high on the open Pacific, might have only a moderate effect on current speed and direction. However, in the more open parts of Juan de Fuca and Georgia Straits, wind might become a major determining factor in the movement of oil spills as current speeds here are normally quite low in contrast to tidal passages. This might be particularly true of Juan de Fuca Strait and current-sheltered portions of the coastline south of Tofino, as winds throughout these regions are frequently quite strong.

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The following general description is based upon a few selected oceanographic and meteorologic parameters on a regional scale. However, in the event of an actual oil spill, site and time specific factors must be used in order to deal realistically with the situation at hand.

Off the southwest portion of Vancouver Island, an oil spill might on average be transported shoreward 10 to 20 miles per day in winter months and under storm conditions this might easily be doubled. Thus, if an oil spill occurred within 100 miles of this coast during the winter, it could under some conditions reach shore within a few days. On the other hand, as winds and currents in this part of the study area are extremely variable, it is quite possible that a major spill would never hit the coastline. Compared to offshore Vancouver Island, oil spilt in the Straits of Juan de Fuca or Georgia would undoubtedly contaminate large segments of the shoreline. From a large spill in Juan de Fuca Strait, no area of Juan de Fuca could be considered safe. A spill in the southern part of the Strait of Georgia might be carried northward in the Strait on the Vancouver side, and eventually southward on the Vancouver Island side, unless the Fraser River plume were strong enough to carry the oil towards the Gulf Islands. Depending on wind conditions, if the spill occurred in winter months, many areas in the Strait could become contaminated, with the possible exception of inlets which have a large freshwater discharge. A spill during spring and summer months would more likely be confined to the southern half of Georgia Strait - the Gulf and San Juan Islands might be heavily contaminated and some oil could find its way into the Strait of Juan de Fuca as well.

CHAPTER III - MARINE RESOURCES

A. BIOLOGICAL RESOURCES

The study region has an excellent diversity and abundance of marine life. It supports some 1100 higher life forms including 300 recorded species of invertebrates, over 200 species of fish, 134 species of marine-associated birds and 16 species of marine mammals.

Similar to terrestrial environments higher life forms of the sea are dependent on the energy of the sun. Phytoplankton in association with basic nutrients harness the sun's energy. In turn the minute animals of the sea, the zooplankton, feed on the small plant life. Plankton supports many smaller fish and filter-feeding shellfish, while grazing animals are dependent on higher plant forms for their environment as well as their food. Thus, in a total perspective, the predatory salmon, seals, killer whales and many marine birds owe their existence to phytoplankton.

The most important zone in the study region that would be affected by an oil spill is the intertidal. The distribution of plants and animals in this zone is dependent on such factors as temperature, salinity, degree of exposure to wave action and the type of substrate. Throughout the study region there is a wide variation in these factors and hence an extreme variation in the distribution and abundance of intertidal life. Some sandy beaches may support only a few species while rocky shores, particularly on the west coast of Vancouver Island, may be literally covered with marine organisms. The intertidal and littoral zones support the immature stages of many animals before they migrate to deeper waters. Although most intertidal life is not of economic importance, it is an integral part of the food chain and total ecology of the region and provides aesthetic and recreational enjoyment for both resident and tourist.

Wintering bird populations in the study area are outstanding. Some areas such as Boundary Bay and the Fraser delta support thousands of birds during late fall, winter and early spring. The migratory waterfowl, salmon populations and some marine mammals are of international importance and the Strait of Georgia is particularly noted for its killer whales.

In this section we have attempted, where meaningful, to map, document and cost biological values within the Straits of Georgia and Juan de Fuca and along the west coast of Vancouver Island to Tofino. We have placed a greater emphasis on those species, particularly birds, that would be most adversely affected by oil pollution. The study does not attempt to provide a pure biological inventory or other detailed scientific information, as collecting data on population sizes and distribution of many species of plants and animals in the study region would be a time-consuming and complex undertaking beyond the scope of this study. As well there still exists only a very limited knowledge of the distribution and abundance of many species. In later chapters of this report, the impact of oil on these resources will be discussed.

1. Plankton

Phytoplankton are vital organisms in the total marine life food chain. They are the key to the energy cycle, harnessing basic nutrients and energy from the sun. The production of phytoplankton in the study region varies markedly both geographically and seasonally and therefore we have not attempted to map or quantify it. Peak production in the Strait of Georgia occurs around mid-April and again during late July or early August with optimum areas of production occurring around the periphery of the Fraser River plume and in inshore embayments. The patchiness in plankton populations results in a seasonal and locational distribution of fish and birds that depend upon plankton productivity. The Fisheries Research Board has carried out fairly intensive plankton surveys in the Strait of Georgia which may provide baselines for comparison of planktonic productivity following an oil spill.

2. Marine Plants

The production of marine plants in the intertidal and littoral zones of the study region is high, particularly in swift-flowing tidal passages and over reefs and shoals where nutrients are abundant. Map 3 indicates the locations of several of the more significant plant communities in terms of both density and quantity.

Marine plants harness the sun's energy through photosynthesis and are a source of food and shelter for a number of animals. Eel grass, for example, provides a site for herring spawning, supports a wide variety of invertebrates and is food for black brant and other seabirds. Besides containing one of the largest species of kelp in the world, the region also may support in the near future a considerable commercial harvest of kelp.

3. Invertebrates

Although many species have no direct commercial importance, all have high ecological and aesthetic values and are of considerable interest to tourists and beachcombers. Invertebrate populations are found in tidal passages, on shoals and reefs, and also on shallow intertidal slopes, particularly in warmer waters. Map 3 shows their more important locations.

Some of the better known examples of invertebrate fauna include octopuses (some of the largest in the world), starfish, sand dollars, sea cucumbers, crabs, shrimps, oysters, clams, barnacles, mussels, snails, jellyfish, sea urchins and chitons. The distribution of these organisms varies widely from one area to another - sandy and muddy shores may have only a few species while rocky shorelines may be literally covered with different species. The dungeness crab, shrimps, prawns, oysters and several species of clams are of considerable economic importance - nearly all of B.C.'s total clam and oyster production comes from the study region. Maps 4, 5 & 6 include the locations of areas utilized for the commercial harvest of shellfish, while Appendix A shows their landed value at $1,072,934 for 1970.

4. Fish

The Straits of Georgia and Juan de Fuca include virtually all species of fish found in Pacific Coast temperate latitudes. In terms of sheer biomass, herring are probably the dominant fish species in the study region and one of the main food sources for higher fish. Although the herring fishery was closed for reduction purposes during the 1967-68 season, a limited fishery for bait and food purposes was carried out until 1972 when the fishery was again expanded under a quota system (refer to Map 7). The sites for herring spawning are usually in inshore waters at a wide variety of locations as shown on Map 8. Sandlance and anchovies are other abundant species and a primary food for marine carnivores while three species of smelt support minor recreational and commercial fisheries.

Halibut, English sole, rock sole, Pacific cod, and lingcod are important deepwater commerical groundfish species, the principal commercial fishing areas of which are shown on Map 9. The majority of these are caught by trawl from mid-October to mid-February or late March, but 90% of the lingcod catch is taken by handline and troll, mostly between March 1 and November 30. Lingcod, several species of rockcod and sole also provide good recreational fishing throughout the study area. The catch values of all commercial fish are shown in Appendix A.

Strictly from a commercial and recreational viewpoint, the five species of Pacific salmon are by far the most important fish species with their average landed value from 1968-71 for the study region being $12,057,700, or over five times the 1970 landed value of all other commercial fish and invertebrates. Salmon are caught commercially by gillnet, seine and troll. The net fisheries concentrate primarily on large runs of sockeye, chum and pink salmon to the Fraser River in late summer and fall, while smaller operations fish the mid-Strait of Georgia chum and coho populations. Commercial salmon trollers are primarily after coho and chinook, with the number of trollers harvesting fish in the Strait of Georgia varying from one hundred to two hundred. All major commercial salmon fishing areas are shown on Map 10.

During migration to the open sea, young chinook and coho salmon are in the study region from April to December with important nursery areas located adjacent to the Fraser delta as indicated on Map 8. Because the Fraser runs are harvested by the United States and Canada, both countries have spent considerable money to rehabilitate the stock to the point that hatchery production may increase natural salmon populations by 25 to 40% and necessitate increased net fishing.

The study region is world-renowned for its coho and chinook sports fishery, the main locations of which are also shown on Map 10. As explained in Appendix A, although estimates of fishing recreation days per year for the study region vary from one source to another, it seems most plausible to assume a figure of 3,000,000 with its value determined to be $45,000,000. Migrating steelhead, cutthroat and dolly varden trout also enter most of the rivers and creeks flowing into the study area, with steelhead in particular supporting a unique and intensive sports fishery

5. Marine-Associated Birds

In a review of the marine-associated birds of the British Columbia Coast, Taylor (1971) has compiled in one document most of the available information on this resource. Birds are of particular interest to this study because of their abundance and susceptibility to damage by oil. Many species migrate through the region on their way to northern breeding grounds or more southerly wintering grounds. The study area is also important as wintering habitat and is a breeding area for colonial nesting sea birds. Taylor found there were 134 species present in B.C. coastal waters at some period of the year, representing 18 families and 75 genera.

There are 60 known colonial nesting sites within the study region most of which are found on small barren rocky islands or cliffs of larger islands in Barkley Sound or the Gulf Islands as illustrated on Map 11. Sea birds are dependent on the biological richness of the sea for their own and their offspring's food requirements.

The bird fauna off the west coast of Vancouver Island differs somewhat from the Strait of Georgia. Pelagic species such as albatrosses and shearwaters are more abundant and, as in the case of the rare short-tailed albatross, may range the Pacific coast from 10 to 500 miles offshore. Migrating shearwaters and shorebirds, like many marine-associated species, have a wide distribution and international significance, and appear in the thousands in May and September. The Pacific west coast is also a nesting and rearing area for 14 species of seabirds. The only Canadian colonies of Brandt's cormorant occur in Barkley Sound and at Wickaninnish Bay near Tofino.

Coastal bays and estuaries along the west coast of Vancouver Island are important wintering grounds for trumpeter swans. A 1970-71 count showed that of 1000 swans wintering on Vancouver Island, 700 were along its west coast - approximately 15% of the world trumpeter swan population. Small estuaries at the heads of inlets provide good habitat for a variety of ducks and other important migrants including the Pacific black brant, dusky, Vancouver and cackling Canada geese, and the lesser snow goose.

The Straits of Georgia and Juan de Fuca are far more important to waterfowl than the west shores of Vancouver Island, as illustrated on Map 11. The eastern shore of southern Vancouver Island, the Fraser delta and Boundary Bay make up the most important wintering area for waterfowl in Canada. Between September and December, 2,000,000 ducks may use these foreshores with counts of over 100,000 ducks having been made in a single day on the Fraser delta and Boundary Bay. During the peak of fall migration, 20,000 greater scaup have been counted on Boundary Bay and the same number of lesser snow geese may be observed at one time along Roberts and Sturgeon Banks. During the height of spring migration, 4,000 to 5,000 brant may be seen about the eel grass beds of Boundary Bay. Important but smaller areas of waterfowl habitat occur amongst most of the northern islands adjacent to Johnstone Strait with Kelsey Bay enjoying one of the largest wintering trumpeter swan populations on the B.C. coast.

Foreshore areas in Georgia Strait are important habitat for the great blue heron in spring, as well as a variety of shorebirds of which the most abundant species is the dunlin sandpiper. Active Pass contains thousands of wintering Brandt's cormorants, loons, and western grebes, while many sheltered bays throughout the Strait of Georgia winter large flocks of diving ducks, loons, grebes, murres, murrelets, guillemots and cormorants. The Strait of Georgia contains the only nesting sites of the double-crested cormorant in B.C. and half the known pelagic cormorant colonies in the province.

Details of estimated economic values of marine - associated birds for 1972 are given in Appendix A and include $4,100,000 for nature study, as well as $98,000 for federal and provincial license fees, $30,000 in payments to landowners for hunting, between $756,000 and $900,000 for hunters' expenditures, and between $420,000 and $500,000 for the value of the hunting experience to the hunters themselves.

6. Marine Mammals

Marine mammals common to the study region include the harbour seal, sea lion, fur seal, killer whale, dall porpoise, harbour porpoise and minke whale. In addition, river otters and mink are abundant along many shorelines. Most of these species are particularly migratory, so we have not attempted mapping their distributions.

Harbour seals are common throughout the area with major concentrations occuring at Boundary Bay and in northern coastal inlets. Sea lion rookeries are found in the Long Beach-Barkley Sound area on the west coast of Vancouver Island with recent surveys indicating there are just over 4,000 northern sea lions on the B.C. coast. Fur seals are only abundant off the west coast of Vancouver Island during their migration to or from the northern breeding grounds on the Pribilof Islands. The region is particularly noted for its killer whales. A recent survey estimated there were approximately 360 killer whales off the B.C. coast with centers of abundance in Johnstone Strait and the Gulf Islands. The movements of the killer whale, dall and harbour porpoises around Vancouver Island are probably related to the abundance of their prey that tend to concentrate in areas of high productivity.

B. PHYSICAL & MAN-MADE RESOURCES

For man, the shorelines within the study region are perhaps the most important parts of the total marine environment. It is at the shoreline, particularly in the intertidal zone, where man as a land animal first comes to grips with the sea. It is here that he finds marine resources most accessible and where his activities usually have the first and most significant effect on the marine environment.

1. Beaches and Beach Use

Under this general heading are included all of the gently sloping intertidal areas composed of relatively fine beach materials (no larger than cobbles) both in their entirety and in scattered pockets. For example, a gently sloping rock shelf which is broken by an overlayer of sandy pockets is termed a beach. (Refer to Map 12.) Beaches with a relatively gentle slope and sandy or gravelly material draw the largest numbers of people. Areas which have pockets of sand intermixed with boulders or gravel are equally as attractive to many people but they have a lower capacity to accommodate recreationists in large numbers.

Most of the natural beaches within the study region are below the high tide mark with driftwood usually lying along that mark. Some of the intensively used sites such as Stanley Park are cleared of driftwood material thereby increasing the usable beach area. The most extensive beaches within the study region belong to the perimeter of the Fraser delta. However, there are larger ones on the eastern shore of Vancouver Island in the vicinity of Qualicum and Parksville, and others along the new Pacific Rim National Park on the west coast of Vancouver Island. Numerous smaller sites are scattered along the shorelines of almost the entire study region.

Most of the larger beaches suitable for recreational use have public access to them and a number have been given park status. There is virtually no private ownership of beaches in the intertidal zone, but many do receive private use where private recreational land development fronts on the foreshore and where the public can enter these areas only by passing through private property or from the sea.

Two sources of information have been used to identify beach areas - Navigational charts for a physical description of the beaches and Canada Land Inventory information to gain insight into recreational capability. We have not attempted to measure acreage directly except in the scenario section of this report, but have estimated 1,350 shoreline miles of beach out of a total of 3,270 for the study region.

It has been virtually impossible to obtain reliable, recent quantitative information on the use of beaches for the region as a whole. Statistics on beach use have not been maintained in any uniform way and even for some of the more heavily frequented sites such as those in the Greater Vancouver area and the Qualicum area, information is fragmented.

In the 1966 Lower Mainland Regional Planning Board study, "Land for Leisure", estimates were made of the total number of annual recreational outings per person in the B. C. Lower Mainland. By applying these figures to census districts 4 and 5, (Vancouver Island and the Lower Mainland) and then estimating the percentage of total activities within those census districts that apply to the actual study area, it can be approximated that there was a total of 10, 332, 000 swimming and beach-activity outings in the study region in 1972. (See Appendix A.) Principal swimming areas are indicated on Map 13.

It should be stressed that the 1966 "Land for Leisure" information is based in part on U.S. Outdoor Resources Review Commission reports from the early 1960's. Extrapolations of that data for 1972 do not take into account changes in recreational habits and other factors introduced by the trend towards outdoor recreational vehicles, nor do they take into account changes that have occurred since the early 1960's in beach access and foreshore land status. The "Land for Leisure" figures therefore simply represent the most recent data available and suggest that far more specific basic inventory information is required. As an indication of the level of beach use in the Greater Vancouver area, the Vancouver Parks Board estimates that nearly 4 million man days of use take place on the beaches of Stanley Park alone. This figure incorporates repeated use by the same person and may be more properly termed beach visits, but the very magnitude of such recreational beach use relative to any other form of outdoor recreation is indeed significant and indicates the importance of recreational opportunities which are close to home.

2. Other Recreational Foreshore Uses

Under this heading are foreshore activities which include diving, beachcombing, nature study, picnicking, sight-seeing and just "walking along the beach". As most of these have quite general distribution throughout the study region, only scuba diving sites are located specifically - these are shown on Map 13. Intertidal rock pools are probably more significant for many summer recreational beach visitors, particularly children, than sandy beaches - the success of Provincial Parks Branch interpretative programmes at sites within the study region is evidence of this. As the biological section of this report has pointed out, the intertidal zone is rich in living organisms that arouse a natural curiosity about the sea and is not limited to any one particular season, although use of it would be most intensive during the summer. Though it is difficult to pinpoint some sites as being more important than others, areas adjacent to recreational sandy beaches and those with good access generally have the highest use.

On the basis of "Land for Leisure" information, these activities account for almost 5,000,000 outings annually. Again, this figure is an extrapolation from data of the early 1960's and does not take into account changes in recreational interests and access patterns since that time.

3. Scenic and Aesthetic Aspects of Shorelines

The general scenic and aesthetic value of the marine environment tends to focus on the land-sea interface - it is the total landscape-seascape created by a shoreline that probably provides the highest total aesthetic experience for most people. There is an obvious although not always well expressed relationship between the aesthetic and scenic aspects of an area and such sedentary activities as driving for pleasure or travelling by ferry. The appeal of a landscape/seascape as a unit and the effect it has in attracting tourists and even residents is rarely explored, although the scenic attributes of an area could well have a greater attractive value for a potential tourist than the specific recreational activities available in it. Too frequently the resident and regular tourist involved in specific marine-based recreational activity lose sight of the importance of this "broad picture" to the more casual first-time visitor. Although it is difficult to single out particular areas because different types of shorelines offer different combinations of values, quite spectacular scenery can be identified among the north and south Gulf islands; in such fiords as Howe Sound, Bute Inlet and Barkley Sound; and in the Pacific Rim National Park.

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In the absence of more recent data, the total estimate of some 15,000,000 annual individual beach and other foreshore recreational outings within the study region is a good indication of the magnitude and potential of this resource use.

4. Pleasure Boats, Marinas and Principal Harbours

Pleasure boating constitutes a major recreational use of the study region. Although there is a shortage of current data on recreational boating in the Strait of Georgia, a detailed study was undertaken for the Federal Department of Public Works by N. D. Lea and Associates in 1966. Their report indicated that residents of the study area owned some 72,000 boats and that by 1986 this would have increased to 144,000. A more detailed breakdown of the statistics onboating use can be found in Appendix A of this report, where both recreational and commercial boating are discussed.

The bulk of the study region offers an expanding opportunity for all types of recreational boating. Intensive use is greatest near major population centres in sheltered waters such as Indian Arm, Burrard Inlet and Howe Sound. The southern Gulf Islands and the islands at the northern end of the strait, particularly near the approaches to Bute and Toba Inlets, are utilized heavily by both Canadian and U.S. boaters on extended holiday cruises, and there is also extensive localized recreational boating near small communities. At present, the density of boating use in the region is light, but at some of the more favoured mooring spots, overuse of shore facilities is already noticeable.

The proximity of sheltered waters and ease of access to them is a key factor in the high recreational boating value of the area. As well, the diversity of boating opportunity afforded, ranging from short day-use to season-long cruising opportunities, enhances this facet of recreational use. Varieties of boating experiences include saltwater canoeing, yachting and competitive sailing. As there is an obvious overlap between recreational boating and tidewater sports fishing, we have provided more detail on the relationship between these in Appendix A.

Because of the mobile nature of boats and boating activities, we have not attempted to map their distribution. Instead, we chose to map marinas and principal harbour locations as they tend to be a reflection of where more of the boating activities occur. As can be seen from Map 14, the bulk of these are located near Vancouver and amongst the Gulf Islands. Most of the marinas are government owned or maintained, while private recreational docks are usually the property of shoreline motels often located along the more isolated shorelines. In addition, recreational boaters are served by a network of small harbour facilities catering to the commercial fishing fleet.

Extrapolation of data from the 1966 Lea report indicates that there are a total of 14.3 million boating recreation days per year by people owning boats within the study region. This does not necessarily mean that all of this activity took place within the study area but it is again an indication of the order of magnitude of recreational boating activity.

5. Log Booming and Storage

As forestry is B.C.'s largest industry, the study region contains a large number of log booming foreshore leases. Major storage areas include Howe Sound, the Fraser River, large wood processing plants such as at Port Alberni and log dumps at tidewater. Log stocks, both in booming grounds and raft transit, represent on the average a volume of approximately 770 million board feet with a value of about $54,500,000. (More details are given in Appendix A.) This figure does not include logs in barge transit or those stored in nontidal sections of the Fraser River. (Refer to Map 15.)

C. LAND STATUS

Included in this subsection are particular classifications and values which man places upon the biological and physical resources already discussed. It is an indication of some of man's priorities and not necessarily a reflection of natural ones.

1. Parks and Park Reserves

Map 16 shows the distribution of parks and park reserves throughout the study region. As park reserves are being frequently added, the distribution presented does not include the most recent acquisitions. Most of the developed parks are located in the southern portion of the study area with many small ones dotting the shorelines of the Gulf Islands. A number of these include facilities for pleasure boaters. All parks shown on the map are provincial, with one significant exception - the new Pacific Rim National Park near Tofino on the west coast of Vancouver Island.

Within the park system of the region, tidewater parks undoubtedly have a higher attraction to visitors than interior parks. They contain an added environment for visitors to explore and appreciate. The biological, recreational and aesthetic appeal of the intertidal zone has been discussed previously in this chapter.

Very little specific information is available on the numbers of visitors to these parks. There are, however, some obvious trends. The developed parks which lie closest in travel time to large population centres receive the largest number of visitors with Stanley Park as a good example. Secondly, summer usage is usually much heavier than winter particularly for those parks in which people camp or in those which are most distant from population centres. The reason is obvious; people are less willing to camp or embark on longer trips in inclement and uncertain weather.

In actual numbers, the statistics of the B. C. Department of Travel Industry, with some interpretation, suggest that 300,000 visits were made in the study region in 1970. Although we are not in possession of actual figures, we have estimated that two thirds of this number would be distributed throughout tidewater parks, i. e. some 200,000 visits in 1970.

The quality of the recreational experience offered within these parks is excellent and irreplaceable, and a number of them offer some of the finest sheltered waters for pleasure craft in the entire world.

Many of the waterways contain moorages and land facilities for the boater as well as for the ferry traveller who has driven his vehicle to campsites nestled in groves of Arbutus and Garry Oak. Recreational surveys done on the Gulf Islands show that visitors and residents spend much of their leisure time on park beaches where they can swim, relax on the sand, or collect oysters and clams from the rich intertidal zone.

2. Ecological Reserves

Ecological reserves are parcels of land of sufficiently unique or representative biological value to warrant preservation. They are held aside by the Provincial Crown to allow natural processes to proceed undisturbed. In the study region are nine ecological reserves whose perimeter abuts the coastline. (Map 16). Their particular features include marine wildlife colonies of mammals and sea-birds, and habitats such as salt water marshes. As most of these reserves are being preserved for study purposes, extensive use of them is discouraged, although limited recreational use is occasionally permitted.

3. Indian Reserves

Map 17 shows the distribution of Indian reserves in the study region - most of them are historic settlements which occupy very attractive and biologically productive bays and estuaries. In many, families of native people live in year-round residence, while in others, the land is vacant or receives itinerant use. Fishing camps in particular are used for only a short period of the year.

The greatest numbers of reserves are found in Barkley Sound and amongst the Gulf Islands with the largest populations of occupied reserves occurring near large population centres. Most of the native people who are employed are in the extractive industries, such as fishing and logging. In more distant reserves, the people pursue a life fairly subsistence-oriented and dependent on the harvest of natural resources. Some are also using parts of their reserve lands for development purposes, e. g. at Tsawwassen and Capilano.

4. Real Estate Values

The value of waterfront land suitable for residential development within the study region has shown a tremendous increase over the past ten years with every indication that the trend will continue. Map 18 indicates by zone approximate land values by waterfront foot. The more accessible southern portions such as the Gulf Islands lie within a Mediterranean climate considerably drier and sunnier than the Lower Mainland of British Columbia. Although, originally, those islands were popular for cottage developments, they now include a significant proportion of permanent residents. Serviced waterfront land on the southern Gulf Islands and on the attractive beach areas of southern Vancouver Island retails for $100 to $250 per waterfront foot. Rocky beach frontage and rock bluffs, serviced, sell for $75 - $150 per waterfront foot. On Vancouver Island, in the vicinity of Nanaimo, cost of purchasing land in waterfront subdivisions averages $150 - $200 per foot. The wholesale value of foreshore property if bought in large parcels averages to $30 per foot.

The northern section of the study region near Campbell River and the northern archipelago are becoming increasingly valued as recreational property. Although the climatic conditions from Campbell River north are more inclement as rainfall is heavier and the number of hours of sunshine is lower than in the southern Gulf Islands, there is every indication that these northern coastal lands will become increasingly valuable real estate as development in the south becomes more dense. Any improvements in access would certainly cause a rapid upsurge in land values.

Toba and Bute Inlets are typical coastal fiords with precipitous walls which plunge into the ocean. Foreshore areas and intertidal zones are narrow and steep - much of their shoreline is therefore unsuitable for residential or recreational development. With the exception of logging road networks which are usually separate from the provincial highway system, access to these areas is by boat only.

The west coast of Vancouver Island is relatively isolated. Roads there focus on a very few coastal communities whose economic purpose is various forms of resource extraction such as fishing, logging and mining. Much of the shoreline on the west coast of the island is precipitous and, according to current market trends, of relatively low value. The rainfall in the area is high - storms from the Pacific bring strong winds, fog and cloud. There are, however, a number of attractive beach areas which remain in a comparatively wild state, and according to our sources of information, many have been examined by land speculators. Successful vacation resorts in the proximity of the new Pacific Rim National Park have already been established. Despite the stormy climate, it appears that land fronting the open Pacific with its attractive intertidal zones and weathered cliffs has attracted an increasing number of vacationers during the past few years. The establishment of Pacific Rim Park will undoubtedly focus more interest on the area, road access will improve and real estate prices will go up.

Overall, the coast within the study area is of very high current or potential land value. At present the principal limiting factor is access. Undeveloped areas furnish an interesting market for land speculators as waterfront land will certainly continue to increase in value.

CHAPTER IV - TRANSPORTATION

A. Movement of Oil and Oil Products

1. Crude Oil

For the purposes of the discussion of the transport of oil and oil products in this chapter, the area of concern is southwestern British Columbia and the states of Washington and Oregon. Within this area there are no sources of crude oil and it is clear that unless a major trans-shipment centre is located in the region, the volume of imported crude oil will be limited to the amount necessary to satisfy the regional demand for oil products. Whether or not such a trans-shipment centre will be established cannot be predicted on the basis of present public information, although the possibility of a new pipeline being built to carry Alaskan oil from Puget Sound to the U.S. midwest has been expressed. Currently, Canada does export a small amount of crude oil to California from Vancouver, totalling about 9,000 barrels per day (bpd).

At present, the entire demand for crude oil in the region is met by the Trans-Mountain Pipeline. This pipeline has a capacity of about 380,000 bpd, and serves four refineries in southwestern British Columbia (102,000 bpd) and four refineries in Washington (240,000 bpd), including Atlantic Richfield's Cherry Point operation. The National Energy Board has made a petroleum product demand forecast for

British Columbia which is shown in Table 1. Also shown is a forecast of the demand for oil via the Trans-Mountain Pipeline in Washington and Oregon, based on the present pipeline throughputs and the annual growth rate of from 3.0% to 3.2% in the demand for oil products being experienced by Washington.

TABLE 1

Year	British Columbia	Washington & Oregon	Total
1975	148,000 bpd	262,000 bpd	410,000 bpd
1980	179,000	307,000	486,000
1985	220,000	359,000	579,000
1990	254,000	420,000	674,000

All of the British Columbia demand is not in the southwestern region, and since Trans-Mountain has been given permission to expand their capacity to 600,000 bpd as required, it is evident that this pipeline could supply the area of concern on its own for at least the next 15 years.

There is a large variation in the estimates of the initial flow of oil through the Trans-Alaska Pipeline System (TAPS) should it become operational. These estimates range from 200,000 to 600,000 bpd, with the design capacity of 2 million bpd being the only generally agreed upon figure, though it is not known when this throughput would be reached. Therefore, any estimates of the volume of tanker traffic which could leave the port of Valdez are uncertain. Two further considerations add to this uncertainty, the first being the possibility of exporting Alaskan crude oil to countries such as Japan. The second is the possibility of a new pipeline being constructed from the Puget Sound area to serve the U.S. midwest. Both of these considerations could greatly affect the volume of oil leaving Valdez and the amount of tanker traffic coming into the Puget Sound area.

Of the present oil movements by tanker to the U.S. west coast, approximately 13% is delivered to Puget Sound and the remainder to California. According to Dr. Wilson Laird, Director of the Office of Oil and Gas of the U.S. Department of the Interior, the addition of Prudhoe Bay oil to the system would not be expected to markedly change this percentage split of deliveries.

The Atlantic Richfield Oil Company (ARCO) would likely be using both 120,000 ton (854,000 barrel) and 70,000 ton (498,000 barrel) single-bottom tankers for moving Alaskan crude oil. One ship, the 70,000 ton "Prudhoe Bay", has already been launched, and four more are under construction - an additional one of 70,000 tons and three of 120,000 tons. It is the larger tankers which would likely be coming into Cherry Point.

Therefore, assuming that all of the oil leaving Valdez would be delivered to the U.S. west coast, Table 2 can be constructed indicating what the frequency of tanker arrivals from Alaska in the study area would be at three levels of TAPS throughput.

TABLE 2

	TAPS Throughput (bpd)		
	200,000	600,000	2,000,000
Volume delivered to Puget Sound (bpd)	26,000	78,000	260,000
Arrivals of 120,000 ton tankers per month	0.9	2.7	9.1

The Alyeska Pipeline Service Company, assuming the use of 120,000 ton tankers has made a similar kind of estimate which is shown in Table 3.

TABLE 3

	TAPS Throughput (bpd)		
	600,000	1,200,000	2,000,000
Sailings from Valdez per month	31.2	57.8	77.0
Arrivals in Puget Sound per month	5.7	6.6	6.6
(% of total sailings)	(18%)	(11%)	(8.6%)
Volume delivered to Puget Sound (bpd)	162,000	188,000	188,000

In a statement made to a U.S. Congressional inquiry, ARCO presented the same estimates of tanker arrivals.

If enough Alaskan oil comes into Puget Sound, it is possible that Canadian oil could be eliminated from Washington State and absorbed into the U.S. midwest. The estimates of tanker arrivals by Alyeska and ARCO yield a volume of crude oil import which greatly exceeds the 100,000 bpd refining capacity of the Cherry Point operation. Use of Dr. Laird's figure of 13% gives import volumes even more out of line with that capacity. These inconsistencies suggest that the U.S. oil companies are anticipating relying on Alaskan crude rather than Canadian crude in the U.S. northwest.

Dr. Laird has also indicated that arrivals in Puget Sound of Alaskan oil would be around 200,000 bpd if Canadian oil is not excluded from Washington State, 400,000 bpd if it is excluded, and 1 million bpd if a pipeline is constructed from Puget Sound to the U.S. midwest. These figures translate to 7.0, 14,0 and 35.2 arrivals per month of 120,000 ton tankers, and are very much out of line with other estimates discussed above. The wide variance in these figures illustrates the lack of reliable information on the use of Alaskan oil.

Only a first approximation of the expected arrivals of tankers from Alaska can be made from various numbers given above. Should TAPS begin operation, there would likely be at least five or six tankers arriving per month at Cherry Point. As the pipeline throughput increased to capacity, the number of tanker arrivals in the study area would also increase, but the amount of the increase is uncertain. Unless the status of Canadian oil in Washington State changes and/or a pipeline to the U.S. midwest is built, the number of arrivals would probably be about sevsn per month, increasing gradually as the demand for oil products increases. Should either of these changes occur, the number of arrivals could easily be double or triple that figure.

The refinery at Cherry Point is currently operating at about one half of its capacity, and receiving all of its crude oil via the Trans-Mountain Pipeline. ARCO is planning to bring in one 120,000 ton foreign flag tanker per month to augment this supply beginning this year.

The various routes used in transporting oil and oil products in the study area are shown on Map 19. The Alaskan tankers would likely come down the west coast of Vancouver Island, about sixty miles off-shore, turn to the south of the La Pérouse and Swiftsure Banks, and enter the Strait of Juan de Fuca from a southwesterly direction. They would then proceed through the strait, pass to the west of Smith Island, and up through Rosario Strait to Cherry Point. Haro Strait could possibly be used as an alternate route, especially for ships leaving Cherry Point in ballast if Rosario Strait is made a one-way traffic lane.

Relative to the volume of traffic in the study area at the present time, the number of tanker arrivals from Alaska would be insignificant. The number of deepsea sailings from the principal Canadian ports in the study area was 3,131 in 1969 and 3,501 in 1970. In 1969, the total number of departures of large commercial vessels from U.S. ports in Puget Sound and along the shores of the Strait of Juan de Fuca and Rosario Strait was 4,368. Thus, the total number of departures was 7,499 in 1969. The total for 1971 was likely greater though the exact figures are not presently available. Assuming that 7 tankers would be arriving per month from Alaska, the annual total of arrivals at Cherry Point would be 84, or about 1.1% of the total 1969 traffic of large vessels in the study area. It can, therefore, be concluded that on the basis of volume alone, the additional traffic in the study area which would result from the establishment of this tanker route would not add significantly to the frequency of ship collisions now experienced. The restricted manoeuverability of these large tankers, however, could involve them in more than an average number of accidents.

One alternative to the Valdez-Cherry Point tanker route is a pipeline through the Mackenzie River valley to Edmonton. From this point the oil could be moved to the west coast via the Trans-Mountain pipeline or eastward via the Interprovincial and Lakehead pipelines. Thus, it is entirely possible to supply Washington with Alaskan crude oil without the use of the proposed tanker route, and at the same time make more oil available to the U.S. midwest. Of course, this alternative would not take into account the supply of crude oil to California, and would complicate the exporting of Alaskan oil. It also merely exchanges one set of environmental hazards for another, though the latter set would appear to be less severe.

2. Oil Products

The movement of oil products in the study area follows a complex pattern. Generally speaking, both British Columbia and the U.S. northwest supply their own needs, and there is very little transfer of products across the border. The Canadian refineries are located in the Vancouver area, and products are moved by barge and tanker up the B.C. coast and over to Vancouver Island. The refineries in Washington are located in the northern coastal section of the state near Anacortes and Ferndale. Products leave these refineries by barge, rail, truck and pipeline. The Olympic Pipeline originates at the northernmost American refinery and extends south to Portland, Oregon. It has a capacity of 200,000 bpd.

In early January, 1972, a questionnaire concerning the movement and handling of oil and oil products in the study region was circulated to Canadian oil companies in Vancouver. From their replies, Table 4 was constructed. Note that Texaco Canada Ltd. was not cooperative in replying to the questionnaire.

Because the data on delivery volumes are incomplete, they cannot be used to determine the total movement of oil products. Discussions with Sea Span International, a towing company which moves about 25% of all oil products in the study area, revealed that they moved 2,770,000 barrels (bbl) of products in Vancouver harbour and 3,260,000 bbl outside Vancouver. It can, therefore, be estimated that about 13 million bbl

TABLE 4

Volume of Oil Products Delivered in 1971 (barrels)

	Vancouver Harbour	Study Area Outside Vancouver Harbour	Beyond Study Area
Imperial Oil	99,500	2,688,000	1,050,000
Gulf Oil	477,000	1,615,000	532,000
Shell Oil	-	1,266,000	?
Standard Oil	1,011,800 *	2,585,800 *	874,700 *
Texaco	?	?	?
Trans Mountain Pipeline:			
crude oil	-	-	1,600,000 *
propane	-	-	2,900,000 *

* averaged over 2 years

of oil products are transported annually by sea about the study area outside Vancouver. Unless refineries and/or pipelines are built to service Vancouver Island and the B.C. coast, this volume will likely increase in proportion to the increase in total petroleum product demand as shown in Table 1. Thus, the marine transportation of oil products would increase to the following levels: 1975 - 20 million bbl; 1980 -

24 million bbl; 1985 - 30 million bbl; and 1990 - 34 million bbl.

Products are transported in barges and small tankers, both of which vary in size from a few thousand bbl up to 30,000 to 40,000 bbl. (The crude oil tankers leaving Trans Mountain's Burrard Inlet terminal are in the 150,000 to 300,000 class; that is, 21,000 tons to 42,000 tons.) The routes over which these vessels move form a very complex pattern as they are dictated by the number and locations of the deliveries, and these variables are always changing. The general pattern of the movements is shown on Map 19, along with the locations of Canadian refineries and marine delivery points (to the extent that they were reported by the oil companies).

In addition to movements originating within the study area, there is some importing of bunker oil and some through traffic. Many companies (including oil companies) bring bunker oil in from California by tanker, but the total volume has not been ascertained. For example, Gulf Oil imported 60,700 bbl in 1971, and one of the 71,000 bbl tankers which collided in San Francisco Bay in January, 1971 was bound for Bamberton in the Saanich Inlet north of Victoria. Bunker oil is also imported to Washington State for similar purposes. The only through traffic we have been able to pinpoint is that carried out by the United Transportation Company of Seattle. They move about four 50,000 bbl barges northward per year via Johnstone Strait carrying gasoline, and bring about six per year southwards carrying diesel fuel. Thus, on the average, two UTC barges per year travel northwards empty.

B. Characteristics of Oil and Oil Products

Several processes affect the fate of oil when it is spilled in sea water. A brief outline of these processes is given here as an introduction to a consideration of the particular characteristics of Prudhoe Bay crude oil and oil products.

When spilled on water, oil floats and spreads quite rapidly, the spreading rate being determined primarily by the volume and density of the oil. The oil slick which results is subject to the effects of three other significant processes - evaporation, emulsification, and mechanical transport. Evaporation leads to an increase in the density and viscosity of the oil with time, as it is the lighter components of the oil which evaporate the most readily. The increase in density could quite possibly result in the oil sinking since it can become more dense than the sea water. The increase in the viscosity of the oil acts to reduce the spreading rate of a slick. Evaporation is retarded by colder sea temperatures, and is enhanced by higher winds which carry away the fumes more quickly and encourage the loss of oil from wave crests. Spreading and evaporation are the major processes affecting spills of the lighter oil products.

Water-in-oil emulsions are formed naturally and reasonably rapidly in sea water, are very stable, and can contain up to 80% water. The lighter oil products, like diesel oil and gasoline, do not emulsify. The famous "chocolate mousse" emulsion encountered in the Arrow and Torrey Canyon incidents is such an emulsion. Oil-in-water emulsions (which disperse the oil in the water column) do not form naturally and must be promoted by the addition of chemical emulsifiers. Emulsification also increases the viscosity of the oil and thus acts to retard spreading. It results in a very stable oil mass which is capable of travelling distances in excess of 100 miles under the influence of wind and current and still remain in a relatively coherent mass.

In consideration of the hazards to a coastline from large spillages of crude oil, the spreading characteristics of an oil spill are probably less important than its mechanical transport by wind, tide and current. Under the influence of wind, slicks have been observed to travel at about 3% of the wind speed. The direction of travel is determined by the combined effects of wind and current.

Atmospheric oxidation and bacterial degradation of oil are two minor processes affecting spilled oil. They both occur too slowly to be of any significance in the context of spill clean-up. The dissolution of some components of crude oil into sea water is likewise not a significant process, especially in our colder northern waters.

1. Crude Oil

Just how these processes will affect a spill of Prudhoe Bay oil should one occur in Canada's coastal waters is a function of the oil's properties. Very little information is available on this crude oil, but it is known that it has an above average specific gravity and pour point, an average sulphur content, and a low proportion of gasoline, two thirds of the crude having a boiling point greater than 530°F. A comparison of the crude with other crude oils is made in Table 5:

TABLE 5

Crude	Specific Gravity at 60°F	Sulphur Content wt %	Pour Point °F	Residue at 700°F wt%
Prudhoe Bay	0.90	1 - 2	20	67 (at 538°F)
Kuwait	0.87	2.5	-25	51.3
Venezuela (Tia-Juana Medium)	0.90	1.54	-30	57.7
Libyan (Brega)	0.83	0.21	45	37.5

Given the fairly low content of light components in this crude oil and the relatively cool water temperatures of the study area, evaporation will probably not alter the characteristics of a spill significantly. Emulsification and mechanical transport will thus be the dominant processes. In the absence of sufficient factual information on the behaviour of Prudhoe Bay oil in sea water, it can be assumed that the rate of natural dispersion will be significantly low to permit water-in-oil emulsions to persist for several weeks.

2. Oil Products

The behaviour of spills of oil products is highly dependent on the type of product considered. The lighter products such as diesel oil, fuel oil, and gasoline spread and evaporate very quickly, and thus do little physical damage. However, these fuels are much more toxic than crude oils and biological damage may be extensive. Heavier products such as bunker fuels react like crude oil when on the sea.

C. Navigation Considerations

1. Characteristics of the Tankers

Considerable disagreement exists in the literature concerning the operating characteristics of super-tankers. On the one hand is the opinion that these ships are cumbersome machines which have such a poor power-to-weight ratio that they can neither stop nor manoeuvre adequately. For example, Dr. P. D. McTaggart-Cowan, Executive Director of the Science Council of Canada and head of Operation Oil which cleaned up after the Arrow incident, made the following statement concerning the 120,000 ton Torrey Canyon to the Canadian Special Committee on Environmental Pollution:

> "I have had conversations with one of the supertanker pilots from Sweden who actually spends six months a year as an oil pollution expert and six months as a supertanker pilot in Goteborg Harbour.

> You are in a different ball game with supertankers. He said, for example, that there was nothing that the captain of the Torrey Canyon could have done for the last 15 minutes even had he known he was heading straight for the Seven Sisters Rock because, with the speed of the ship, the size of the ship, even if he had gone full astern, full starboard or full port, the ship would not have responded in time to miss the rocks. On the really large tankers, apparently, it is about 12 to 15 minutes from the time that the pilot alters the setting of the rudder to the time that the bow knows that something has happened."

Similarly, Captain R.A. Roberts, a marine transportation consultant and a Master Mariner, writes:

> "Once it was possible for a ship's Captain to apply his years of experience to the handling and manoeuvring of his ship, and he was very capable of anticipating the result of his orders to the engine-room and the helmsman. Now, the responses of these very large vessels are so slow and so very difficult to predetermine, that the art of anticipating is no longer useful. The Captain has to have access to instruments which will assist him to accurately predict the responses of his ship to the movements of the engines and rudder. Even the effect of wind and current and the difference between manoeuvring in deep and shallow water can no longer be anticipated. The issuing of an order must be exactly at the right moment, because the vessel will respond so slowly, that correction may not be possible in time to avert the danger which has to be cleared. Errors take too long to correct."

On the other hand, there are equally respected opinions that supertankers are not as unmanageable as people generally believe. For example, Lord Geddes, then Chairman of the Tanker Committee of the International Chamber of Shipping, testified before the U.K. Select Committee on Science and Technology in 1967 as follows:

> "It is surprising how closely the manoeuvrability of these ships

> follows that of very much smaller ships. A tanker of 200,000 tons, length about 1,050 feet, although ten times the size, is only about twice the length of a 20,000 tonner, length about 550 feet. Manoeuvrability is, however, related to length, and the turning circle of a 200,000 tonner is therefore only twice the diameter of that of aship one tenth her size .... Their turning circle is half a mile for a complete circle. But they can change course very rapidly. Their stopping distance, if you want to do a crash stop, which is a very rare thing to want to do, is something under two miles."

In a paper published in <u>Safety at Sea International,</u> Captain A. F. Dickson, a director of Shell International Marine Ltd., states that:

> "There is no evidence whatsoever to show that ships have been involved in collisions because of their inability to stop, and it is interesting that a comparison between Shell-owned 200,000 ton ships and battle ships in service with the Royal Navy immediately before the last war shows that the manoeuvring charactertistics are not dissimilar, and yet battle ships were regarded as being reasonably manoeuvrable and were required to sail in fleet formation in close order."

Since the use of these ships has become a fairly "hot issue", there undoubtedly exists some bias on both sides of the argument. However, the extent of the disagreement, particularly with respect to the manoeuvrability of supertankers at slow speeds in confined waters, indicates that they should be used with caution, especially since they carry a cargo which is potentially dangerous to the marine ecosystem. Since by far the most important contributing factor to accidents involving both stranding and collision is human fallibility, one of the best ways to exercise caution in their use is to ensure that they are manned with the highest quality staff. A second precautionary measure is to ensure that, until much more experience is accumulated in the handling of supertankers, they are given special consideration when they enter confined coastal waters.

2. Characteristics of the Waterway

On examining the Strait of Juan de Fuca-Strait of Georgia waterway, one finds that over most of its length it is reasonably safe. Navigation is simple in clear weather; the aids to navigation are numerous; the chart is a good guide; and depths are usually fairly great. Apart from the considerable traffic which results in danger of collision anywhere in the waterway, there are only two areas along the proposed tanker route where navigational hazards present a significant danger of grounding. The first is the entrance to Juan de Fuca Strait where, owing to fogs and the irregularity of currents and tidal streams, every precaution must be taken. To quote from the British Columbia Pilot: "The strait is liable to all those vicissitudes of weather common in these latitudes, and in few parts of the world is the caution and vigilence of the navigator more called into action than when entering it from the Pacific Ocean.... The weather off the entrance as a rule is exceptionally severe." There are also two large and important fishing banks off the entrance - La Pérouse and Swiftsure Banks - where large numbers of fishing vessels may be encountered during the period from April 1 to September 30. Fog is also most prevalent during this time of year, reaching its maximum in August when 20 days of it is not unusual. The fog frequently extends a long distance seaward and, when combined with smoke from forest fires or burning logging slash, becomes exceptionally dense.

The second area which presents a high risk of grounding is at the eastern end of Juan de Fuca Strait where there are two banks - Hein Bank and Partridge Bank - as well as Smith Island lying across the route approaching Rosario Strait. The southern entrance to Rosario Strait - 6 miles wide - is straddled by two reefs not more than 2 or 3 fathoms below the surface of the sea and 2 miles apart. The northern entrance is similarly obstructed by islands and rocks. Within the strait itself, depths are considerable (30 to 40 fathoms) and at its narrowest, the strait is about 1.5 miles wide, but there are also several rocks and reefs. To quote again from the British Columbia Pilot: "The tidal streams attain maximum rates of from 3 to 7 knots in the narrower parts of the strait, and from 2 to 5 knots in the wider parts; they should, therefore, be specially guarded against at night or in thick weather. Special caution should be observed when passing the entrances of the various channels leading out of the strait."

3. Navigational Problems

We can now make an assessment of the navigational problems associated with the proposed tanker route, given the operating characteristics of the tankers and the nature of the waterway (Refer to Map 20). Two major hazard zones for grounding can be identified, the first being at the entrance to the Strait of Juan de Fuca where navigation is made difficult by the existence of two large fishing banks and by the generally poor navigational conditions. The second is in the Rosario Strait area where the existence of reefs and islands at both entrances, as well as fairly large currents, make safe navigation difficult. The level of manoeuvrability associated with large ships travelling fully loaded under their own power makes these dangers very significant, especially in bad weather.

Relative to the danger of collision in the greater part of the waterway, there is a large danger in both the mouth and the eastern end of the Strait of Juan de Fuca. At the mouth of the strait, traffic patterns are apt to be complex as ships move to and from the Pacific, and the danger of collision is consequently greater than within the strait. The danger of grounding is also greater here owing to fogs and the irregularity of currents and tidal streams. At the eastern end of the strait, the traffic routes to and from Haro Strait, Rosario Strait and Admiralty Inlet (Puget Sound) converge. Also, it is here that both the Canadian and U.S. pilot stations are located (Race Rocks and Port Angeles respectively) so that ships will be leaving the shipping channels, stopping, and then coming back into the traffic. A regular ferry service from Victoria to Port Angeles, directly across the traffic routes, further complicates the picture. In this area, then, traffic patterns are very complex and apt to be confusing. The recent collision of three ships at the Canadian pilot station serves to illustrate the confusion dramatically.

The possibility also exists that Haro Strait may be used as an alternate route for tankers bound for Cherry Point. This strait offers similar dangers to navigation as does Rosario Strait, with perhaps a greater danger of grounding at its northern exit. Here, there are a number of rocks, reefs, and islands which obstruct the shipping lanes and make navigation difficult. The British Columbia Pilot says of the area: "Haro Strait and Boundary Pass are deep and for the most part broad; but on account of the reefs which exist in certain parts, the scarcity of anchorages, and, above all, the rate and varying directions of the tidal streams, great caution and vigilance are necessary for their navigation." Therefore, Haro Strait should also be considered an area of higher spill probability.

D. Spill Probabilities

Any attempt at predicting the number of major oil spills which will occur in the study area must necessarily first of all attempt to predict the number of collisions and groundings which will occur. Such predictions are tenuous at the very best, as they must be based on accident data which are historical and/or from another part of the world. They must also rely on forecasted traffic volumes which carry their own inherent uncertainty. The applicability of these data to the analysis of accident probability in the study area is, therefore, open to serious question. Some studies have been made which try to predict the likelihood of major accidents in the Strait of Juan de Fuca - Strait of Georgia area, but from the above discussion it can be seen that they lack any solid credibility. All that can be said with any certainty is that, should supertankers begin calling regularly at ports in the study area, an oil spill of major proportions will occur sometime. Whether the first one will occur within the next five, ten or twenty years cannot be stated with any large degree of assurance. However, based on our analysis of the accident probability derived by Honeywell Inc. and our understanding of the operating characteristics of the tankers and the navigational problems of the study region, it is concluded that there is a 50% chance of an oil spill involving a supertanker occurring at least once every twenty years. This conclusion is derived from a statistical analysis, and the fact still remains that such a spill might never happen, or it might happen this year.

While the frequency of major oil spills is difficult to predict, it is possible to identify those parts of the study area in which the likelihood of them occurring is large relative to the rest of the area. It is to be emphasized that a collision or grounding resulting in a large spill can occur anywhere, especially in bad weather. What we are delineating here are those areas in which there is a noticeably greater likelihood of such a spill as a consequence of the local geography, oceanography and weather.

Based on the discussion in the preceding section (Navigation Considerations), there are three zones in the study area where there is a relatively large possibility of a major oil spill. These zones are shown on Map 20 and are:

(i) The entrance to the Strait of Juan de Fuca;

(ii) The eastern end of the Strait of Juan de Fuca as encompassed by Race Rocks, Port Angeles and Hein Bank;

(iii) Rosario Strait, including its southern approaches.

Should Haro Strait be used as an alternate tanker route to Cherry Point, it must also be considered a significant spill danger zone, particularly at its northern end (Boundary Pass). If supertankers are controlled by tugs from the area of the pilot stations, it is only the Rosario and Haro Strait zones which will be eliminated.

Oil spills which occur during cargo loading or unloading, bunkering or ballasting operations have been far more frequent than those resulting from breakup, collision, or grounding incidents. Though they have been much less disastrous individually, they account for most of the oil found on the waters of the study area. However, elaborate safety precautions are to be taken at Cherry Point during the entire time a ship is at the terminal, so that the danger of a significant spill occurring during the transfer of oil to the refinery would be very small. The U.S. Coast Guard is now monitoring about 50% of all oil transfer operations which take place in the greater Puget Sound area, and will be monitoring every transfer operation at the Cherry Point terminal. This surveillance has led to a drastic reduction in the number of unidentified slicks in the area.

To obtain an understanding of how much oil could escape should a supertanker be involved in an accident in the study region, the record of other such accidents in the world can be examined. Table 6 lists the relevant aspects of some of the more significant accidents which have occurred in recent years.

The table indicates that major oil spills have resulted primarily from groundings rather than collisions. In a collision, a relatively low proportion of the cargo (about 10% or 20%) has escaped, while a high pro-

TABLE 6

Incident	Circumstances	Cargo	Amount Escaped
Anne Mildred Brovig	collision in dense fog, drifted, grounded and broke in two	39,000 tons crude	20,000 tons (50%)
Arrow	grounded in favourable weather, broke in two	18,000 tons Bunker C	10,000 tons (55%)
Benedicte	collision in thick fog but generally good sea conditions	70,000 tons	2,300 tons (3%)
Keo	broke in two in severe storm, sank	210,000 bbl fuel oil	210,000 bbl (100%)
Ocean Eagle	grounded while entering harbour, broke in two	135,000 bbl crude	83,400 bbl (62%)
San Francisco	collision of two 10,000 ton tankers in harbour at night in fog	20,000 tons bunker	2,600 tons (13%)
Tampico Maru	grounded, sank	60,000 bbl diesel oil	60,000 bbl (100%)
Torrey Canyon	grounded in rough seas, broke in two	117,000 tons crude	100,000 tons (85%)
World Glory	broke in two in severe storm, sank	322,000 bbl crude	322,000 bbl (100%)

portion, if not all, of the cargo has escaped in a grounding incident. The table also indicates a significant danger of a large tanker breaking up in a severe storm.

Apart from the entrance to the Strait of Juan de Fuca, the study area is well protected and the high seas which tear a stranded ship apart do not exist. Thus, the extent of damage done to a grounded ship would likely not be as severe as is indicated in the above examples. A typical 120,000 ton tanker has 10 wing (outside) tanks of 55,000 bbl capacity each, and 5 centre tanks of 98,000 bbl each. Such a tanker could have 3 or 4 tanks ruptured in a grounding incident. Thus, taking the examples and discussion given above into account, it is concluded that the grounding of a 120,000 ton tanker could result in a volume of oil in excess of 40,000 tons (approximately 284,000 bbl) escaping on to the sea. Should a grounding occur on the west coast of Vancouver Island, a considerably larger amount of the cargo could escape. A collision would likely cause a smaller oil spill than would a grounding.

E. Oil Spill Insurance

While it is not the intention of this section to condone the movement of crude oil through the study region in supertankers, a method of protection from the potential impacts of these movements is proposed since there appears to be little that Canada can do to prevent them from occurring. The Strait of Juan de Fuca/ Strait of Georgia/ Puget Sound inland sea represents a contiguous environment - the fact that man has arbitrarily divided it into two jurisdictions means little to the fish and birds which inhabit it. It is a whole, and a major oil spill anywhere in the whole will spread and disperse in total ignorance and total disregard of the international boundary. Therefore, measures to prevent potential oil spills and clean up ones that have occurred must logically be based upon international cooperation between Canada and the USA. A preventative system incorporating international cooperation is presented in Appendix B. Here we propose an internationally operated means of providing funds for the clean-up of spills.

What is proposed is that an international fund be created out of which are paid the costs of maintaining oil spill clean-up contingency forces and the costs of cleaning up individual spills. This fund would be financed by a tariff on all oil and oil products being transported by barge or tanker in the inland sea. It would have to be set up to be compatible with the Canadian Marine Pollution Claims Fund which is already in existence, and with any similar funds which are in effect in the U.S.A. While the establishment and operation of such a fund would no doubt be a difficult task, we believe that the environmental imperatives of the study region demand that the task be undertaken.

To determine the order of magnitude of the tariff which would be involved, the following assumptions are made:

(i) Only the volume of oil expected to be coming in to the inland sea from Alaska is considered. This volume is estimated to be 8.65 million tons per year (6 arrivals of 120,000 ton tankers per month).

(ii) It is desired to be prepared for a major oil spill costing $25 million to clean up (See Scenario # 1) every twenty years.

(iii) The cost of maintaining an oil spill clean-up contingency force is $200,000 per year.

Based on these assumptions, the annual cost of major oil spills is $1.45 million, and the tariff required to offset this cost is 16.8 cents per ton.

Of course, a number of factors would conspire to alter this tariff, including:

(i) Much more oil and oil products is moved in to, out of, and within the study region than the volume of Alaskan oil alone. This factor would tend to reduce the tariff.

(ii) There are many other tankers and barges operating in the study region, and the costs of cleaning up spills caused by these vessels would also be paid out of the fund. This factor would tend to increase the tariff.

(iii) The costs of labour, materials and equipment are generally increasing. This factor would tend to increase the tariff.

(iv) Monies accumulated in the fund would earn interest which could become part of the fund. This factor would tend to reduce the tariff.

(v) To build the fund up to an acceptable level initially might require a tariff larger than 16.8 cents per ton.

This proposal is presented primarily to establish the idea that such a fund is needed. It is not meant to be precise in economic terms, but only attempts to present an order of magnitude appraisal of the tariff which would be required. The presentation of the proposal is prompted by our fear that attempts to deal with the environmental impacts which could result from a major oil spill will be frustrated by international debates over who is responsible for cleaning up and paying the costs of the spill.

CHAPTER V - THE IMPACT OF OIL SPILLS

A. BIOLOGICAL AND PHYSICAL CONSIDERATIONS

1. Biological Effects

Crude oil or its by-products floating on the surface of the water can cause widespread damage to marine life. Very small quantities of oil, either ingested or on plumage, can kill birds. It smothers intertidal animals and plants, interferes with the normal feeding and respiratory mechanisms of shellfish in particular, introduces toxic components into the water column, increases the level of hydrocarbons in the marine food chain, and alters communities to a point of extreme ecological instability. Direct economic losses occur when the flesh of fish or shellfish becomes oil-tainted or when it is no longer possible to utilize fishing gear in oil-polluted waters.

Laboratory and field studies carried out to date have indicated the extent, increasing seriousness, and harmful effects of oil pollution. However, there are practically no long-term studies to indicate "safe" levels of oil products in the marine environment under continuous or long-term exposures, and we know little of the sublethal effects of oil and its breakdown products on marine life.

The adverse effects of oil on marine bird populations alone is sufficient cause for alarm. If no other consequences could be demonstrated, the welfare of bird populations alone would justify extreme caution. If more funds were spent on the prevention of oil spills, there might be less concern with studying their effects.

Once a large oil spill does occur, it is often difficult to determine its effects. Very little is known about natural mortality rates of animals in the sea and hence it is difficult to separate natural mortality from oil-induced mortality. It has been a problem to separate the effects of oil pollution from natural long-term and seasonal fluctuations in animal numbers and the lack of baseline information prior to a spill taking place makes it virtually impossible to compare conditions after the spill.

It is not easy to predict the biological effects of a spill from laboratory toxicity tests or from information gained from previous spills elsewhere. The types of oil spilled, the environmental conditions at the time of the spill, and the degree and duration of confinement of the oil are some of the variables that make it difficult to generalize on the harm that might be done.

However, examination of experiences gained at major recent spills was the main option left open to us and on this basis we attempted to assess probable effects in the study region. Our survey of available literature indicated that:

(i) Oil and oil products should be regarded as poisons that damage the marine ecology;

(ii) Marine resources can be endangered by a direct kill or by the long-term accumulation of petroleum hydrocarbons in the marine food web. The steady accumulation of oil in the marine environment may be far more serious than single large spills;

(iii) Oil spills may present a public health hazard by increasing the level of carcinogenic hydrocarbons in seawater and bottom sediments, thereby increasing their concentration in sources of human food from the ocean;

(iv) Dispersants introduce oil with its water soluble components into the water columns. Toxicological studies have indicated that chemically emulsified petroleum oils are several fold more toxic than the same oils spilled on the water surface and naturally mixed by waves, winds and tides. Tarzwell (1970, in "Water Pollution by Oil", ed. P. Hepple) after carrying out fairly extensive tests on the toxicity of oils and oil dispersant mixtures, concluded that it was undesirable to use dispersants unless absolutely essential for final clean-up or to protect waterfowl or damage to shore installations and beaches;

(v) Acute toxicity of oil is largely due to the lighter volatile fractions that are evaporated or dispersed quickly in open water areas. Toxicity could cause widespread damage in the study region if oil arrived on intertidal areas, estuaries or shallow littoral zones shortly after spillage;

(vi) The physical effects of oil (such as interference with normal feeding or respiratory mechanisms, or alteration of the substrate on which animals live) could cause widespread damage to intertidal organisms, birds and juvenile fish;

(vii) Marine-associated birds would be severely affected by a major oil spill;

(viii) Where oil was allowed to reach the shore, intertidal organisms would be severely affected. Although many of these organisms would recover, the effect of chronic pollution could lead to a reduction in the diversity of species and a greatly increased tendency to ecological instability. For example, a reduction in grazing mollusc populations can bring about an overabundance of marine algae;

(ix) The eggs and juvenile stages of fisheries resources are extremely vulnerable to oil pollution. Herring spawn and larvae and juvenile salmon could be adversely affected.

The following is a brief account of the possible effects of oil on specific marine resources within the study region:

a) Plankton

It has been demonstrated under laboratory conditions that petroleum products and by-products are toxic to a variety of plankton and that in combination with low oxygen concentrations may cause an adverse synergistic effect. Oil may also inhibit light penetration and thus interfere with phytoplankton production.

Under field conditions it has been difficult to demonstrate the effect of oil pollution on plankton, primarily because of the lack of baseline information and natural seasonal or long-term fluctuations in plankton numbers.

At Chedabucto Bay, particles of bunker C oil in the water column were in the size range of food for zooplankton but appeared to have little effect on the organisms ingesting it. Similarly, there was no evidence of gross effects of crude oil on plankton in the Santa Barbara Channel. On the other hand, where refined products or toxic crudes were confined to small embayments for considerable periods of time, there would likely be a direct toxic effect on plankton.

The uptake of oil into the marine food web and day-to-day accumulation of oil in the marine environment are matters of concern. Blumer at al. (1970) state:

> "Treatment of oil spills with detergents produces oil droplets of such small size that they can be eaten and taken up in the body of many sea animals. Once assimilated, this oil passes through the food chain and eventually reaches marine products in concentrations that may be unsafe for human consumption. These oil particles may produce an undesirable flavour or accumulation in human food of long-term poisons derived from crude oil, as for example, cancer-causing compounds."

b) Marine Plants

A major oil spill would initially damage some species of marine plants in the study region. Studies have shown that algae was affected after the wreck of the Tampico Maru in Lower California, the Argea Prima off Puerto Rico and the Torrey Canyon. North and his colleagues, in a seven year examination of the Tampico Maru spill, found that kelp forests not only recovered from the damage but spread across more than half the available sea-bottom. The increased kelp beds went through two complete growth cycles before grazing animals were able to bring them under control - Tarzwell (1970).

A few months after the Torrey Canyon spill, rocks along parts of the Cornish coast were covered with a thick growth of green algae. The following year this growth was replaced by brown algae in greater density and variety than usual. It was expected to take several years before limpets, topshells and winkles would bring about a restoration of the previous balance - Tarzwell (1970). A severe spill on this coast would probably have similar effects with eel grass in particular being seriously affected because of the tendency of oil to cling to it readily.

c) Invertebrates

The effects on intertidal organisms following the spill of 60,000 barrels of diesel oil from the Tampico Maru in 1957 demonstrate what could happen to marine life in this region. The diesel oil was confined to a relatively small cove off the coast of California and virtually all marine life in the cove was destroyed. A tiny snail, Littorina planaxis, and a large green anemone, Anthoplura nanthogrammica, survived. Dead Pismo clams littered the shore for a month after the wreck, while other dead species included lobsters, abalone, sea urchins, starfish, mussels and clams. Ten years after the wreck, 69 species of animals have re-established themselves, but the cove is still not the same as it was before the spill - many species have only recently appeared and cannot be considered abundant.

Tarzwell (1970) has described the effects of oil on marine life:

> "Oil or its degradation products may produce repelling effects, effects on the sensory organs so that normal behaviour cannot be achieved, and adverse effects on feeding mechanisms, enemy avoidance, or on sexual attraction. Ingestion of oil may be directly toxic or there may be breakdown products or degradation products of the oil which are incorporated as hydrocarbons in the body tissues of the organisms and are harmful through their carcinogenic effects or harmful to those who consume the organisms."

Not all oil spills have produced as drastic effects as the Tampico Maru. The Santa Barbara spill demonstrated that if crude oil remained at sea for several days, damage to intertidal life would be limited to the smothering of some species. Recolonization of intertidal areas at Santa Barbara, after clean-up operations, commenced within seven weeks of the spill and as of November, 1970, most intertidal areas had a normal population of invertebrates, but this was probably assisted by higher water temperatures.

There was a 20% mortality of clams on beaches at Chedabucto Bay as bunker C oil clogged clam burrows, smothering the inhabitant. Even if oil does not kill molluscan shellfish, it will render them unsaleable as a result of tainting, with shrimp particularly susceptible to this. Mackin and Sparks (1962) demonstrated that it took two months for oysters to lose their oily taste once tainted.

The harvest of shellfish could be severely affected in any of the areas outlined on Maps 4, 5 & 6 with economic losses highest on the eastern shores of southern Vancouver Island.

d) Fish

i) Eggs, Larvae and Juveniles

It has been demonstrated under laboratory conditions that a variety of fish eggs and larvae are highly sensitive to oil at fairly low concentrations. These findings may have particular significance for this area since large numbers of young herring and salmon spend their early life in such shallow waters as the Fraser delta and Boundary Bay. Herring spawn on intertidal marine plants, particularly eel grass, and the affinity of eel grass for oil would likely increase the exposure of herring eggs to it. While it is inconceivable that herring populations would be affected over the whole of the study region, a particular age class could be eliminated from specific spawning areas. Furthermore, a severe reduction in herring populations could influence some of the higher fish dependent on them for food. Herring spawning locations that could be affected by an oil spill are shown on Map 8.

ii) Adult Fish

Generally the hazards to fish and fish foods are limited as long as oil remains as a surface slick, but when emulsification and dispersion occur, direct contact is possible. Fish may be affected by toxicity or by the mechanical action of oil droplets on the gill apparatus preventing the exchange of gases and resulting in suffocation.

It was concluded from the Chedabucto Bay, Torrey Canyon and Santa Barbara spills that there was relatively little effect on commercially valuable fish, so it is unlikely that a spill would affect adult herring, salmon, groundfish or other adult fish. However, large numbers of young salmon spend a considerable period of their early saltwater life in shallow inshore waters and it is conceivable that a toxic oil could cause considerable mortality to these young fish.

Virtually all the major oil spills studied have demonstrated that it is impossible to utilize fishing gear properly on oil-covered waters. Depending on the area a spill covered, any of the B.C. gillnet, seine, troll and trawl fisheries could be interrupted for the period of time that oil remained on the surface, and the trawl fishery would continue to be affected if oil were sunk with dispersants. Seasonally the most critical time for the salmon fishery would be between April and December. If a spill occurred during the peak of the sockeye or pink migrations to the Fraser River, there would be little or no harvest resulting in very heavy escapements which could affect upstream spawning facilities.

A large laundromat with a capital cost of $26,000 was built at Chedabucto Bay to clean nets fouled by oil. This was done in far less time and at substantially lower costs than replacement with new nets through a claims procedure would have required. However, on the west coast, the large number of nets that might be affected and the critical timing of salmon runs through Juan de Fuca Strait would limit the short-term applicability of such a laundromat.

e) Marine-Associated Birds

Marine bird casualties from oil pollution number many thousands each year. The following documented examples indicate the severity of the problem:

(i) In the winter of 1951-52, an estimated 100,000 birds were lost to oil pollution on the coasts of the British Isles (Zobell, 1962);

(ii) Hawkes (1961) estimated that a breeding colony of 250,000 seabirds nesting on Newfoundland was decimated by oil in a two-year period;

(iii) The Torrey Canyon wreck resulted in the oiling of 30,000 birds on the coasts of England and France;

(iv) The virtual extinction of the razor-billed auk in Newfoundland has been attributed to the effects of oil.

Most oiled birds disappear at sea before they can be counted, hence figures quoted for bird mortalities are generally underestimates. The long-term effects of bird mortalities are largely unknown because population estimates can seldom be correlated between conditions before and after the spills. This situation would prevail in the study region since very little is known about the natural mortality and population sizes of most species.

As virtually the whole shoreline of the study region during winter months harbours marine birds, an oil spill occurring anywhere along it would cause deaths, but the greatest impact would occur adjacent to seabird nesting colonies shown on Map 11 and on major waterfowl wintering areas also shown on Map 11. Mortalities could be as low as several hundred birds, or as high as one hundred thousand. If oil covered large areas of the Fraser delta or Boundary Bay during peak periods of bird abundance, mortality would be in the tens of thousands. Virtually all species of marine birds would be affected but mortalities would be highest among such diving species as cormorants, loons, grebes, murres, murrelets, guillemots, mergansers, scoters, oldsquaws, scaups and goldeneyes. A significant proportion of the Pacific coast trumpeter swan, brant and lesser snow goose populations could be killed by a single large oil spill.

Almost all major oil spills have resulted in attempts to rehabilitate oil-soaked birds. The results of these operations have been so poor that researchers are now recommending that heavily oiled birds be destroyed. The problems have been revealed as:

(i) Curing the initial poisoning from ingestion of oil;

(ii) Preventing chilling due to the loss of thermal insulation by the plumage;

(iii) Removing the oil from plumage;

(iv) Replacing the waterproofing characteristics of plumage;

(v) Developing proper housing, feeding and other care designed to keep that particular species in captivity long enough to rehabilitate it.

Aldrich (1970) has reviewed the results of research and cleaning attempts and concludes that:

> "Oil of varying sorts can be cleaned from the plumage of birds with several kinds of cleaners, but so far there is no convincing evidence that the natural water-repelling qualities can be restored to the cleaned feathers by known methods."

Some researchers have had a fair amount of success by holding birds until the next moult so that water repellancy is restored before the birds are released.

f) Marine Mammals

We have not placed emphasis on marine mammal populations because it has been demonstrated in a number of cases that they are not adversely affected by oil pollution. Seal populations in Chedabucto Bay were reduced after the Arrow spill, but it was felt that the presence of the oil and disturbances during clean-up operations forced the seals to move elsewhere. Santa Barbara tagging studies showed a low mortality of seals even amongst those that had been literally coated with oil.

However, it is conceivable that an oil spill off the west coast of Vancouver Island during the fur seal migration could reduce the value of fur seal pelts. River otters and saltwater mink could suffer if large expanses of intertidal shoreline were heavily coated with oil.

2. Effects on Physical and Man-Made Resources

a) Beaches and Other Foreshores

The actual physical impact of oil on a shoreline depends on the configuration, slope and composition of the shoreline as well as on water and air temperatures. (Appendix D of this report deals in more detail with the actual physical accumulation of oil on shorelines and clean-up methods.) Heavy oils tend to concentrate at the high water mark of a shoreline. The oil will cover the surface of rocks in the intertidal zone and penetrate to a depth which increases with air temperatures and the degree of energy expended on the shoreline by water and tidal action.

Oil deposited on beaches tends to mat the beach material and stabilize its normal movement under tidal conditions. It also forms nodules that become covered with a surface layer of sand which can in turn be broken up by tide and wave action. After a period of exposure to tidal action, oil becomes mixed with beach materials to varying depths and may form an impervious layer beneath the sand's surface.

The implication of any of these effects on shorelines for outdoor recreation are obvious. The biological implications have been considered elsewhere and at this point we deal solely with the effects of oil on outdoor recreation that are not directly related to the biological community.

Basically, oil on any type of shoreline seriously inhibits recreational use of that shoreline until such time as the oil is removed. The aesthetic implications of seeing oil on shorelines needs little elaboration and the sheer physical inconvenience of it on foot gear, clothing and recreational equipment certainly detracts from the recreational experience.

This reduction of recreational use of a shoreline as a result of the presence of heavy oil is obviously related directly to the speed with which oil is removed. Natural wave action will ultimately move much of the oil from rocky and, to a lesser extent, cobbled shorelines, but the effects on sandy beaches are longer lasting. Unless the oil is removed while still on the surface of the beach, then longer lasting deterioration of the beach for recreation will result. Assuming a fairly rapid clean-up (within 2 to 3 weeks of a spill), then the recreational impact on shorelines will not be of a lasting duration other than the biological impact that would reduce natural history activity or other resource-based activities such as clam digging or oyster gathering.

The season of the year at which a spill occurs is also a critical factor. A spill occurring at the peak of the recreational season in a given area would seriously detract from recreational use of affected shorelines. Although the effects of spills are likely to be localized depending on the magnitude of the spill so that comparable types of outdoor recreation could be available at alternative sites, this would be offset during peak recreational periods by lack of available accommodation facilities elsewhere. Day users would be affected to a lesser degree, but any kind of disruption of recreational activity does have a social impact, as discussed in Section C of this chapter.

The impact of petroleum materials other than heavy oils is less clear. Generally, they disperse fairly rapidly through evaporation and emulsification. While the effects of petroleum products upon marine organisms may be more toxic than the effects of heavy oils, the impact on outdoor recreation will almost certainly be far more temporary. Objectionable odours and a shorter period of actual beach contamination would create a shorter term interference with recreational activity. Also, spills of these materials would usually involve far lower volumes than spills of crude oil and the effects would be far more localized.

b) Pleasure Boats, Marinas and Principal Harbours

The presence of oil in an area used for recreational boating would seriously inhibit normal recreational use. There would, of course, be sightseers interested in actually seeing an oil spill, but presumably restrictions would be imposed on use of an area while clean-up operations were underway to avoid interference.

The aesthetic implications of oil on water and the possibility of craft being fouled by oil would prevent boaters from venturing forth in waters actually affected by a spill. However, the effects of even a major spill on recreational boating would be of a limited duration. Alternative areas away from the localized spill would be available to boaters and, as other sections of this report point out, it is possible that either the slick would be contained and oil removed from the water, or weather conditions would disperse the oil to the point where it no longer affected one particular area.

The major direct damage to docks and pleasure craft would be the fouling of structures by oil. Such damage would be measured in terms of clean-up costs, with steam cleaning the most efficient and least costly method of cleaning both vessels and dock facilities. Oil washed from the boats could be collected by floating peat moss and removed from the water.

A telephone survey of local marina operators indicated that few expected to suffer any appreciable damage to their installations. Their major concern was that recreational boating use would likely diminish in the case of a spill and consequently their business would suffer.

c) Log Booming and Storage

The forest industry is not unanimous regarding the degree of oil spill damage to log stocks. Many companies have not experienced oil on logs and can therefore only speculate on the impact of a spill. In most cases, the companies who have not been affected by oil contamination feel no damage would result, while those who have had some experience with petroleum pollution have indicated the following:

(i) Light oil such as lubricating oil might penetrate wood more readily than heavy oils such as bunker C;

(ii) Handling problems could be encountered when logs are covered with heavy oil. For example, jack ladders in some cases are not able to handle large logs due to slippage caused by the oil. One company noted that unions may demand "dirty pay", which might increase costs by $2.00 per Mbm. Included in this would be items such as replacing boom men's clothing at every change in shift;

(iii) In nearly all cases, logs are debarked by a hydraulic debarker before being processed so that oil which has not penetrated the wood is eliminated at this stage. The oil impregnated bark then becomes hog fuel and is burnt. No reports exist of air pollution caused by utilizing oily hog fuel. The major biological difficulty encountered with the hydraulic debarking process appears to be recontamination of the water supply. Industry has not studied this problem to date;

(iv) Logs which are oil-coated for a period of time are stained if the bark covering is broken. Also, oil is likely to penetrate into log ends and cause two adverse effects:
- The stained portion cannot be chipped and utilized for pulping purposes. A loss of approximately $6.00 per Mbm (Cedar) was shown by one company;
- Oil stained lumber is degraded. For example, Cedar Clear Lumber (export grade) is reduced in value by approximately $200.00 per Mbm and the lumber is no longer suitable for export;

(v) Oil-contaminated log booms will not sell on the open market unless logs are in short supply. With a delay in processing, the oil has time to penetrate the wood. One company indicated that such logs could not be utilized and would cause a disposal problem;

(vi) Indirect costs would rise in the event of a large oil spill as log rafts would have to be rerouted to avoid a spill and some booming grounds may be unavailable for an extended period of time. If a processing plant did not have a substantial inventory, other log sources might have to be contacted and, if this were not possible, temporary plant shutdown might occur. An important secondary biological effect would be the transfer of oil from one area to another through moving contaminated booms.

3. Effects on Land Status

a) Parks and Park Reserves

The great focal importance of the intertidal zone in the recreational opportunities provided by parks and park reserves has already been emphasized in the marine resources inventory. Considering recreational usage alone, the intertidal zone would be unattractive to any usage while oil is apparent on the shoreline. Gathering and collecting intertidal organisms such as clams and oysters would be impossible until the beach had been thoroughly cleansed, either by natural weathering and degradation, or by man, and consequently, the numbers of people visiting these areas would decline for the time that the beaches remained contaminated.

b) Ecological Reserves

For those ecological reserves which were established to preserve unique biological communities directly associated with tidewater habitats, a serious oil spill would be permanently damaging. The main purpose of conferring ecological reserve status on these communities is to allow natural processes to go on undisturbed. Both the scientific value and the "museum" value of ecological reserves would therefore be destroyed and the very reason for their existence would be negated.

c) Indian Reserves

Indian reserves are frequently very attractive and often productive real estate. Due to their unique land status and the current unrest about both the legal status of the native Indian and his land or historic rights to it, damage to Indian reserves resulting from an oil spill could cause further complication to already complex political issues.

On a more immediate level, some of the native people, particularly on the more isolated reservations within the study region, are still heavily dependent on marine resources such as fishing for their subsistence. They would be affected immediately in the case of a severe oil spill and it is quite possible that they would require financial relief during crisis situations.

d) Real Estate Values

The value of certain real estate would clearly be affected by pollution from an oil spill. A polluted shoreline would immediately be reduced in usefulness and hence the value of the property would be lowered. In the case of a particular spill, the magnitude of the reduced values would depend on both the severity and the duration of the pollution. In most cases it is estimated that the aspects of oil pollution which are offensive to human use would be temporary, perhaps one to two years. In this case, the reduced market value would be directly related to the reduced value in use for the period in which properties were contaminated.

In a more general sense, the value of real estate, in any of the areas of the study region which could be contaminated, would likely be affected. The values could be reduced because of the possibility they might be polluted in the future. This aspect could be quite large, but as it would be so widely spread and as other market factors are continually changing, it would probably not be possible to accurately measure this effect.

A more detailed discussion of the methods of assessing these changes in property values is contained in the following section of this chapter. Furthermore, an example of the expected reductions in values for a particular oil spill is given in detail in the scenarios.

B. ECONOMIC ASSESSMENTS

This section establishes the appropriate methodology for identification and evaluation of the economic costs associated with a marine oil spill. The methodology is structured in a manner which leads to a summary of the net costs to society based on economic definitions of costs. An earlier attempt at this was made by Mead and Sorenson after the Santa Barbara spill. Specific dollar value figures are not determined in this section, rather a description of considerations and procedures relevant to assessing economic damages from oil spills is developed. It is in Chapters III and VI and Appendix A that dollar figures are developed explicitly.

Within the constraint of existing income distribution, a free enterprise economic system will achieve an optimum allocation of resources given the following two broad assumptions: first, that markets are perfectly competitive, second, that there are no external costs or benefits arising from activities of individuals or firms. The economic problem is largely concerned with attempting to achieve an optimum allocation of resources, given that the above assumptions are often not applicable.

One of the generally accepted functions of government is to regulate business activity in such a manner as to control the distorting effects of non-competitive conditions and external benefits and costs. This is generally attempted through a combination of administrative actions and taxation. For the purpose of this discussion we are concerned with a certain type of pollution which, without regulations, would be an external cost which oil companies impose on other parts of society. The economic objective in the most general sense would be to assess these external costs and force the firm or fims to "internalize" them, or bear the costs themselves. This would cause a move closer to the optimum allocation of resources, but might not cause the oil company to alter its proposed oil route. A forced internalization of the costs could be brought about through taxation and contingency funding. Even at this stage, the problems of the proper compensation for those who may suffer damages would in the best of circumstances be difficult. With the added international implications in which damages could occur to Canadians in a spill from a foreign tanker in international or American waters, the problem of compensation becomes even more formidable. These compensation problems must at some time be considered, but this is not the purpose of this section. Its purpose is to take only the first step to develop the methods of assessing the level of economic costs.

In economic terms, to measure the social costs of a disruption from pollution one would ideally like to measure the sum of the changes in what is technically termed consumer and producer surpluses. This type of measurement is difficult and in practice one can only strive for an accurate approximation to these values. The economic costs of an oil spill are not measured simply by adding up the dollars spent on clean-up and the assessment of property damages. Instead the costs must be measured in terms of opportunities which are foregone plus decreases in utility resulting from certain damages. These foregone opportunites are an important part of the real costs and damages of an oil spill and they can be very diverse in nature. They include the production lost when resources are transferred to clean-up use, lost leisure time, lost recreation values, reduced utilization and enjoyment of marine resources, and other uses of the marine environment which would be precluded for a period of time. Even if current production were held constant and all restoration was accomplished by overtime work without pay, there would be a real economic cost. Individuals would at the least be sacrificing leisure and recreation time which is certainly valuable to them. When measuring the extent of the opportunities which are sacrificed, initial difficulties are encountered in attempting to quantify each into its own unit of measurement. These difficulties are further compounded when trying to compare one to another or to measure one in terms of another. When reaching for a common denominator with which to measure the relative value of one thing to another, the economist will use the medium of exchange, or monetary value. In this case the dollar value does not always work perfectly because many environmental and aesthetic values are not usually priced. However, even here a measure for comparison with other scarce commodities is needed, and where possible an attempt to assign dollar values should be made.

Any study of this nature will encounter problems of non-priced goods and other difficulties in quantification. In a similar context the study can never be any better than the available data. In the case of an oil spill, exact biological and environmental data may never become available, or the long-term effects may become known only after a great many years. With this in mind it is necessary to make the best estimates possible, with qualifications identified. It should also be noted that as biological and environmental data are continually being developed it may be necessary in time to revise the economic estimates.

The purpose of the development of this methodology should ultimately be to determine the average external cost factor imposed on others by a tanker route. This average cost factor, say for a given year, or per quantity of oil shipped, could then be used by decision-makers when assessments are made to force an internalization of costs on firms causing the risk of oil pollution. To do this would require an extension of the analysis in this chapter to include estimates of statistical probability concerning the quantities of oil which would be spilled per unit of time (Chapter IV) plus statistical probability estimates of the effects in various locations in which these spills would occur (Chapter VI). This section analyses only the methods to be used to assess the costs of any particular spill.

1. Clean-up and Property Restoration

If there are no monopolistic distortions in the price paid in the private sector for resources used in clean-up efforts, and if labour is close to being fully employed, all of the costs incurred for clean-up and restoration should be included in the tabulation of the social cost of a spill. This would generally be measured by the prices paid to the resources which are drawn from alternative uses, for these prices would closely reflect the values of the opportunities and production foregone. These costs should include all payments for clean-up labour, materials expended, and rental or imputed cost for machinery which is used. Care should be taken not to count both the price paid to a factor plus the value of that factor's lost production in its original activity. One value should reflect the other, but to count both would be double counting.

Concerning governmental agencies, one should still consider social costs in terms of foregone alternatives. Certainly all extra expense caused to such an agency like extra employees, overtime pay, extra materials consumed, and extra rental costs on machinery should be counted. Furthermore, the cost of individual government employees switched from productive work to oil spill control efforts should be included in the costs. However, during a spill, the cost of a government employee whose normal duty is directed toward pollution control should not properly be charged as a social cost of one particular spill. In a similar respect, no portion of the fixed or carrying costs of a previously-established agency should properly be charged to a particular oil spill. If, on the other hand, a government agency is created specifically to deal with pollution because of the threat, say from a particular tanker route, this expense is a social cost. These particular expenses accrue at a constant level because of the risk of spills. They can be charged as a general cost of protecting the environment against a particular tanker route, but should not be counted as part of the cost of any single oil spill.

The tabulations of clean-up and restoration costs can be concluded at one of three points. One would be when <u>all</u> clean-up and restoration has been completed. Two would be when it is determined that <u>all possible</u> clean-up is completed. Three would be when it is determined that the only <u>unrestored resources are not worth the cost of restoring</u>. The conclusion in case one is obvious. In case two, the damage to resources left unrestored would be assessed as the difference in use or utility after contamination as compared to their original state. In case three, if the value of damaged resources is less than the cost of restoring them the loss should also be assessed on the basis of their reduced utility or value.

2. Commercial Fishery

Damage to the commercial fishery would vary greatly depending on the season in which a spill occurred. During the short duration of an assumed oil spill fishermen are "locked into" a position of investment in boats and gear, and are not sufficiently mobile to move into other areas of employment. The value of their lost labour and use of capital would then be a social cost. In a similar context there are many others who, in the short run, are "locked into" the business of production of fish products. This would include many facets of production in the fish processing industry. In the short period of a spill it would not be possible to switch these resources to alternative production. The value of each input up the chain to the final product would be lost. It is then proper to sum the loss at each level, counting only the extra value added at each level which would be lost. The output value at each level includes the value of the previous level's inputs, and to sum them all would be to over count. This problem is greatly simplified by the availability of data on the value of the final product as it is finished in the plant. This value is the sum of all previous inputs and would be proper for damage assessment. The value of variable or out-of-pocket expenses in the production of fish products should be deducted from this final product value.

3. Tourist Industry

In assessing social costs to the tourist industry it is necessary to distinguish between actual losses and mere transfers. If tourism was reduced during the short period of a spill a social cost would occur because owners and operators in this industry could not turn to alternate production. However, tourists who merely go to other locations in British Columbia are simply transferring their expeditures. There would be a gain to the tourist industry in the alternate location which would offset losses in the spill area. To assess the social cost, the increased income in the alternate locations should be deducted from the lost income in the oil spill area. It would also be proper to include the reduced utility to Canadian tourists who were forced to pick a less preferred vacation area if they so chose. This is almost impossible to assess monetarily, however, so we have included it descriptively later in this chapter in the section entitled "Social Implications".

4. Property Values

The initiation of a major oil tanker route in the Georgia Strait region would be expected to affect shoreline property values within the study region. To discuss this effect with respect to shoreline property only is over-simplistic. Shoreline property tends to be more highly valued than non-shoreline property, and this premium is attributed in part to the value of direct access to the water, beach, etc. The risk that an oil spill would interrupt the usefulness of the shore would of course have a negative influence on the present value of shoreline property. But this same effect could also be felt on non-shoreline property where part of its value arises from its location with respect to access to the waterfront. The risk that waterfront use might be interrupted would tend to reduce the value of this property, as well as that of actual shoreline property.

There appear to be two ways in which property values would be affected. On the one hand the value of all shoreline property could be depressed as a result of the risk of an oil spill. Additionally, the value of any shoreline actually contaminated by a particular spill would be depressed. These two cases are discussed separately.

a) Values Depressed Due to Risk of Oil Spills

The risk of a major oil spill from a new tanker route could reduce property values throughout the area exposed to this danger if it were a recognized risk. This reduction in value would reflect uncertainty on the part of buyers and sellers of property as to the "usefulness" or "continuity in usefulness" of waterfront property within the exposed area. In the region which is relevant to this study, a uniform reduction in property values would not be expected as the risk of contamination appears much higher for some areas than others.

Empirical measurement of the extent to which property values are reduced by such risks does not appear practically possible, and would in any case require an after-the-fact investigation. Likewise there does not appear to be any technique which would be relevant to forecasting this effect. Many factors other than the risk of oil spills are operative in determining shoreline property values within the study region, and the interaction of these factors in recent years has resulted in consistently rising values. If the tanker route were initiated, realization that the property was subject to the risk of major oil spills would probably cause values to rise less than they otherwise would have, resulting in a lower rate of increase as measured through time. To isolate the effect of the oil spill risk on property values when all other factors determining property values are constantly changing would not appear practical at present.

b) Contamination by a Particular Spill

A particular spill which contaminated waterfront property would render it less useful and hence reduce its value. It is assumed that contamination from any one spill would be relatively short-lived (1- 2 years) and that once the shoreline had been restored to pre-spill condition the property would regain its normal usefulness and hence its normal value. In such cases the measure of the cost to property owners can be estimated by imputing a return, similar to a rate of return on capital, to the reduction in rental value of the property during the time the shoreline is contaminated. This rate of return represents a monetary expression of the utility derived each year from ownership and use of the property.

As a simple example, assume that a shoreline property is contaminated by an oil spill which renders the waterfront unusable for one year after which time it returns to its pre-spill condition and normal usefulness. For the duration of the contamination the shoreline property would be comparable, in terms of the utility it provided, to non-shoreline property. If it is assumed that the shoreline property had a value of $20,000 and a comparable piece of non-shoreline property had a value of $8,000, the difference in these values provides a basis for estimating the cost of contamination to the property owner. The utility received each year from use of the property can be approximated from the rental value which is assumed to be 12 percent of market value. In this example the rental value of the shoreline property would be reduced to that of the comparable non-shoreline property for one year. This represents an imputed loss of utility of $1,440 for that year (a rental reduced to $960 as opposed to a "normal" rental of $2,400). The capitalized value of this loss of utility represents the appropriate measure of the cost of the oil spill to the property owner.

5. Recreational Values

An oil spill would have an adverse effect on the quality and therefore the value of recreation in areas near the spill. The net loss in recreation values should be estimated and included as a cost.

Most of the recreation affected would be centered on the use of public recreation areas. Of these, boating, fishing, beach use and swimming would be most important with walking, beachcombing, and perhaps hunting of value in some areas. In these cases the alternatives available to those who are affected must be determined. In some instances, because of the short nature of an oil spill, people might have no alternatives to a particular recreation endeavour. One example is that of an avid sports fisherman whose boat could not be moved from the marina because of large amounts of oil in surrounding areas. In such cases the social cost is the value of the entire recreation experience which is lost. An estimate would have to be made, possibly through direct survey techniques or by imputing results from other similar surveys, for the per person value lost on a daily basis. This would then be combined with estimates of the number of days of recreation lost due to the effects of the spill. For some individuals an oil spill would only cause a transfer of activity to another location or perhaps a transfer to another activity. Then the proper measure of the social cost would be the sum of the increased costs, if any, of moving to another supposedly less attractive location or activity, plus the difference between the value of the original activity and its substitute. In many cases where people are indecisive about choosing between two or more recreational activities, these costs will be small. The practical aspects of making the required assessments are the outstanding difficulties in this area. For practical application, the constraints of available data may enable one to only roughly approximate average values for recreation and days of use.

For recreation centered on the use of private property or "semi-private" beaches, individuals have paid location or site premiums which are reflected in the high price of waterfront property. The loss in recreation that these individuals suffer is accounted for by the previous consideration of decreased "rental" values. The recreation lost to private owners of waterfront property should not be included with other estimates of recreation losses in such cases, as it would be double-counting.

6. Option Demand

The preceding discussions have dealt with those costs which can, at least in theory, be directly measured. For the most part they relate to direct uses of the marine and associated shore and land environment and their measurement requires that the reduction in such uses due to an oil spill be estimated and the value of such "foreclosed" use be established.

The concept of option demand has evolved within the last decade through efforts to refine the application of benefit-cost analysis. For publicly provided goods or services, where user charges are often non-existent and are seldom market determined, the appropriate measure of benefit is the sum of revenues collected plus the consumers' surplus. (In this study, for example, the consumers' surplus appropriated by outdoor recreationists would be estimated as the value of benefit from that form of resource use.) It has been argued, however, that where there is uncertainty in demand, there may be a further form of benefit, called option value, that must be added to the consumers' surplus. Option value relates to possible future use of a good or service and is the premium which a person who is an uncertain demander would pay to ensure the availability of that service. It was initially suggested by Weisbrod (1964) that for option value to be relevant for public policy three conditions had to be met. These conditions were:

(i) That there are persons who are uncertain about future use or demand for the commodity or service in question;

(ii) That a decision about supplying the service in the future is about to be made, and if the service is curtailed in supply, re-establishing or expanding it would be extremely costly or technically impossible;

(iii) That there is no practical way for the resource owner providing the service to collect the option value because exclusion is not possible; that is, it is not possible to identify all those who would benefit from assured availability of the good or service and exclude from benefits those who refused to pay for an option.

Subsequent discussions of the concept of option demand have attempted to clarify whether in fact option value exists separately from consumers' surplus, and under what conditions it is likely to be significant. This discussion has established that where individuals are certain about their future demands for the good or service in question, option price will just be equal to consumers' surplus and there will be no option value. Where individuals are uncertain as to their future demand for a good or service, option price will be greater than consumers' surplus and there will be a positive option value. Also, even for certain demanders when there is uncertainty of supply in the future, there will be a positive option value.

It seems valid therefore, to claim that option value does exist for some of the services provided by the marine environment of the study region. The uses to which it would apply are those which are outside of the normal forces of market transactions - outdoor recreation of various types and opportunities for education and research. Within the broad spectrum of those who could in future use the study region for these purposes, it seems reasonable to assert that there will be many who are uncertain demanders and would pay an option price to ensure continued supply of the service. There also appears to be uncertainty regarding the provision of at least some of these services in the future. To the date of this report, however, no practical means of estimating option value have been proven.

A pre-condition for the concept of option demand to be relevant for public policy, however, is that a decision about supplying the service in the future is about to be made, and that if the service is curtailed in supply it will be extremely costly or technically impossible to re-establish or expand. In the present case, where the possibility of oil spills is being considered, this condition does not appear to apply. The knowledge at hand suggests that an oil spill would only reduce the supply of any service for a limited time, after which it could be re-established or expanded. Furthermore, the costs of re-establishment or expansion of supply do not appear to be large.

Thus, while it seems clear that there are option values associated with possible future use of the marine environment of the study region, it is not as clear that these values will be affected to a significant degree by the occurrence of an oil spill or spills except where the spills were continuous and precluded all future use. To the extent that option values relate to ensuring the supply or availability of a service in the long run, it is difficult to argue that they are significantly reduced by a short-run reduction in the quantity of that service being provided. If on the other hand an oil spill would have the effect of permanently reducing or eliminating the supply of a service, option value would be a relevant policy consideration.

C. SOCIAL IMPLICATIONS

This study was triggered because people on the west coast were concerned about the impact that the transportation of Alaskan crude along their coastline would have on their lives. It is within this context that we have reviewed the physical and economic impacts of oil spills on the west coast, realizing that as far as Alaskan crude is concerned, we stand the risk of spill damage but have absolutely no dependence on that oil as a source of energy.

Throughout this report we have stressed the relatively recent nature of any serious study of the oil spill problem. However, within the short period of time since the Torrey Canyon disaster, much technical research has been undertaken and there is already a good body of literature on the immediate and short-term effects of spills that have occurred. Some attention has been paid to recreational and aesthetic effects in general terms and, of course, some of the information has been interpreted in economic terms, but other than in a few passing comments mostly relating to public relations, there appears to have been little serious consideration given to the broader social implications of the impact of an oil spill.

In the absence of good prior information based on previous spills, it is beyond the terms of reference of this study to undertake detailed original research in what is at best a fairly subjective and site specific field. This section of the report must therefore be considered in that light. It is an informed but nonetheless subjective assessment of those societal impacts of a spill not covered under economic impact and loss of recreational resource values.

Social considerations fall under two main headings: The first is actual publicly expressed response to the oil spill threat and subsequent public relations and political implications. The second is the effects that an oil spill would have on the difficult-to-define aspects of the life-style of the people living in the region affected by the spill, the psychological effect of knowing that a spill is taking place in the area, and the concern people feel for unique and irreplaceable resource values.

1. Public Concern and Oil Spills

The study terms of reference indicate that "Public concern has been strongly expressed over the potential dangers that would arise to the marine environment from oil shipments down the west coast."

It would be beyond the scope of this report to dig deeply into every possible source simply to substantiate the degree of this public concern, but its presence must be stressed.

a) <u>The Public Media</u>

Inevitably, the whole question of public concern is closely related to the public media. We recognized from the outset that the argument can be raised that statements in the media can be both a reflection of public opinion and a deliberate attempt to mould it. This begs the question. The public media does provide one vehicle for people to obtain and express their views on major issues, therefore, we have undertaken a review of media coverage surrounding the oil transportation problem to date in Canada primarily dealing with the west coast.

This has involved a review of press coverage in the four major west coast dailies, Vancouver Sun, Province, Victoria Colonist, Victoria Daily Times, a review of letters to the editor as an expression of public feedback, and a review of other media coverage, particularly television documentaries.

It should be borne in mind that a number of events have occurred during the course of the study to keep the whole question of oil transportation very much in the public eye. The discussions surrounding the U.S. Department of the Interior's report on the environmental impact of oil transportation from Prudhoe Bay to Valdez and transportation from Valdez down the west coast has regularly supplied news stories throughout the study period. The associated discussion of the transportation of oil and natural gas via a Mackenzie Valley pipeline route across Canada has again provided a good basis for news coverage.

Several statements by federal cabinet ministers and members of the House of Commons on the west coast on the tanker problem have been given good local media coverage, as has legal action initiated by west coast M.P. Mr. David Anderson and the Canadian Wildlife Federation in the U.S. courts. Perhaps most significant of all is the fact that there have been a number of minor spills throughout the study period, culminating with the wreck of the Vanlene off the west coast of Vancouver Island within the last few weeks of the study programme, and coinciding with the release of the U.S. Department of the Interior's environmental statement on the Alyeska pipeline and west coast tanker route.

No attempt has been made to keep a total record of media coverage or to make a detailed analysis of it - that would have been a major study in itself. However, it is significant that there have been nearly 100 editorials on oil transportation in the four major daily newspapers during the past eighteen months. Stories and articles in the news sections and in the business sections of B.C. newspapers have resulted in some kind of coverage associated with oil transportation virtually every day.

For example, a monitoring of the Vancouver Sun for a six-week period during February and March, 1972, indicates that a news story directly related to the points being covered in this study and relating to the study region, appeared in every issue. The Vancouver Sun on March 21, (the date on which this particular section of the report is being written) contains no fewer than 27 separate news items dealing with oil. Public feedback in the form of letters to the editor has also been virtually continuous since the latter part of 1970, with much emphasis on the environmental aspects of oil spills.

Other media, particularly television, have maintained a steady coverage of the oil spill problem, especially when it is related to the local spill problems referred to briefly in the foreword to this report. Some of the policy implications of this broad spectrum of media coverage will be discussed later.

b) Other Indications of Public Concern

Citizens' groups of almost every type have been initiating public meetings and expressing their organizations' views on oil transportation. These groups include not only the traditional conservation ones, but church groups, service clubs and particularly, boards of trade and chambers of commerce in the study region.

All of the regional districts and the bulk of the municipal governments surrounding the study region have expressed public concern over the potential dangers of oil spills, and the B. C. Government has expressed strong concern over the threat that oil spills pose to the B. C. coast.

Letters to MLAs, regional governments and particularly members of parliament indicate a strong public concern over the potential dangers of an oil spill. Significantly, we have observed no defence whatsoever in Canada for the west coast tanker route.

c) The Significance of this Concern

In the report of the task force on the clean-up of the Arrow oil spill in Chedabucto Bay, particular emphasis was placed on community relations. "The community relations unit was immediately formed by the task force to establish contact with the fishermen and other local inhabitants and to provide daily reports for the news media. It was vitally important to place the facts before the public and inform them of the kind of attack and progress made . . . . . It is concluded that good community relations are essential in dealing with a disaster of this type and that formation of a suitable PR unit should receive top priority in any future incident."

Our observations of the spills that have taken place to date in this study region have indicated scepticism on the part of people reading media reports and on the part of local residents observing responses to spill clean-up. To date, of course, the relatively minor spills that have occurred in the region have been remote from major population centres and therefore inaccessible for the most part both to people from outside and, to a lesser extent, the media.

A failure to keep people adequately and honestly informed of the impact that a spill would have, and a failure to provide an honest assessment of the success of the clean-up operation would result in public anger and mistrust and an inevitable lack of confidence in the government departments and decision-makers responsible for contingency planning and clean-up operations.

A second major consequence is the fear and doubt that would be raised in people's minds about the actual implications of a spill for them. News coverage and personal communications and observation indicated this in connection with the Torrey Canyon, San Francisco and Santa Barbara spills. It also was particularly noticeable at Chedabucto Bay. One serious problem associated with lack of complete public understanding is the inevitable build-up in political pressure to take short-term action to solve a spill problem that certainly would not be in the best long-term clean-up interests.

In the event of a major oil spill incident in hazard zones on the Pacific west coast, private property is likely to be affected. Information must be available on questions such as legal liability for clean-up, responsibility for damage suits, and direction to citizens whose property and interests are affected by a spill. The Chedubucto incident took place in a very remote part of the country, where a relatively small population, albeit very directly associated with the sea, was affected. This would certainly not be the case in the event of a major spill in the lower Strait of Georgia region.

This exploration of the concern being expressed over just the possibility of an oil spill in the study region and a brief analysis of the sketchy material available from previous spill incidents should provide a good forewarning of the kind of public response that could be expected should a major spill of Alaska crude oil occur within this study region. Two scenarios selected for detailed study incorporate substantial portions of the coastline of Victoria and the whole of Boundary Bay - both areas where human activity or interest is extremely high.

The international implications of this strong public feeling that oil spillage in these hazard zones would create need little elaboration. The resentment that would be aroused against the oil industry also needs little elaboration and the implications of public response to government departments responsible for oil spill cleanup are obvious too.

Our assessment of public response through the media and discussions with representatives of organized groups interested in the environment and with a much broader section of people concerned about the implications of oil transportation, indicate that people expect action on two major fronts.

First, they expect the Canadian government to register the strongest possible objections that it can to oil transporation by tanker down the west coast. There seems, however, to be a latent feeling of frustration that no matter what Canada does in this regard, the tanker route will go ahead anyway.

Secondly, if the tanker route from Valdez to Cherry Point is established, then people will demand:

(i) That Canada do everything within her power unilaterally to control oil transportation within the waters under her jurisdiction,

(ii) That every effort be made to cooperate in every way possible with the U.S. marine traffic authorities to ensure that the highest possible level of spill preventative measures are taken,

(iii) That an effective contingency planning organization be established to combat any spills that should occur,

(iv) That people are made aware of the legal implication of an oil spill both with respect to their personal property rights and with respect to responsibility for clean-up costs incurred by the Canadian government.

2. The Effect of Oil Spills on People

Approximately 1 million Canadians live near enough to the Straits of Juan de Fuca and Georgia to be considered coastal residents. It is true that not all of these people have a direct interest in the sea from a viewpoint of work, recreation or even a state of general awareness, but nonetheless, many do deliberately choose to live on the Gulf islands and along the shores of the Strait of Georgia and the Strait of Juan de Fuca because they particularly want to live in a marine environment. (Consideration of the aspects of the option value that people place on the availability of a marine environment is discussed in the preceeding economic section of this chapter.)

a) Life-Style Disruption

It is extremely difficult to define just what is meant by a "life-style" and it is more difficult yet to determine just what the impact of a drastic temporary change in environmental quality would have on the life-style of an individual. The expression of concern about the possible changes inherent in the tanker movement of oil is itself one indication that people are extremely uneasy about what that impact might be.

Right from the outset then, there is a general anxiety and concern - felt more deeply by some people than others - at living under the threat of possible disaster. This in itself is disruptive and an important component of the social impact of an oil spill. Just as anticipation of a pleasurable event is a pleasing experience, the anticipation of an unpleasant event can be a stress factor on a human being.

Loss of jobs and resultant social disruptions need little amplification, and the economic results of unemployment are only one way of viewing the loss. It is important to realize also that some of the jobs associated with the marine environment - fishing, catering to recreationists - are extremely seasonal and a loss of income for even a relatively short period could be completely disruptive to the kind of life-style that many people in those occupations choose to adopt. They are prepared to trade-off the security of a steady job against freedom and the personal pleasure that they get from the kind of occupation that they choose.

Again, firm data are lacking but there is little question that many people, both young and old, live among the Gulf Islands and at many locations around the Strait of Georgia in a state of retirement or semi-retirement because they enjoy the total marine atmosphere. The psychological impact of a drastic change in an environment of which an individual really feels a part is difficult to assess in anything but subjective terms, but it is nonetheless very real both to the people affected, and to the many who ultimately look forward to enjoying that kind of life-style.

b) <u>Loss of Recreational Opportunity</u>

A second major area of social impact, of course, is the loss of recreational opportunity. Although this can be measured in terms of loss of income to entrepreneurs in the recreation business, that is only a fraction of its true value. Many people choose to live and work around the Strait of Georgia because of the marine-oriented recreation opportunities the region presents. The loss of recreation opportunity, be it a temporary loss of a favourite fishing ground or a more long-range loss of a favourite beach, will again be a difficult impact to measure, but nonetheless a real one. Those who have walked at the water's edge along beaches that were fouled five years ago by the Torrey Canyon still find oil just inches below the surface.

Another equally important aspect of the loss of recreational opportunity that certainly is not measured in economic values alone, is the possible loss of an annual vacation arising from an oil spill. It is true we have already indicated that the actual physical area of a spill would likely be limited compared with the region as a whole and it could be argued that vacationers could move elsewhere, but this is not a very real alternative when accommodation and camping facilities throughout the region are frequently operating at saturation point during peak vacation seasons. An individual may be at the site of his annual vacation because he is very attached to that particular site and returns to it year after year - the loss of just that one vacation coupled with anxiety about the future becomes a real social loss.

c) Education and Research Use

We have already referred to the general recreational values of the marine environment, but a more specific educational interest from elementary school to the university level exists too, not simply through specialized research but also through the "outdoor-classroom" potential. There is no way in which the value of benefits of this type can be estimated.

A more specialized and intensive use of the natural environment lies in the field of scientific study and research. Although it is not possible to predict the results of such study or to estimate the value of its findings, it is widely agreed that society should maintain a "scientific preserve of research material as required for advances in the life and art sciences." The ecological reserve programme discussed elsewhere in this report recognizes these values. While measurement or quantification of these in monetary terms is not presently possible, it is possible to make some qualitative judgement of the effect that an oil spill could have on them.

In terms of general education use, the effects of any one spill would not be significantly large because within the study area there are many possible sites for alternate use. It could even be argued that there could be some short-term educational benefit in enabling students to see the impact of an oil spill as part of their education - perverse though this might be.

The effects of an oil spill on more serious scientific study, such as that referred to in the grounding of the Vanlene near the research station at Bamfield, could be more severe. Scientific research programmes are spread over a period of time and frequently involve considerable investment of both time and facilities at a particular site. Such investment could be destroyed by an oil spill. If the research could be re-located elsewhere or continued at its original location after the clean-up of the oil spill, then damage caused by the spill could be measured by the cost of time and expenditure necessary to re-establish the research. On the other hand, the loss of a long-range baseline monitoring programme might never be replaced.

d) Loss of Unique and Irreplaceable Values

One final area closely related to social and option values is the very real concern that people have for the preservation of unique and irreplaceable resource values. There is little question that these values do exist within the study region. The Pacific Rim National Park - an excellent case in point - has been established because it is a unique part of Canada that has not been drastically changed by man. The impact of an oil spill on unique features such as this is in a real sense irreversible.

The argument is equally true of the impact of a spill on unique ecological areas within the region, particularly on those areas that have been set aside for scientific research. Again it is difficult to measure in economic terms, but it is ironic that the Vanlene grounded adjacent to a marine research centre established by western Canadian universities at Bamfield because of the relatively undisturbed marine ecosystems of the area.

The social impact of an oil spill on unique sites of this type, some of which are already under various ecological reserve status such as national parks, and some of which are under active consideration for establishment as major marine park areas, is felt far beyond the actual study region.

Social preservation values are recognized by people who have no intention of directly using a site for any particular activity, yet still attach value to the knowledge that it is preserved in an unchanged state. This concept is separate from option demand and is expressed in many different ways:

- "Just knowing it is there"
- "The quality of the natural environment which would give rise to a value is at a point which is beyond

the material and recreational values that we can more readily identify "

- "The preferences of society and the satisfactions gained from the assurance that natural phenomena can continue to exist"
- "Preservation and continued availability are a significant part of the real income of many values."

While there is difficulty in defining these values, they are there in a very real sense when people make political decisions.

It should be borne in mind that in this particular study region, the natural environment is constantly being modified by industrial, commercial and recreational activities, and any one decision - including that of tankering oil - will not in itself result in the total destruction of the environment. At the same time, many small decisions taken independently would have the collective effect of transforming the environment into a state of reduced quality unacceptable to those having any strong preference for the preservation of a natural environment.

Usually it is these social factors more than immediate economic implications that provoke widespread public concern over any kind of environmental disaster. Significantly, all of these social factors have to be weighed in the light of the fact that the people who would be affected most, both inside and outside of the study region, do not depend upon shipments of crude oil through the area for their own energy needs.

D. ASSESSMENT OF OIL SPILL IMPACT

1. Development of an Oil Impact Index

The method used to assess the impact of an oil spill is based on the construction of an index showing, for any part of the study region, the damage which would be done to a selected set of resources in the event of a major oil spill. The index is a set of pure numbers expressing the amount of damage relative to the damage which would occur in any other part of the study area. The sole purpose of the index is the identification of those portions of the study area which exhibit a relatively higher vulnerability of damage due to oil. It does not express an absolute amount of damage, and should in no way be applied to any assessment of actual damage resulting from a real spill.

The set of resources upon which the impact of oil was evaluated is made up of resources that would be seriously affected by oil spills within the study area. These resources were discussed and mapped in Chapter III. Our selection is biased towards those resources which are either harvested for human consumption or important in other human activities, but an attempt has been made to include the broad ecological or "non-man-centred" point of view in the evaluation of impact. Our methodology does not consider the various interactions and interdependencies among resources (e.g., the plankton-herring-salmon-man food chain); it merely shows the immediate, direct effects of an oil spill on biological, physical and man-made resources. To handle these interdependencies quantitatively would have required the development of an extremely complex methodology. Therefore, interactions and interdependencies are discussed in the text. (Chapter III - Marine Resources, and Chapter V - Section A - Biological and Physical Implications)

We have taken five steps in developing the index; the Grid, the Quantity, the Impact, the Relative Importance, the Index. Each step is briefly described below.

a) The Grid

A system of grid squares was superimposed on the base map. Each square represents an area of approximately 100 square statute miles.

b) The Quantity

It was not practical to measure, in standard units such as acres or gallons, the actual quantity of resource throughout the study area. Our rating system identifies the quantity of each resource relative to the general level of abundance of that resource in the entire study area, and attempts to provide for quantitative comparability between resources. Each resource was assigned a numerical value for each of the squares in the grid system. This number, based on a 0-5 scale (where 5 is high) represents the quantity of each particular resource within the square.

To show the quantity of each of the nineteen resources for every grid square examined would be a cumbersome task, so only one example is given below. The grid square illustrated is M-12 and the resources quantified are in the same order left to right and top to bottom of the square as they appear in Table 7:

TABLE 7

M

4	2	1	0	0
3	3	0	2	3
4	0	5	3	0
0	0	1	4	

12

Individual categories here correspond to those listed in Table 8.

In the scenarios, actual quantities of resources which would be damaged by an oil spill are assessed.

c) The Impact

To determine the impact of oil on the quantified resources, the following assumptions have been applied:

(i) That there is an equal probability of a severe oil spill occurring in all parts of the study area;

(ii) That the actual assessment of impact presupposes the conditions of a severe oil spill;

(iii) That the type of oil spilled is Prudhoe Bay crude oil;

(iv) That the oil spill has occurred when each resource is at its most abundant if it shows cyclic variations;

(v) That the spill occurs where human use of the resource, both consumptive and non-consumptive, is at peak intensity.

Impact is considered in three categories - commercial, recreational, and aesthetic-intangible. Again, we have evaluated impact in a relative sense; a high impact was assigned a value of 5, a low impact was rated at 0 or 1. For example, given that a severe oil spill spreads across waters used by the commercial herrring fishery, although herring could still be captured by purse seine, the contamination that would result from taking the herring through the polluted surface layer would render the catch unmarketable. Therefore, this case was given a commercial impact value of 5. (Refer to Table 8.)

If the particular resource in question was subject to both a commercial and recreational harvest, the impact on each type of resource use, in the case of a severe oil spill, was evaluated. Salmon and herring, for instance, are subject to both a commercial and sports fishery. In both types of resource extraction the impact of an oil spill was high and rated a value of 5.

The most difficult elements to incorporate into any index measurement are the aesthetic and intangible factors; that is, people's subjective reactions to and visual and aesthetic experiences of a particular area. How are the effects of an oil spill on these "values" to be assessed?

TABLE 8

RESOURCE	Relative Commercial Importance *	Relative Recreational Importance *	Impact of an Oil Spill on Commercial Use of Resource *	Impact of an Oil Spill on Recreational Use of Resource *
A) NATURAL RESOURCES				
1. Intertidal Areas				
- Beaches	N.A.	5	N.A.	5
- Marine Plants & Invertebrates	N.A.	4	N.A.	5
- Clams	1	3	5	5
- Oysters	1	3	5	5
2. Subtidal Areas				
- Water Column	N.A.	5	N.A.	5
- Shrimp, Prawn & Crab	1	2	5	5
- Groundfish	3	4	5	5
- Herring - Reproductive & Juvenile	N.A.	1	N.A.	5
- Adult	1	2	5	5
- Salmon - Juvenile	N.A.	3	N.A.	5
- Adult	4	5	5	5
3. Deepwater Areas				
- Resident Seabirds	N.A.	3	N.A.	5
- Migratory Waterfowl	2	4	5	5
B) MAN-MADE RESOURCES				
- Marinas & Principal Harbours	4	5	5	5
- Log Booms & Storage	5	N.A.	3	N.A.
C) LAND STATUS				
- Parks & Park Reserves	N.A.	5	N.A.	5
- Ecological Reserves	N.A.	2	N.A.	5
- Indian Reserves	2	2	3	5
- Real Estate Values	5	5	1	3

* None - 0; High - 5

N.A. - Not Applicable

The word "value" has been at the crux of philosophical thought for 2500 years. In recent years, the semantics of the word have concentrated on monetary worth rather than on its broader philosophical implications. Perhaps Whitehead's definition of "value" comes the closest to defining the subjective approach to "values" as distinct from the narrower economic interpretation of the word:

"Value is in its nature timeless and immortal; its essence is not rooted in any passing circumstance." This definition provides the context within which we have developed the assessment of these values in the impact evaluation.

Any value judgement relating to aesthetic and intangible values is necessarily a subjective one and therefore shows an automatic bias. To keep this bias within reasonable limits without completely sterilizing our attempt at making the judgement, we have applied the following "ground rules" to the evaluation process:

(i) Recognition of the limits to which an oil spill would in point of fact affect the visual-aesthetic experience;

(ii) The fact that the various combinations of resource values within the study region are in certain instances an indicator of the intangible-aesthetic values;

(iii) That this incidence of abundance (for want of a better term) is related to a site specific relationship with a given region and not to any one particular resource;

(iv) That these factors should be considered in the light of a broad range of understanding of other areas where similar values have been, or are being, considered by the same people making value judgements on the study region; and

(v) Experience in making analytical value judgements involving aesthetic and intangible values; e.g., art, music, architecture.

While the commercial and recreational impacts are evaluated on a resource by resource basis, the aesthetic-intangible impact has been evaluated on a grid by grid basis as it is site rather than resource specific. As with the commercial and recreational impacts, a scale of 1 to 5 was used. The commercial and recreational impacts are shown in Table 8 and the aesthetic-intangible impacts on Map 21.

d) The Relative Importance

Within commercial resource uses, oysters and clams represent a much less important harvest in economic terms than salmon. Strictly within the consideration of harvest values, oysters and clams are less important than salmon. We have adopted this rationale for our system of rating. Wherever the commercial harvest of a particular resource has been documented, we have expressed its dollar value as a fraction of the commercial values of the total complement of examined resources, and applied this fraction as a weight to represent relative importance. Excluded here are any considerations of interactions between organisms.

A similar type of deliberation was used to assign the overall importance of each of the examined resource features to recreation associated with the water bodies or intertidal zones. We reviewed the sources of information available on the types of recreational activities that people pursued within the study area, and attached a partly intuitive relative importance to each of the examined resources based on our understanding of current recreational patterns. A scale of 1 to 5 was used to indicate relative importance. The results are shown together with the impacts in Table 8.

As the aesthetic-intangible category is not based on particular resources, it is not subject to any of these considerations of relative importance.

e) The Index

There are three indices of oil spill impact in every grid square, one applying to each of the impact categories (i.e., commercial, recreational, and aesthetic-intangible). The indices are not summed but simply considered together in assessing the total impact oil spills would have.

For each of the commercial and recreational categories, the index is calculated on a square by square basis as follows. For every resource, the product of (a) the relative importance figure (refer to Table 8/ columns 2 and 3), (b) the impact figure (refer to Table 8/ columns 4 and 5), and (c) the quantity figure (refer to Table 7) is calculated. The sum over all the resources of this product is the final index for that grid square. The index of the aesthetic-intangible category is simply the impact figure alone.

For example, the final indices for grid square M-12 are:

Commercial Impact	276	It must be stressed that these indices are not relative to one another and therefore not additive.
Recreational Impact	595	
Aesthetic-Intangible Impact	4	

2. Hazard Zones

The identification of zones where there exists a higher hazard of spill damage is based on a consideration of both zones of higher spill probability as determined in Chapter II, and areas of higher potential resource damage. These hazard zones have been delineated for the purpose of choosing scenario sites and of identifying areas where a greater degree of oil spill contingency planning is required.

To determine areas of higher potential resource damage, an index value of arbitrary proportionality relative to all grid figures in each category was chosen to indicate the lower limit of high impact. These values are:

Commercial Impact	250
Recreational Impact	625
Aesthetic-Intangible Impact	5

Map 22 shows the results of this analysis. Three major zones of higher potential resource damage are identified on the basis of each square within them having at least one impact category exceeding its lower limit:

a) Long Beach/Barkley Sound

b) Gulf Islands, and

c) Lower Howe Sound/ Vancouver/Fraser Delta

A high spill impact is also indicated for smaller areas on the east coast of Vancouver Island between Comox and Nanaimo, and around Cortes and Hernando Islands in the northern part of the Strait of Georgia.

a) Long Beach/Barkley Sound

Foremost in this area are high aesthetic and intangible resource values which would suffer severely were an oil spill to occur. In fact, because of this zone's high biological productivity and recreational potential, much of it has been set aside as a national park (Pacific Rim National Park), extending from Long Beach through Barkley Sound and perhaps eventually to the Nitinat area.

The intertidal ecology of the coves and archipelagos in Barkley Sound is outstanding and the main reason for the high threat from oil. In the sound also are seabird nesting sites, shrimp, crab and groundfish commercial fishing areas, and herring spawning sites.

There are several sheltered marinas in this zone, such as at Bamfield and Ucluelet, as well as a number of beaches and coves with waters warm enough for swimming. Although present real estate values are low compared to the study region as a whole, the recreation potential is high, as evidenced by an ecological reserve, several provincial park reserves, and the Pacific Rim National Park in the area.

b) Gulf Islands

Both recreational and commercial uses of resources in this zone show high potential vulnerability to oil damage, primarily due to the abundance of excellent waterfront land and the variety of marine life.

Much of this marine life is concentrated in tidal passages where water exchanges replenish food supplies for planktonic organisms through to larger fish such as herring and salmon, upon which eventually seabirds feed. Shrimp, crab, oyster, salmon and groundfish are of economic importance commercially, while salmon also support an intensive recreational sports fishery. This zone contains many seabird nesting sites and supports a vast number of wintering marine-associated birds.

That the zone is important recreationally is evidenced by the large number of marinas, harbours, parks, park reserves and ecological reserves located within it. The waters are often warm enough for swimming, and scuba diving is carried on in many sites even during the winter. Because of its high productivity, it is an area traditionally used by Indians from its several reserves. With excellent waterfront and beach properties and close proximity to British Columbia's two largest cities, Vancouver and Victoria, land values are among the highest in the study region.

c) Lower Howe Sound/Vancouver/Fraser Delta

Although most of this zone stands out because of its high commercial value, it is also important from a recreational viewpoint around Burrard Inlet and lower Howe Sound because of its proximity to Vancouver.

The Fraser delta and Boundary Bay are key components in Pacific waterfowl habitat and contain the largest wintering waterfowl and shorebird concentrations in Canada. As well, the Fraser delta is an important nursery and transition area for seaward bound and returning migrant salmon, with Boundary Bay and parts of Howe Sound important for herring spawning. Considerable shrimp fishing takes place in Howe Sound, Burrard Inlet and the northern half of the Fraser delta, while crab fishing is located off the southern half of the Fraser delta and in Boundary Bay. The study region's most important zones for log-booming are located within Howe Sound and the Fraser delta.

Besides a tremendously valuable salmon sports fishery throughout most of this zone, other recreational activities include bird watching, waterfowl hunting and crab fishing. Swimming is important in Burrard Inlet and Boundary Bay where there are located a number of beaches; diving is more usual along the eastern shores of Howe Sound where the coast is generally quite rugged. This zone abounds in marinas and major harbour facilities because of the large population requiring recreational and commercial moorage, and it is also because of this concentration of people that real estate values are highest for the study region as a whole.

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After analysis of higher spill probability zones (Map 20) and higher potential resource damage zones (Map 22), we were able to identify hazard zones within which scenarios could be selected. The two principal hazard zones derived on this basis turned out to be: a) the Semiahmoo Bay, Boundary Bay, Point Roberts and Fraser Delta area, and b) the Victoria, Saanich Peninsula and Southern Gulf Islands area. To examine these in detail, we were able to identify within them two possible scenarios which are described in the following chapter.

CHAPTER VI - SCENARIOS

We have identified two scenarios on the basis of both higher spill probability zones for supertankers as determined in Chapter IV and higher potential resource damage zones as identified in Chapter V. The development of these scenarios was based on the following:

(i) The usual oceanographic and meteorological conditions for the seasons and locations involved;

(ii) A determination of spill size with mathematical formulae from the oil spill literature employing the assumption that 500 microns is a meaningful slick thickness;

(iii) The premise that oil would stay together within major slicks rather than divide into smaller patches (for both convenience in cartographic representation and textual description);

(iv) That the clean-up operations described would not take into account (as far as possible) specific agencies by name, and would describe possible practical procedures within known technology rather than any present capability to carry out a clean-up operation.

These two scenarios are not meant in any way to be precisely predictive but rather they represent a composite of what could easily occur. The multiplicity of factors involved and the importance that any one of them might have on hazard potential make it obvious that many other types of oil spills are possible. The slicks shown in the scenario mapping indicate the full areas covered, assuming that no clean-up procedures were carried out.

A. SCENARIO #1

During the last week in March on its approach to Cherry Point a 120,000 ton tanker loses its steerage as it slows down and is pushed on to Alden Bank by 20 knot winds from the south. The stranded vessel incurs damage to its hull and some 40,000 tons of Alaskan crude oil is spilled over a period of 24 hours. The wind speeds are sufficiently great that attempts to bring barges or other tankers alongside the grounded vessel for the purpose of off-loading the oil in the damaged tanks are unsuccessful.

1. 0 - 18 Hours (Map 23)

The grounding occurs at the beginning of a flood tide. With the winds creating a drift current of about 0.6 knots and the tide current having a mean of about 0.5 knots from the southeast, the resultant set of the initial slick is 7 miles north-northeast for the 6 hour flood tide. At the end of the flood tide, the slick is in the form of a long plume extending northwards from the ship and covering an area of about 1 square mile. The ensuing ebb tide from the northwest at 0.5 knots combined with the 20 knot wind moves the head of the slick about 3 miles to the northeast. After the first full 12 hour tidal cycle, the head of the slick is off Birch Bay about 8.5 miles north of the spill site, and the area of the plume is about 3 square miles. The next flood tide carries the head of the oil plume, now spread to an area of over 7 square miles, just across the international boundary so that it almost blocks the opening of Semiahmoo Bay. Some of the oil begins to wash up on the shores of Birch Point.

a) Impact

By 18 hours after the spill, Canadian authorities are deeply concerned about herring, crab and bird populations in Boundary Bay. The first oil-soaked birds have come ashore off Birch Bay.

A reconnaissance flight carried out by the Canadian Wildlife Service 20 hours after the spill shows that a minimum of 60,000 birds are in the Boundary Bay area. High tide and rough weather make it difficult to estimate the actual number of birds. Spring migration of waterfowl and shorebirds is well underway and it is estimated that thousands of birds will use Boundary Bay as a resting area in the next few weeks, including a significant proportion of the Pacific black brant population.

Herring spawning surveys carried out in February and early March showed a good spawning had taken place with 5 statutory miles of spawn deposited. This represents 45,000,000 herring, or 4,500 tons. Approximately one quarter of the spawning occurred in Semiahmoo Bay and three quarters in the western half of Boundary Bay.

b) Clean-Up

American authorities take initial action on the spill and send detailed reports to Canadian authorities who reconnoitre the spill and order full alert of contingency forces. As outlined in the deployment section of the contingency planning appendix, peat moss bombing commences. Boom-towing tugs, slick-lickers, oil recovery and peat moss barges, plus empty barges to collect absorbent material, set sail to eventually arrive just before nightfall.

The complete shoreline from the border around Boundary Bay to Point Roberts and up to the Roberts Bank terminal is reconnoitred by helicopter during daylight hours and critical areas to be protected are identified. After the initial reconnaissance is complete, the task force meets to establish what areas might be contaminated first. Equipment is despatched to place booms across the Serpentine and Nicomekl Rivers, around the marina and beach at Crescent Beach, around the jetty at White Rock and at Beach Grove. Marine access routes have been designated along Boundary Bay and are cordoned off from public use. Caterpillar equipment is ordered in to construct roads to the tidal area. Peat moss stocks are being placed at these access points. Disposal sites have been located in the Surrey municipality north of the freeway. Radar-equipped tugs position booms in a north-south direction along the edges of the oil spill and peat bombing continues until nightfall.

Peat moss on the barges is then used throughout the night to absorb the oil before it becomes emulsified with slick-lickers employed to pick up the soiled material. By 16 hours a naval vessel has arrived at the grounded tanker and is directing Canadian oil recovery and clean-up efforts. The army has moved in men and equipment to the abandoned Boundary Bay airport and has set up a communications centre. Biological sampling which began on the ebb tide at nightfall is continued throughout the night.

As daylight breaks, command posts are set up at strategic locations along the beach, as are kitchen facilities and first aid stations. The Civil Defence has helped organize the volunteers in the White Rock and Crescent Beach area where they are mobilized in teams to spread peat moss along the shoreline. Launches are despatched to this area to aid in that operation while the Burlington Northern Railway dumps peat moss stock piles along the shoreline.

2. 18 - 24 Hours (Map 24)

The following ebb tide carries the head of the slick on to the Canadian coast south of Crescent Beach and into Semiahmoo Bay. Thus, after the first 24 hours of the spill, the slick has travelled about 17 miles northward, spread to an area of about 14 square miles, and contaminated approximately 2 miles of beach. The oil is also beginning to emulsify into a "chocolate mousse". The leaking of oil from the stranded tanker has stopped.

a) Impact

Efforts to frighten birds away from the area have been partially successful but 200 to 300 have already been washed up on the beach. The main species affected include scaup, goldeneye, bufflehead, harlequin, pigeon guillemot, murre, murrelet, grebe and loon. Interested citizens are beginning to pick up oiled birds, but as yet there are no facilities or materials organized for bird rehabilitation. The oil slick is now just west of the Semiahmoo herring spawning site. Several seals have been observed in the area but none is affected.

b) Clean-Up

The leading edge of the slick still escapes from the booms but continues to be bombed with peat moss. A weather ship arrives at Tsawwassen and is set up as marine headquarters. All marine equipment such as additional booms and barges are being marshalled here. A survey of the beach material is complete by noon and areas where heavy equipment can be used are designated and equipment stands by waiting for the slick to come ashore. Peat is readied for quick application to the shoreline when the slick nears shore as access points are bulldozed through the log debris at the high tide line.

3. 24 - 30 Hours (Map 25)

The tidal cycles at the start of the second day carry the slick up into Boundary and Mud Bays, causing contamination of the intertidal areas. Semiahmoo Bay is also gradually being inundated by oil.

a) Impact

The oil now covers a large enough area that birds cannot be kept away from the slick. As a result of extreme public pressure, facilities for rehabilitating oiled birds have now been set up. The effect on birds is about the same as at 24 hours. An estimated 1,000 birds have been affected. As the main tidal flats in Boundary Bay become covered, seagulls and dabbling ducks are beginning to be coated with oil.

The western flank of the slick is now approaching the main herring spawning and brant feeding grounds in Boundary Bay as well as covering portions of the spawning grounds in Semiahmoo Bay. The Federal Fisheries Service has put a closure on the Boundary Bay crab fishery. While the shores of Crescent Beach Park have been coated extensively, the booming at the entrance to Crescent Beach marina has proved effective in preventing oil contamination of some 125 power boats.

b) Clean-Up

Short booms are being towed parallel to the shore off Crescent Beach in an effort to intercept some of the oil-soaked peat. Oil escaping under the booms is bombed with more peat. By nightfall the oil is on shore at Mud Bay. A small flotilla of boats and landing crafts (some fitted with slick-lickers) is being used to spread fresh peat moss and collect soiled material. Biological sample stations are monitored during contamination. While a systematic means of feeding and housing crews is being initiated in prefabricated units moved in by heavy trucks, it is discovered that heavy equipment cannot be used in the Mud Bay area because of the silt beach material.

4. 30 - 36 Hours (Map 26)

The ebb tide countered by 20 knot southerly winds tends to push the slick towards the northeast into a more circular configuration.

a) Impact

As this period is during night darkness, the effects between 30 and 36 hours cannot be determined, but as the tide ebbs, eel grass and shellfish beds will become fouled with oil. It is expected that birds feeding during the night along the tideline and on the eel grass beds will be severely affected.

b) Clean-Up

The oil which is carried toward the mouth of the Nicomekl River is intercepted by booms and no contamination of the shoreline results. Peat moss is spread from boats as aircraft cannot be used at night.

5. 36 - 42 Hours (Map 27)

This flood tide causes the slick to cover a much larger portion of Boundary Bay, as well as to push further into Semiahmoo and Mud Bays.

a) Impact

Although major impacts would not be apparent until dawn, it is feared that extensive biological damage is occurring.

Persons out on White Rock wharf report oil has coated several boats tied to it.

b) Clean-Up

Spreading and collecting absorbent material continues. Trucks are transporting the soiled material to disposal sites in the Colebrook area. Oil-soaked peat moss picked up around the bay has been transported to Roberts Bank by barge where it is being transferred to rail cars.

6. 42 - 48 Hours (Map 28)

Although the tide is retreating during this period, a heavy coating of oil remains covering thousands of acres of intertidal zone.

a) Impact

Daybreak and a slack tide reveal the extent of damage caused since the last daylight period. Approximately 10 miles of Boundary Bay shoreline are coated with oil. Oil also covers the upper tidal marshes and log debris along the shore. Dead or dying birds are evident along the whole 10 mile length with the known number of birds affected having risen from 1,000 to 10,000. The actual number of birds oiled is estimated at five times the known number. Virtually all species inhabiting the bay have been oiled, including 2,000 black brant. As the tide ebbs, it is apparent that eel grass beds are severely contaminated and although most of the herring spawn lies below low tide line, Federal Fisheries Service officials fear that the year's production of herring will be lost. As shellfish beds become coated with oil, the mortality of clams, oysters, mussels and snails is expected to be severe.

b) Clean-Up

With an ebb tide exposing the tidal flats and oil and oil-soaked peat moss being simultaneously deposited on the intertidal zone, large clean-up crews are mobilized as daylight breaks. Upwards of 3,000 people follow the receding waters using boats, dune buggies, tracked vehicles, scrapers and graders to clean up the contaminated areas.

7. Beyond 48 Hours (Map 29)

After 2 days, the slick reaches its maximum area of some 35 square miles. Although it is quite possible that alternate winds or a greater complexity of tidal currents could result in the oil going around Point Roberts towards Roberts Bank and being carried over to the Gulf Islands by the Fraser River influence, we have assumed for the purposes of this scenario that the strong southerly wind would keep the oil within Boundary Bay.

a) Impact

The flood tide has now carried oil on to nearly the complete shoreline of Boundary Bay. Virtually all eel grass beds are covered with or overlain by oil. A number of dead crabs and fish have been observed. Known bird casualties are 15,000, while the actual number affected is believed to be about 75,000. With migrant birds entering the bay each day, it is estimated that over 100,000 birds will be killed, including a maximum of 5% of the Pacific black brant population. Efforts to rehabilitate birds have been highly unsuccessful. The 400 or so seals that were in the bay have moved elsewhere as a result of disturbance. The shores of Centennial Beach Park are by now thickly oiled.

Fifty four hours after the spillage of crude oil off Cherry Point, most of the intertidal area of Boundary Bay is coated. Much of the oil on exposed tidal flats has combined with silt and sand. Greasy solids continue to float in channels and tidepools, recontaminating higher beaches with each flood tide. The spill has resulted in the contamination of eel grass beds, a closure of the crab fishery and a known bird kill of 15,000. The actual number of birds affected is expected to be more than five times this amount.

The long-term biological effects of the spill on Boundary Bay may never be known. The extent of damage to shellfish beds, herring, crabs and many other invertebrates cannot be assessed for several weeks. However, it is expected to be severe. Oil will remain in the substrate and in the marine food chain for months, recovery of marine organisms will be slow, and the effects will ultimately be felt over a much wider area than the bay itself. In time there may be a reduction in the diversity of species inhabiting the bay, with a tendency toward ecological instability. A reduction in grazing molluscs may bring about an increase in the growth of marine algae. Where portions of the crude have combined with silt, anaerobic action may produce toxic compounds. The majority of the oil will be removed only by oxidation and bacterial degradation.

In terms of effects on human activities, a significant degree of damage will occur to recreational uses of the foreshore. Hunting activities will likely drop off for a season until waterfowl populations return to more viable levels, while the collecting of shellfish for consumption will be impossible for a similar period of time because of recurrent tainting. Beach activities including bathing and beachcombing will cease because of incessant occurrences of re-oiling from the large expanse of contaminated Boundary Bay intertidal materials. Although originally over 100 pleasure boats were threatened by the spill, damage to them and marina facilities was both minimal and short-term. As most of the private foreshore property within Boundary Bay is classified as residential with frontage foot values ranging from $200 to $400, there will be extensive short-term loss either aesthetically or financially to individual property owners.

b) Clean-Up

Major clean-up operations such as beach cleaning, disposal and bird de-oiling continue for up to a month because of the large quantity of oil involved in the bay. As the more obvious presence of oil diminishes, most crews, including volunteers, are demobilized. However, there is a stand-by unit which continues to deal with re-oilings for half a year after the accident first occurred.

B. SCENARIO #2

In a thick pre-dawn fog in mid-August, a collision occurs between a 120,000 ton tanker en route to Cherry Point and a 30,000 ton freighter outbound from Vancouver. The accident occurs about 5 miles south of Race Rocks near the international boundary, and results in an immediate spill of about 20,000 tons of crude oil. A flood tide with a mean speed of 1 knot from the southwest is just commencing and there is no wind.

1. 0 - 24 Hours (Map 30)

Movement of the slick during the first flood tide is about 7 miles to the northeast. However, as the 1 knot ebb tide approaches, a southwesterly morning wind of 15 knots rises, the net effect being a movement of the slick of 3.5 miles to the southwest or back toward the accident site during the ebb. The slick is now roughly circular and 4.5 square miles in area. With the wind continuing at 15 knots, it moves an additional 7 miles to the northeast over the next 12 hour tidal cycle and spreads to an area of 13 square miles.

a) Impact

Within 3 hours of the collision, Victoria press and radio have alerted citizens to the possibility of oil coming ashore along their coastline. This news initiates several meetings at the University of Victoria to discuss the impact the oil might have on marine resources. Twenty biology students and 2 professors design a shoreline sampling programme to determine the variety and abundance of intertidal organisms at specific localities along the shore. Facilities and materials required for cleaning birds are organized by University of Victoria students and local radio stations provide information on where to take oil-soaked birds. By 18 hours the shoreline sampling programme is completed and although the information is crude, it should provide significant baseline data on intertidal life prior to the oil coming on the beach. While by 24 hours it is definite that the oil is coming ashore, the actual extent of the slick and damages will not be obvious until daylight.

b) Clean-Up

The collision is initially reported to both American and Canadian authorities who mobilize their contingency units. Two hovercraft soon arrive on the scene and temporarily deploy booms which were carried aboard the tanker. Aerial bombing of peat moss by armed forces aircraft is commenced within 2 hours of the collision. Skimmers, slick-lickers and oil recovery barges arrive on the scene within 6 hours. Bombing is limited to one end of the slick so that skimmers may collect oil at the tail end which is free of absorbent. The booms are used in a V configuration at the head of the slick and slick-lickers are placed in the apex of the V to pick up the oil-soaked peat moss.

Both Canadian and American authorities are taking action on the spill. A naval vessel has been despatched from Esquimalt and is positioned near the slick to serve as a marine headquarters for Canadian recovery operations. Light booms are placed around marinas at Pedder, Oak and Cadboro Bays and across the entrance to Victoria harbour so vessels can move in and out freely. The army has set up command posts at the marinas, and the RCMP has cordoned off main beach access roads. Peat moss has been stock piled along the beaches. A disposal site near Albert Head has been located and routes to this area are also cordoned off. Civil Defence is organizing public volunteers and helping to set up sanitation and feeding facilities along the shoreline.

2. <u>24 - 30 Hours (Maps 31 and 32)</u>

Before the completion of the next flood tide, the slick hits the shore around Gonzales Point and approaches Plumper Passage near Discovery Island where the currents are 1.5 knots to the north and the 15 knot winds have been topographically modified into a northerly direction. Much of the oil then passes around Cadboro Point and enters Haro Strait by the end of that flood tide. In the process, the slick spreads to its maximum area of about 17.5 square miles and has contaminated about 15 miles of Vancouver Island coastline to the southeast of Victoria as well as the shores of Discovery and Chatham Islands.

a) <u>Impact</u>

Surface fronds of kelp off the Trial Islands and around the Chain Islets are becoming oil soaked and the kelp beds are not dense enough to hold back any appreciable amount of oil from covering large portions of the intertidal zone. The first oiled birds have come ashore, including grebes, cormorants, harlequin ducks, black-bellied plovers, surfbirds, black turnstones, black oystercatchers, red phalaropes, gulls, and common murres. Approximately 500 birds, mainly gulls, have been oiled. Most of the smaller shorebirds are dead. By 30 hours, Discovery and Chatham Islands are surrounded by oil. The extremely rapid spread of the oil has been detrimental to bird populations. Efforts to frighten birds away from the area have not been successful. Increasing numbers of oil-soaked grebes, cormorants, gulls and shorebirds are scattered along various shorelines.

Beacon Hill Park foreshores are covered at about 28 hours, while by 30 hours two park reserves further north have also been affected. Although at one time it appeared uncertain whether the booms located in front of Oak Bay and Cadboro Bay marinas would work, it now appears that the 700 craft at the two marinas will not be affected.

b) Clean-Up

Forces have been mobilized on shore and are awaiting the oil to come ashore. Contingency force headquarters set up at Esquimalt are using the Patricia Bay air base for aerial support, with crews and peat moss being air-lifted to the Trial, Chatham and Discovery Islands. It has also been decided to use landing craft to get crews with equipment on to the beaches as poor road access exists in most areas. The narrow roads soon become congested with traffic and large equipment cannot reach the beaches, though it has been discovered that in most cases large equipment cannot be used anyway as most of the beaches are rather steep and not very large.

In an effort to divert the oil off the Victoria area and the Chatham and Discovery Islands, booms are positioned parallel to the prevailing current and winds. At the same time, strings of short booms are being run across the mouths of small coves to prevent them from being contaminated. However, the operation is only partially successful as some of the oil is driven under the booms by local currents. Peat moss is spread on the slick as it intercepts the beach. The continuous application of absorbent material and pick-up of contaminated peat moss is carried out from landing craft and small barges. Accommodation and transportation facilities have been established so the beach clean-up crews can work in shifts.

3. 30 - 36 Hours (Map 33)

This ebb tide returns much of the slick towards the south and somewhat towards the east so that even the most easterly shores of Discovery Island become contaminated.

a) Impact

As the tide ebbs, much of the intertidal zone is re-coated with oil. On most beaches the oil is mixed with gravel and sand and carried into the subtidal area by wave action. Many of the more fragile intertidal organisms, including limpets, shorecrabs and tidepool fishes are killed. Several river otters have been observed along the shoreline with oiled pelage, but the 40-50 seals that normally inhabit the area appear to have moved elsewhere. More oil-soaked birds are coming ashore with the live ones being taken to the central depot for rehabilitation.

All recreational activities along the foreshores have long since ceased and individuals are instead volunteering their help with beach clean-up. Pleasure craft are being requested not to enter the area.

b) Clean-Up

A fair percentage of the coastline is composed of non-porous rock which is being continually re-contaminated by oil. The clean-up task force is debating whether to leave the rocky shoreline to recover by itself in time or to clean it using talc and naptha. It is decided at 36 hours that high pressure water jets will be used in an endeavour to remove the bulk of the oil from the rocks. Much of the marine life is stripped from the rocks with the water jets so the use of talc and naptha will be re-assessed when all the oil is removed from the water and there is no chance of re-contamination. Along the booms in front of Oak Bay and Cadboro Bay marinas, slick-lickers are attempting to remove some of the thicker concentrations of oil.

4. Beyond 36 Hours (Map 34)

Part way through the following flood tide, the slick is northeast of Cormorant Point where the winds, having funnelled through the Gulf Islands, are from the northwest at 15 knots. The tide current is 1.25 knots to the north. Thus, the slick is pushed closer to the international boundary. The following ebb tide moves the slick along the border to the SSE, and the flood tide carries part of the slick over the border and on to San Juan Island under the influence of the westerly wind out of the Strait of Juan de Fuca. The remainder of the slick is located around Discovery Island where following tidal cycles oscillate it back and forth, pushing more and more oil on to the shores of the islands and the coastline east of Victoria.

a) Impact

The intertidal zones on Discovery and Chatham Islands continue to be appreciably affected by oil brought ashore by wind and tides. The biological sampling of species diversity and abundance carried out prior to the spill reaching the shoreline is found to be extremely valuable in forming the basis for estimating the actual extent of damage to intertidal organisms, and, eventually, their rates of recovery.

Observable effects 51 hours after the spill include the contamination of 15 miles of intertidal coast plus the shores of Trial, Chatham and Discovery Islands. The Chain Islets, a colonial seabird nesting site, are virtually covered with oil. Of the mammals in the area at the time of the spill, it is estimated that about 20 adult and young river otters will be killed. Of the following birds in the area, some 6,500 or 60% of them were affected: red-necked grebe (150), western grebe (25), brandt's cormorant (125), pelagic cormorant (1,400), harlequin duck (1,000), black-bellied plover (20), surfbird (150), black turnstone (250), wandering tattler (25), lesser yellowlegs (20), least sandpiper (150), dowitcher (25), western sandpiper (150), black oystercatcher (100), red phalarope (1, 000), glaucous-winged gull (3, 000), california gull (500), bonaparte's gull (1, 000), heermann's gull (500), common murre (1, 000).

The long-term effects of the spill will likely never be known. More birds are expected to be contaminated in the next few weeks but the effect on the total population of particular species will probably not be severe. The Chain Islets seabird colony should be free of oil by the next nesting season and, in time, river otters will repopulate the islands. Beaches and rocky shorelines will continue to be re-contaminated and oxidation and biological degradation of the beached oil will be quite slow.

In retrospect, an important short-term effect on human use of the area will have been on recreational activities such as pleasure boating and beachcombing. Although the waters are usually too cold for swimming, scuba divers are forced to use other sites for some weeks following the spill. The sports salmon fishery has also been able to relocate further to the southwest. The use of booms at Oak Bay and Cadboro Bay marinas prevented extensive oiling of some 700 boats. Foreshore property values in the area are very high, sometimes over $400 per frontage foot, and people who wish to sell their lots are already having difficulty in doing so. It will likely be years before the oil saturating the beach material decomposes to the extent that the beaches return to their pre-spill condition.

b) Clean-Up

While major clean-up operations continue along most of the shoreline, it is discovered that the gravel pit near Albert Head is beginning to seep oil back into the ocean. A boom is put in place and peat moss used to prevent further spreading. A conveyor and squeezing machine is installed and the excess oil is wrung out of the soiled peat before being placed in the pit. The recovered oil is transferred by tanker trucks to tank farms.

After one week of concentrated clean-up activities, it appears that most of the major oil contamination has either been cleaned from the shores or has disappeared in the water. However, it is decided that a small stand-by crew will remain on site for another month to handle any intermittent re-oilings.

C. SCENARIO #3

This scenario is an account of an actual spill of gasoline which occurred on December 14, 1971 at Lang Bay, south of Powell River. This spill was a relatively small one, but it illustrates the kind of accident which can easily occur due to normal human error.

At about 2:00 a.m. on a cold winter night, a half million gallon capacity barge pulled into the Gulf Oil products terminal wharf at Lang Bay to unload gasolines into the shoreside tanks located approximately 100 yards from the water. The local agent for Gulf Oil gauged the tanks in order to determine the available capacity and notified the barge operator as to the volume of products which were to be off-loaded. The agent then stayed on the barge while the products were being pumped.

Sometime later, it was noticed that there was a very strong odour of gasoline about the terminal and dock site. Pumping was immediately stopped. Upon investigating the situation, the agent found that he had made a mistake in determining the available capacity of the gasoline tanks and they had overflowed. He estimated that the maximum leak-rate had been between 40 and 60 gallons per minute for about 3 hours, and the total spill was on the order of 8,840 gallons (36 tons). The gasoline had flowed out of the hatches on the top of the tanks, down the tank sides, and underneath the dyke which surrounded the tanks for the purpose of containing any spilled gasoline. The gasoline then flowed down the hillside, on to the bay, and finally into Malaspina Strait. It evaporated rapidly and became dissipated by wave action. Two days later, only slight traces of gasoline could be found on the water and beach of Lang Bay.

The spill resulted from the compounding of two human errors. The first was the error on the part of the Gulf agent in misgauging his tanks. That this kind of error is anticipated by the oil company is evidenced by the fact that they had constructed a dyke surrounding the tanks to contain any spilled gasoline. However, the dyke was poorly constructed in that it was built on top of gravel which permitted the spilled gasoline to seep right under it - the second human error which contributed to the spill.

a) Impact

The impact of this particular spill was negligible. Biological damage was minimal as the intertidal zone in Lang Bay is not particularly productive, there are no shellfish beds and only a few waterfowl were in the area. While the bay is a potential herring spawning ground, spawning does not occur in December. Apart from the costs of investigation by fisheries and MOT personnel, there were no economic impacts. The only social effects were the anxiety and loss of sleep suffered by the few residents of the area.

However, this type of spill could easily occur in much more vulnerable locations. A number of similar products terminals exist in both the northern and southern Gulf islands, as well as in Barkley Sound. In these areas, there are far richer intertidal zones and biological communities which would be severely affected by a spill of gasoline, a highly toxic material. Such a spill could easily be much more disruptive to commercial and recreational activities than the Lang Bay spill, and cause much greater social and economic impacts. While the accident record of the barging industry is excellent, it is only a matter of time until a severe products spill occurs unless more stringent preventative measures are implemented. These types of spills are much more susceptible to being prevented than they are to being contained and cleaned up.

b) Clean-Up

No attempt was made to contain or clean up the spilled gasoline as there were no facilities on hand to do so, and because the gasoline was rapidly evaporating and spreading out into Malaspina Strait where it was dissipated by wave action and disappeared. Before the extent of the spill was completely realized, the use of a chemical dispersant was considered, but permission to use it was denied by the local fisheries officer. As it turned out, however, the dispersant was not necessary. The Malaspina Fire Department sent a truck to the site in case of explosion or fire, but none occurred.

D. ECONOMICS OF LOST RESOURCE VALUES FOR SCENARIOS

1. Boundary Bay Scenario

The economic costs relevant to this spill are in three categories: biological, private property, and recreation. It is felt that the vast majority of any tourist losses are absorbed by transfers to other areas of British Columbia. However, some losses in this area might occur and by the omission of these losses, the estimate might be slightly understated. Also, no attempts were made to quantify option demand, education values, and preservation values as lack of data in these areas plus the short duration of the spill indicate that the required effort to quantify these values is not justified, although this could also cause some understatement of final estimates.

a) Biological Values

The biological effects of the spill prove to be some of the most difficult to identify in terms of economic costs. Biological losses could affect the commercial fisheries values in the short term, or in the longer term could work their way through food chain interactions to harm the commercial fisheries in the future. Furthermore, for both present and future considerations, biological damages could cause reduced values from the aesthetic point of view and possible reduced values in recreation values such as sports fishing. However, to quantify these economic costs it is necessary to know within certain confidence limits the chain of events of many intricate and complicated biological interactions. Where contamination by oil is concerned many of these longer term relationships are not fully understood and perhaps will never be known. Because of these limitations it is felt that a reliable economic estimate of biological losses cannot be made at this time, although it is certainly not the intent to ignore them. Indeed, the desire is to include them, but the tools are just not available. (With these qualifications in mind, we do attempt in the last part of this section to give an example of assumed waterfowl losses affecting hunter recreational activities.)

b) Property Values

The evaluation of the effects on property values presents some interesting complications because of the diverse nature of the ownership of adjacent properties, and the actual uses of each. Information concerning the ownership, values, and use of the properties in question was obtained with the assistance of members of the Surrey Planning Department, the Surrey Parks and Recreation Commission, the Surrey Assessor's Office, the Delta Parks and Recreation Department, the Delta Assessor's office, and census data.

In many cases, the actual ownership of the waterfront property is not a reflection of the total value of that property in use, and therefore does not represent the actual values lost because of oil contamination. The most obvious example is the White Rock beach area. Legally it appears the waterfront property is owned by the Burlington Railroad by prior possession but the area is heavily used for recreation. This latter use determines the economic value lost from contamination because the oil does not adversely affect the value to the legal owner. Furthermore, in some cases, not only the actual waterfront values are affected, but also the values of adjacent properties. Table 9 lists in detail the ownership and use of properties on and near the waterfront from Peace Arch Park to the eastern border point at Point Roberts and indicates those affected by the spill.

It can be seen from this table that much of the property suffers no loss in value. This is indicated for farming lands, some of the various government owned lands, and some of the railroad owned lands. Those most affected are the residential property near or adjacent to the waterfront, some business property near the water, and public properties used as parks.

At this point only residential property is analyzed as it is contended that any possible loss of business property values occurs because of reduced income to the business. This is not included as an economic social cost because it is felt the income lost by those in the area will be spent in other parts of British Columbia and therefore represents a transfer of income rather than a net loss. Of course, the dislocation and "local" costs of this nature should not necessarily be ignored. Equity might dictate some transfer of public funds to assist those who suffer, but this aspect is beyond the scope of this section. We are now concerned only with net costs to society. The loss to public recreation properties are assessed in terms of lost use by the public.

TABLE 9

Waterfront Ownership	Actual Use	Use of Adjacent Property	Area in Front Ft.	Value Affected by Spill: Actual Use	Value Affected by Spill: Adjacent Property
Indian Reserve	Indian Reserve	Indian Reserve	7,060	Not Contaminated	
Indian Reserve	Leased as Park	Leased as Park	2,310	Not Contaminated	
Private R.R.	R.R. and Public Beach	Business and Residential	12,000	Yes	Yes
Private R.R.	R.R. Use	Residential view property	9,875	No	No
Private R.R.	R.R. and Public Beach	Residential	500	Yes	Yes
Private R.R.	R.R. and Public Beach	Public Reserve	1,750	Yes	No
Private R.R.	R.R. and Public Beach	Residential	5,750	Yes	Yes
Public Beach	R.R. and Public Beach	Residential	4,530	Yes	Yes
Public Beach	R.R. and Public Beach	Public Reserve	6,250	Yes	No
Private R.R.	R.R.	Farming	8,500	No	No
Private	Farming	Farming	560	No	No
Provincial	Reserve	Reserve	155	No	No
Private	Farming	Farming	37,030	No	No

Waterfront Ownership	Actual Use	Use of Adjacent Property	Area in Front Ft.	Value Affected by Spill	
				Actual Use	Adjacent Property
Department of Transport	D.O.T.	D.O.T.	5,500	No	No
Private	Farming	Farming	3,000	No	No
B.C. Harbours Board	Roberts Bank Use	Roberts Bank Use	4,760	No	No
Private	Residential (Undeveloped)	Residential (Undeveloped)	13,000	Yes	Yes
Public Beach	Public Beach	Park	7,000	Yes	Yes
Private	Residential	Residential	4,120	Yes	Yes
			133,650		

The loss in value to private property owners in this area is considered in two separate categories: first, waterfront property; and second, property near the water which is largely dependent upon this proximity for its value. In each case, the owner loses a large portion of the utility or usefulness of his property for a one year period. The analysis compares properties on and near the water with properties of similar type without the advantage of nearness to the water. The basic assumption is that the oil spill eliminates the advantages of proximity to the water for a one year period and thus the utility or implicit rental value of property on or near the water becomes equal to the rental value of other property with no water benefits. This difference represents the spill cost. (See section B of Chapter V for a further discussion of this methodology.)

There are 27,900 waterfront feet of residential type property in the spill area of which 26,000 feet are polluted. Thirteen thousand feet are developed with an estimated value of $350 per front foot and another 13,000 feet are under development with an estimated value of $265 per front foot. Calculations of estimated loss are shown in Table 10.

To determine the number of households owning lots with close proximity to the water, but not adjacent to it, data were extracted from the 1966 census and updated estimates were made for 1972. No value is lost for Ocean Park properties as a result of the spill since the shoreline is steep and much of the value is derived from the view. Only 50% of the residential lots in White Rock are affected,

TABLE 10 - Loss to Waterfront Properties

Average lot without water benefits assumed to be worth:

$8,000 Serviced 70 x 70 size
$2,000 Not Serviced 70 x 70 size

	Waterfront Serviced	Waterfront Under Development
Front feet	13,000	13,000
Value per front foot	$ 350	$ 265
Total Values	4,550,000	3,445,000
Assumed yearly rental return	x 12%	x 12%
	$ 546,000	$ 413,400

	Non-Waterfront Serviced	Non-Waterfront Not Serviced
Front feet	13,000	13,000
Value per front foot equivalent	$ 114	$ 28.50
Total Values	1,482,000	370,500
Assumed yearly rental return	x 12%	x 12%
	$ 177,840	$ 44,460
Reduced rental values for 1 year	$ 368,160	$ 368,940
Approximate present values of reduced rental rates using 10% discount per year	$ 350,000	$ 350,000
Total reduced rental value	$700,000	

while all of the Crescent Beach lots are affected as well as all those in the community of Boundary Bay. The calculations of loss are shown in Table 11.

c) Recreation Values

The assessment of lost recreation values is concerned mainly with lost swimming and beach use in White Rock, Crescent Beach and Centennial Park as well as losses in waterfowl hunting. There is also some lost sport fishing values, but these are restricted to the short period when boats moored at Crescent Beach are not usable. Therefore, the sport fishing values lost in this case are thought to be very small.

The beaches in White Rock, Crescent Beach, and Centennial Park are all heavily used during the summer months, especially on weekends. Other forms of use in other seasons are much lighter, but all beaches are used all year round. Beach users are mostly local people, and it is thought there are not many good substitutes for these beaches in nearby locations. Crowding factors preclude much transfer to Vancouver city beaches, and transfer costs to other similar activities are likely high because of the distances involved. Beach activity is probably the most important recreational activity of the Boundary Bay area and although data on actual beachuse are not precise, usage is estimated via counts by the Crescent Beach lifeguards, discussion with both the Surrey and the Delta Parks and Recreation Department, and discussions with the Crescent Beach and White Rock swimming clubs. Calculation of usage and values are shown in Table 12.

TABLE 11

Loss to Properties Close to the Water

	Service lot near the water		Service lot without proximity to waterfront
Estimated Value	$ 16,000		$ 8,000
Number	3,100		3,100
	$49,600,000		$24,800,000
Assumed yearly rental rate	x 12%		x 12%
	$ 5,952,000		$ 2,976,000
Reduced rental value for 1 year		$2,976,000	
Approximate present value of reduced rental rate using 10% discount per year		$2,827,200	

TABLE 12

BEACH USE

	WHITE ROCK	CRESCENT BEACH	CENTENNIAL PARK
14 week summer period	152,600	60,200	35,000
Off season period use	61,040	24,080	14,000
Total	213,640	84,280	49,000
Value per day	$3.00	$3.00	$3.00
Total Value	$640,920	$252,840	$147,000
Total	$1,040,760		

Amongst the several thousand waterfowl affected by the spill, the species of importance to Lower Mainland waterfowl hunters include mallard, widgeon, pintail, green-winged teal, and Pacific black brant. The loss of breeding stock coupled with a poor breeding season could result in reduced fall and winter waterfowl concentrations in the Boundary Bay / Fraser Delta area and to lesser extent throughout the Pacific flyway. Equally damaging to fall and winter populations could be the destruction of important food sources in Boundary Bay so that the area would not be able to support its normal complement of birds.

It may be over-simplistic to assume a significant reduction in fall and winter waterfowl populations in the study region as a result of the spill, but that assumption is made here. The impact on waterfowl populations would probably not lead to a restriction in hunting seasons, as the populations are frequently subject to natural fluctuations of equal magnitude. But the reduced availability of birds would probably lower the quality of each individual hunting experience, and result in a reduced value of waterfowl hunting in the Lower Mainland the following season.

Waterfowl hunting in the Lower Mainland has an average annual value of $300,000 to $356,000. It is assumed here that this value would be reduced by forty percent ($131,000) for the hunting season immediately following the spill. While a forty percent estimate may seem high, it is felt that it is reasonable when one considers the direct loss of breeding stock plus the destruction of food sources in Boundary Bay. It is further assumed that there would be no reduction in license revenues and fees to either the federal or provincial governments.

It is important to note that there is not a forty percent reduction simply in waterfowl hunting activity, but a forty percent reduction in value. Some hunters continue to hunt the same amount as with "normal" waterfowl populations and absorb the impact in terms of a lower value per day of hunting. Other hunters react by hunting less than with "normal" waterfowl populations and their loss in value is borne in this manner.

In summary, the total recreational value including waterfowl hunting lost as a result of this oil spill (to the extent that data and technique allow an economic measurement of this loss) is $1,171,760. The total economic loss exclusive of the clean-up costs for the Boundary Bay area thus comes to $4,698,960 for total reduced rental value, loss to properties close to the water and recreational losses.

2. Victoria Scenario

The method used to quantify the economic costs of this spill is basically the same as that used to quantify the costs of the Boundary Bay oil spill. The categories for these costs are: biological, private property, and recreation.

The area under examination - from Clover Point in Victoria to Telegraph Cove in Saanich - is almost entirely residential with small park sites. It is felt any tourist losses to the few businesses in the area are small and are absorbed by other parts of British Columbia. Also, no attempt is made to quantify option demand, education values, and preservation values, as lack of data in these areas plus the assumed extremely short duration of the spill indicate the required effort to quantify these values is not justified.

The beach areas are most severely polluted with oil for a two week period by which time almost all clean-up efforts are completed. Because some small amounts of re-oiling occur in the months following the clean-up, a total of one month is used as the time period in which the beaches lose the larger part of their usefulness to the local residents.

a) Biological Values

The biological values which are lost, although significant, cannot be given a reliable economic estimate for reasons similar to those discussed in the Boundary Bay scenario. Once again, the intent is not to ignore them, but to indicate that with available data they cannot be quantified.

b) Property Values

Almost all property in the area is used for residential and recreational purposes. Information concerning ownership, values, and use of the property on and near the water was obtained with the assistance of the Victoria Planning Department, the Victoria Assessor's Office, the Oak Bay Assessor's Office and the Saanich Assessor's Office. Table 13 indicates the front foot ownership and use by groups for the appropriate

TABLE 13

MUNICIPALITY	WATERFRONT OWNERSHIP	USE	AREA IN FRONT FT.
Victoria	Public	Small amount of beach use	5, 500
"	Private	Residential	4, 320
Oak Bay	Public	Park and beach use	9, 200
" "	Private	Golf Course	5, 200
" "	"	Residential - South of Estevan St.	22, 250
" "	"	Residential - North of Estevan St.	6, 100
Saanich	Public	Park and beach	835
"	Private	Auto court	430
"	"	Residential	20, 000
		TOTAL	73, 835

areas of the three municipalities affected.

The loss in value to private property owners in this area is considered in two separate categories: first, waterfront property; and second, property near the water which is largely dependent upon proximity to the water for its value. The analysis compares properties on and near the water with properties of similar type without the advantages of nearness to the water in terms of the differences in implicit returns or rental value for a one month period. (See Section B of Chapter V for a further discussion of this methodology.)

There are 53,100 waterfront feet of residential property in the spill area. Table 14 shows the calculation of reduced rental values for the one month period of the spill. The loss to householders owning properties close to the water is calculated and presented in Table 15 . Those affected are households within four blocks from waterfront areas (on the basis of data extracted from assessors' maps). To include a larger number of households in this category ignores the fact that waterfront areas are not very distant from any point in the Victoria, Oak Bay, Saanich municipalities. Therefore, values relating to proximity to the water will not be damaged significantly by this spill for those who have many substitute waterfront areas nearby. Also, many of the properties in these municipalities have relatively high values because of the ocean view, rather than the ease of access. It is felt these values will not be affected to a significant degree by the spill. As indicated in Tables 14 and 15 , the total loss to private property

TABLE 14

Loss to Waterfront Properties

		Victoria	Oak Bay South of Estevan St.	Oak Bay North of Estevan St.	Saanich
WATERFRONT	Front Ft.	4,320	22,250	6,100	20,430
	Value/Front Ft.	$ 280	$ 300	$ 425	$ 350
		$1,209,600	$6,675,000	$2,592,500	$7,150,500
	Assumed Monthly Rental Return	1%	1%	1%	1%
		$ 12,096	$ 66,750	$ 25,925	$ 71,505
NON-WATERFRONT	Front Ft.	4,320	22,250	6,100	20,430
	Value/Front Ft.	$ 100	$ 100	$ 100	$ 100
		$ 432,000	$2,225,000	$ 610,000	$2,043,000
	Assumed Monthly Rental Return	1%	1%	1%	1%
		$ 4,320	$ 22,250	$ 6,100	$ 20,430
	Reduced Rental Value for One Month	$ 7,776	$ 44,500	$ 19,825	$ 51,075
				TOTAL	$ 123,176

TABLE 15

Loss of Properties Close to Water

Estimated Value	$ 25,100	$ 12,500
Number	3,700	3,700
	$92,870,000	$46,250,000
Assumed Monthly Rental Rate	1%	1%
	$ 928,700	$ 462,500

Reduced Rental Value for One Month Period $466,200 owners is just under $600,000.

c) Recreation Values

The assessment of lost recreation values is concerned mainly with lost beach use in the Victoria, Oak Bay, and Saanich municipalities. Lost sport fishing values are small as most effort is relocated in other nearby areas. Also, the local marinas are well protected from oil damage by booms.

The beach use under consideration is small when compared with the population base of the area and tourist visits. Three reasons account for this: one, the water in the area is extremely cold and not well-suited for swimming; two, the poor quality of sewage pollution treatment causes the water to be frequently too polluted for swimming; and three, there are many substitute outdoor recreation activities on and near Vancouver Island.

Beach use affected, as estimated with the assistance of the Oak Bay Recreation Department, was 122,000 visits for the one month spill period with the value lost per visit estimated at $2.00, giving a total value of $244,000. This is lower than used for the Boundary Bay estimates because of the reduced swimming opportunities, the availability of beach activities in other areas nearby, and the availability of other substitute outdoor activities in the lower Vancouver Island area.

In summary, the total economic loss for the period of the spill is approximately $833,000 exclusive of the costs of clean-up. When comparing costs for the Victoria spill to those of Boundary Bay, it should be noted that the differences in losses depend primarily upon the length of time the beach areas are contaminated which in turn is dependent upon the nature of the beach material and the area of tidal flats.

E. SOCIAL CONSEQUENCES FOR SCENARIOS

1. Boundary Bay Scenario

Boundary Bay is one of the largest natural tidal flats on the entire Pacific coast, and its importance to migratory waterfowl has given it international significance. Although proposals have been advanced for various types of industrial, harbour and residential development, the outcome of some fifteen years' controversy has been a generally accepted recognition that the bay will be retained for recreation and resource values. Recreationists and conservationists in the Lower Mainland have acquired a strong proprietary interest in Boundary Bay, and studies to develop a range of alternative plans for its development for recreational purposes and for the maintenance of its natural values are underway. Because its real significance lies in future rather than present use, it is an area where the concepts of option demand and option value would be most applicable if they were more fully developed.

The assessment of waterfowl economic value indicates the degree of loss to hunters from the oil spill, but does not cover the sometimes misguided, albeit real, humanitarian interest that is aroused by oiled birds. Although the most humane treatment for waterfowl affected by an oil spill may be to destroy them, people just cannot see it that way. In the case of the Boundary Bay scenario, public pressure results in the establishment of cleaning stations for the huge number of birds that are affected as people seem to be far more concerned about individual birds than they are about the future of their habitat.

A strong argument can be developed that Boundary Bay is still a wilderness within forty-five minutes' reach of Vancouver. Public controversy over the bay always seems to have resulted in strong support for the preservation of that wilderness, despite the fact that very few people make recreational use of anything other than its beaches. The speed with which citizens' groups and the media express the public's opposition to plans for industrial development of the bay indicates the proprietary interest that people in the Lower Mainland have in it.

No major educational or scientific programmes relate directly to the bay, although it is used to some extent for casual field trips. However, the potential for these is immense, particularly if government agreement were reached for a development programme.

2. Victoria Scenario

Although the natural physical and biological losses of this scenario are less than those of Boundary Bay, the area affected is much closer to urban and suburban populations. Consequently, more individuals are concerned with this spill and there are more public relations programmes needed to direct community efforts in spill clean-up, particularly with respect to oiled birds and beaches.

In terms of the proximity of colonial seabird nesting sites to the University of Victoria and the Provincial Museum, education values are considerably jeopardized as alternate sites do not exist close to the capital. Long-term research programmes of intertidal and marine-associated organisms are also disrupted and most aesthetic values associated with recreational activities such as boating and beach-combing in the area are temporarily curtailed.

F. COST OF SPILL RESPONSE AND CLEAN-UP FOR SCENARIOS

The Boundary Bay spill of 40,000 tons is determined to take one month to clean-up and the Victoria spill of 20,000 tons one week to control. Longer action is necessary on the Boundary Bay spill due to the difficulty encountered in clearing the extensive tidal flats. Both purchase and rental or one-time use costs of some items have been presented for comparison. Only the rental or one-time use cost has been used in determining the total cost of cleaning up each spill; capital costs are shown only for comparison. No costs were incurred at Lang Bay.

With reference to Tables 16 and 17, all the land and water-based equipment costs are calculated on an 18 hour working day. Fueling and maintenance requirements are attended to in the 6 hours between shifts. Aircraft rates are based on a 10 hour day as are labour rates. Oil containment booms are rented on the basis of an 8 hour day so that the actual daily rental rate is three times the rate indicated by the lessor over a 24 hour period.

The following is a list of background considerations to scenario costing:

- Booms: Three types of booms are required: heavy deep sea ones for rough water, lighter ones around marinas and harbour entrances, and pneumatic booms where boat traffic through harbours must continue.
- Slick-lickers and Skimmers: A larger number of slick-lickers than skimmers are used because skimmers are less efficient in rough offshore waters and cannot pick up oil-soaked absorbent.

- Tugs: Large tugs (over 1500 HP) are only required in salvage operations. Vessels with 1000-1500 HP are used to tow barges and position offshore booms while smaller craft deploy the lighter booms.
- Barges: Oil recovery barges work in conjunction with both debunkering salvage and oil pick-up equipment. Deck barges are loaded with peat which is spread at night when aircraft cannot fly. Work barges, possibly with cranes, are used for transporting oil-soaked absorbent to marine terminals.
- Absorbents: The quantity of peat moss is calculated on the basis that one cubic yard of peat picks up approximately one barrel of oil. This figure may be in error as such factors as the degree of oil emulsion may vary it. The cost of sand for replacing oil-soaked beach material is not considered as the quantity which may be required cannot be approximated.
- Aircraft: Aircraft (Hercules and Buffalo classes) are required to bomb the spills with at least one half of the peat being deployed. Normal forest fire retardant bombing aircraft (Canso and A 26 classes) cannot be used as they are not in the province in March and are engaged in forest fires during the summer. Light planes (Cessna 185 class) are used for aerial reconnaissance. Small helicopters are also used for reconnaissance and some light equipment ferrying. The large machines aid in such operations as transporting collected oiled peat from outer tidal flats to a collecting site near shore.
- Vehicles: Four wheel drive vehicles (especially those equipped with high flotation tires) are used extensively on soft beach areas. A greater number of these vehicles, plus dune buggies and small amphibious vehicles in conjunction with tracked equipment like Nodwells, are equipped with trailers

and are used in the Boundary Bay spill to move men, equipment and peat moss on the large tidal flats. A large percentage of the Victoria shoreline is rocky and thus inaccessible to this type of vehicle.

- Heavy Equipment: Caterpillar tractors are used only to construct road access and skid driftwood logs off the beaches. They are relatively inefficient for clean-up operations. Rubber-tired skidders cause less damage to the beach material than tracked equipment and are also faster and easier to move from site to site. Few "cats" and skidders are used in the Victoria spill as they are committed to combatting forest fires. Graders and self-elevating scrapers are used on only approximately 10% of the Boundary Bay tidal area (approximately 1000 to 1500 acres) due to the soft nature of the tidal silts. The number of units employed is based upon a clearance rate of 1 hour per acre and an 18 hour working day. These machines are not used in the Victoria spill due to the relatively small and steep beaches on that coastline.
- Miscellaneous Equipment: High-pressure water pumps are used to clean rocky coastlines, particularly in the Victoria scenario.
- Manpower: Although the skilled personnel required in both spills is approximately 800, a figure of 400 is used in the tables as some of the equipment rates include operators. In the Boundary Bay spill in particular, a large number of labourers is required to clean up the extensive tidal flats whereas far fewer are needed in the Victoria incident. Although some of the labourers may be volunteers, we have assumed that all are paid at the rate of $2.00 per hour. The expenses incurred in providing accommodation and catering facilities is based on a minimum of 2,000 labourers and skilled personnel being accommodated. It is assumed that the balance of manpower will live at home.

- Miscellaneous Costs: The costs of some equipment, such as railcar rental, soiled absorbent compressor squeezer rental, and fishnet laundromats are not calculated. No specific costs are available for establishing field maintenance facilities and no attempt is made to cost fuel consumed. Some rental rates do, however, include maintenance and fuel cost, although mileage charges on such vehicles as pick-up trucks are not included. The cost of utilizing men and equipment of the Armed Forces is not calculated. It must also be noted that even though some equipment such as lowbeds are not in operation 18 hours a day, they must still be on standby at all times. Additional costs including clothing, equipment for steam cleaning and those incurred during demobilization of forces are not evaluated either. Therefore, 20% of the gross total computed is added to cover such additional costs.

The major costs which are incurred in both scenarios were for booms, tug leasing, absorbent materials and personnel with their attendant requirements for housing.

On the assumption that no equipment is purchased, the approximate overall clean-up cost for the Boundary Bay spill is \$24,363,000 and for the Victoria spill \$4,965,200. The full implications of these figures and their relationship to costs of preventative measures and contingency planning are discussed in the conclusions to this report.

TABLE 16

APPROXIMATE OVERALL EQUIPMENT & MANPOWER COSTS - BOUNDARY BAY SCENARIO

ITEM	NO. OF UNITS	CAPITAL COSTS	RENTAL/ONE TIME USE
MARINE EQUIPMENT			
Booms:			
Heavy	40,000 ft.	1,200,000	3,600,000
Light	40,000 ft.	400,000	1,800,000
Skimmers	30	900,000	486,000
Slick-lickers	40	400,000	389,000
Hovercraft	2	-	government
Tugs:			
1500 HP +	2	-	146,000
1000 - 1500 HP	4	-	2,052,000
800 - 1000 HP	20	-	702,000
Landing Craft	20	-	military
Small Work Boats	100 - 200	-	324,000 (min.)
Barges:			
Oil Recovery	30	-	360,000
Deck	8	-	72,000
Work (with crane)	8	-	84,000
MARINE SUPPLIES			
Peat Moss Absorbent	280,000 cu. yds.	980,000	980,000
AERIAL EQUIPMENT			
Cargo Planes	10	-	military
Helicopters:			
3 place	4	-	186,000
4 place (jet)	4	-	288,000
cargo	4	-	600,000
Light Planes	3	-	63,000

ITEM	NO. OF UNITS	CAPITAL COSTS	RENTAL/ONE TIME USE
VEHICLES			
Tank Trucks	30	-	324,000
Vacuum Trucks	60	-	117,000
Dump Trucks	100	-	810,000
Lowbed Trucks	10	-	108,000
Buses	30	-	27,000
4 Wheel Drives	25	-	15,000
Pick-Up Trucks	30	-	9,000
Dune Buggies	25	-	7,500
Trailers	50	-	7,500
HEAVY EQUIPMENT			
Caterpillar Tractors	20	-	270,000
Rubber-Tired Skidders	20	-	162,000
Front-End Loaders	10	-	162,000
Tracked Vehicles	20	-	162,000
Graders	20	-	259,000
Self-Elevating Scrapers	20	-	432,000
Cranes	5	-	54,000
MISCELLANEOUS EQUIPMENT			
High-Pressure Pumps	20	-	45,000
Steam Cleaners	5	-	54,000
Portable Power Generators	15	-	9,000
Conveyors	5	-	40,500
Portable Radios	100	85,000	6,500
Hand Rakes & Shovels	3000	9,000	37,500
Bird Scarers	100	-	30,000

ITEM	NO. OF UNITS	CAPITAL COSTS	RENTAL/ONE TIME USE
MANPOWER			
Organization Personnel	10	144,000 (year)	12,000
Field Supervisors	100	-	360,000
Consultants & Advisors	100	-	450,000
Skilled Personnel (Machine Operators)	400	-	1,200,000
Military Personnel	1000	-	military
Additional Personnel	2000 - 4000	-	1,200,000 (min.)
Accommodation for Additional Personnel	-	-	1,800,000 (min.)

TOTAL CAPITAL COSTS	4,118,000	
TOTAL RENTAL/ONE TIME USE COSTS		20,302,500
PLUS 20% OTHER COSTS		4,060,500
GRAND TOTAL		24,363,000

Note: Rentalor one time use costs instead of capital costs are used in the grand total because of the lack of predictability of the duration of this spill. As a result, the rental or one time use cost sometimes exceeds the capital purchase cost.

TABLE 17

APPROXIMATE OVERALL EQUIPMENT & MANPOWER COSTS - VICTORIA SCENARIO

ITEM	NO. OF UNITS	CAPITAL COSTS	RENTAL/ONE TIME USE
MARINE EQUIPMENT			
Booms:			
Heavy	30,000 ft.	900,000	630,000
Light	30,000 ft.	300,000	315,000
Skimmers	20	600,000	75,000
Slick-lickers	30	300,000	68,000
Hovercraft	2	-	government
Tugs:			
1500 HP +	4	-	64,000
1000 - 1500 HP	30	-	359,000
800 - 1000 HP	20	-	164,000
Landing Craft	30	-	military
Small Work Boats	100 - 200	-	75,000 (min.)
Barges:			
Oil Recovery	20	-	56,000
Deck	5	-	10,500
Work (with crane)	5	-	12,000
MARINE SUPPLIES			
Peat Moss Absorbent	140,000 cu. yds.	490,000	490,000
AERIAL EQUIPMENT			
Cargo Planes	10	-	military
Helicopters:			
3 place	4	-	43,000
4 place (jet)	4	-	67,000
cargo	4	-	140,000
Light Planes	3	-	15,000

ITEM	NO. OF UNITS	CAPITAL COSTS	RENTAL/ONE TIME USE
VEHICLES			
Tank Trucks	20	-	50,000
Vacuum Trucks	40	-	18,000
Dump Trucks	80	-	151,000
Lowbed Trucks	2	-	5,000
Buses	30	-	6,000
4 Wheel Drives	20	-	3,000
Pick-up Trucks	30	-	2,000
Dune Buggies	5	-	300
Trailers	25	-	900
HEAVY EQUIPMENT			
Caterpillar Tractors	5	-	19,000
Rubber-Tired Skidders	2	-	4,000
Front-End Loaders	10	-	38,000
Tracked Vehicles	5	-	9,000
Graders	0	-	-
Self-Elevating Scrapers	0	-	-
Cranes	5	-	13,000
MISCELLANEOUS EQUIPMENT			
High-Pressure Pumps	40	-	21,000
Steam Cleaners	5	-	13,000
Portable Power Generators	15	-	2,000
Conveyors	5	-	9,000
Portable Radios	100	85,000	2,000
Hand Rakes and Shovels	3000	9,000	9,000
Bird Scarers	100	-	7,000

ITEM	NO. OF UNITS	CAPITAL COSTS	RENTAL/ONE TIME USE
MANPOWER			
Organization Personnel	10	144,000/year	3,000
Field Supervisors	100	-	84,000
Consultants & Advisors	100	-	105,000
Skilled Personnel (Machine Operators)	400	-	280,000
Military Personnel	1000	-	military
Additional Personnel	2000 - 4000	-	280,000 (min.)
Accommodation for Additional Personnel		-	420,000 (min.)

TOTAL CAPITAL COSTS	2,828,000	
TOTAL RENTAL / ONE TIME USE COSTS		4,137,700
PLUS 20% OTHER COSTS		827,500
GRAND TOTAL		4,965,200

Note: Rental or one timeuse costs instead of capital costs are used in the grand total because of the lack of predictability of the duration of this spill. As a result, the rental or one time use cost sometimes exceeds the capital purchase cost.

CHAPTER VII - CONCLUSIONS

1. Starting this year, 1972, oil tankers of the 120,000 ton (854,000 barrel) class - the size of the Torrey Canyon - will be travelling from the open Pacific through Juan de Fuca and Rosario Straits to Cherry Point at the rate of about one per month. This rate will increase to one every five or six days if Alaskan oil becomes available for use at the Cherry Point refinery. On the basis of existing accident probability information, it is concluded that there is a 50% chance that this tanker traffic could result in an oil spill occurring at least once every twenty years, which would dump upwards of 20,000 tons of crude oil on to the sea in a manner that would seriously affect the Canadian coastal environment.

2. Extreme caution must be exercised in dealing in regional terms with the highly site specific impact of even an extensive oil spill, particularly in an area with the shoreline diversity and oceanographic complexity of the Strait of Georgia - Strait of Juan de Fuca. There is a natural tendency to consider the impact of a spill in the light of overall values of the total resource complex of the region, but this can be extremely misleading. The actual spread of oil from a spill is dependent on the rate at which the oil is being spilled, characteristics of the oil and, particularly, on existing oceanographic and meteorologic conditions. Furthermore, it is extremely unlikely that a collision or grounding of a tanker would result in the total loss of its cargo. These statements are not intended to down-play in any manner whatsoever the very serious implications of the sort of spill that could well take place

within the study region, but are intended to forestall the kind of criticism that can be levelled at statements which say that the contents of a supertanker could form an oil slick around the entire shore of Vancouver Island, and from that point automatically assume that the total resource complex of the shoreline is going to be affected. While dramatic positions such as this catch public attention, they do not constitute a realistic approach to dealing with the serious site specific reality of oil spills.

3. Crude oil or its by-products must be regarded as poisons that damage the marine ecology and as such will ultimately have to be treated with the same concern now shown for DDT and other chemical pesticides. While we have attempted to show on a general and site specific basis the environmental impact of a major oil spill in the study region, we are left with the overriding concern that since the scientific community still knows very little about the impacts that would result from the spillage of large volumes of oil at this latitude, oil spills may be doing far more harm than we can appreciate. However, the damage that would be done, plus the unknown long-term and sublethal effects of oil indicate that we cannot afford major oil spills even at twenty year intervals. If we are serious about protecting ecological and environmental values in the Straits of Georgia and Juan de Fuca, then we should conscientiously examine alternative means of transport for Alaska crude oil within both a national and international context.

4. The major social impact of oil transportation is probably the part that it plays in contributing to the general anxiety that society is expressing for environmental protection. While it is possible to

assess economic and recreational losses and, to a lesser extent, the disruption of life-style and the impact that an oil spill could have on human interest in unique and irreplaceable resources, it is extremely difficult to come to grips with the stress created by the awareness that once major crude oil shipments begin moving to Cherry Point, the vulnerability of the Canadian coastline leaves us holding yet another environmental time bomb. Coupled with this is the sense of frustration that people seem to feel about the fact that there is so little Canada can do unilaterally to protect herself, particularly with the knowledge that there are absolutely no economic or social advantages for Canadians in the tanker route.

5. Since no two oil spills are alike, it is necessary to simulate a real spill in order to identify its impacts and implications. A scenario of the kind of spill which could occur indicates that about $5 million worth of identifiable resource values could be lost as well as significant biological and social values, and the complete clean-up costs to restore shorelines to as nearly as possible their original condition could be in excess of $24 million. To put these figures into perspective, an advanced traffic management system designed to control the speed and route of all major ships in the study region for the purpose of minimizing accident probability would cost about $3 million to install and $400, 000 annually to operate. To establish a contingency force capable of reacting effectively to major oil spills would cost not less than $2. 5 million to $4 million to create and about $200, 000 annually to administer. In addition, the cost of replacing clean-up materials after each spill would be in the

order of $500,000 to $1 million, though this cost would be much less if peat moss were not stockpiled strictly for oil spill clean-up.

6. As human error is a key factor in over 90% of all oil spill incidents, the use of advanced navigation and shore-based traffic control equipment can only reduce the frequency of spills to a socially acceptable level; it cannot eliminate them. Measures for the prevention of oil spills are therefore concerned with minimizing the likelihood of oil spills occurring as a result of accidents during the transportation, transfer to and from vessels, and storage of oil. At present, these measures are largely lacking, though transfer operations in the American part of the study region are becoming increasingly more regulated. Only the barest beginnings are being made to regulate ship movements in the study region, and a concerted international effort to establish a comprehensive traffic management system in the Strait of Juan de Fuca/Strait of Georgia/Puget Sound area would be a major step toward reducing the frequency of oil spills occurring in it. The necessity of implementing such a system cannot be over-emphasized as similar systems in other parts of the world have shown that they significantly reduce the frequency of shipping accidents.

7. Areas of concentration of high marine resource values and areas of high oil spill probability have been identified for the study region. Through a literature review, through discussions with people who have been involved in oil spill clean-up operations, and through first-hand observation of major and minor

oil spill clean-up operations, we conclude that every effort should be made to refine our knowledge of the resource complex within the high hazard zones, both as a means of determining the priorities for clean-up operations and as a way of assessing resource losses arising from a spill. Regardless of increasingly sophisticated clean-up technology and the use of the best transportation and communication aids, successful oil spill clean-up still depends on the degree to which clean-up efforts are sensitive to the environmental values that the clean-up is protecting.

8. Oil spills occur at three main levels and can perhpas be treated analogously to one, two and three alarm fires.

The first level - the one alarm spill - is the result of human error and mechanical failure in ship-to-shore and ship-to-ship transfer operations, and from deliberate or accidental discharges within harbours. These spills are usually small in size, techniques to clean them up are already developed, and most contingency planning efforts by the oil industry have been directed towards them. Spills of this type should be handled by oil industry, transportation companies, and local harbour authorities.

The second level - the two alarm spills - are those resulting from accidents to vessels distributing refined oil products and from the loss of bunker fuel arising from accidents to vessels operating within the region. The lack of firm data on marine transportation within the study region makes prediction of this type of spill virtually impossible. Such a spill calls for a higher level of contingency planning than that required for local harbour spills, although equipment stockpiled for harbour spills and for the major type of oil spill can both be used in dealing with this second hazard level.

The number of one and two alarm spills is much greater than the number of major tanker spills. Technology to control them is increasing,and they are on the level at which Canada can, and should, be expecting to undertake contingency planning on a unilateral basis in the study region.

The third level - the three alarm spill - is the major spill resulting from an accident involving a tanker transporting large quantitites of crude oil or oil products. Just as no single fire station is equipped to handle a three alarm fire, neither Canada nor the USA could be individually prepared to clean up a major spill, and every consideration should be given to joint Canada - U.S. preparations to handle these spills, especially those which could involve a supertanker on the approaches from the Pacific to Cherry Point, since the shorelines of both countries are equally vulnerable.

Notwithstanding these specific possible areas of responsibility, the lack of knowledge on the long-term effects of a continual build-up of oil in the marine ecosystem means that far more stringent international regulations must be imposed on the transport of oil by sea. Since oil is becoming a ubiquitous substance on the seas of the entire planet, it is obvious that no maritime nation can hope to protect its seashores on its own, and that international action to control oil pollution of the seas is long overdue.

9. It is concluded that attempts to deal with the environmental impacts which could result from a major oil spill, and impinge upon both Canada and the USA, could easily be frustrated by international debates over who is responsible for cleaning up and paying the costs of cleaning up of such spills. One method of avoiding such delays would be to create an international fund to pay for the clean-up costs of all spills occurring in the Strait of Juan de Fuca / Strait of Georgia / Puget Sound inland sea as well as the costs of maintaining contingency forces. This fund could be financed by a tariff in the order of 17 cents per ton on all oil and oil products being transported in the region. Compensation for loss of resource values not adequately covered by other means could be paid out of an expanded fund. The costs of spills caused by vessels not carrying oil or oil products as cargo could be paid directly by the owner of the vessel and/or cargo. The fund would have to be administered in close conjunction with any international oil spill clean-up contingency arrangements between Canada and the USA.

10. The point has frequently arisen in the literature and in our own field experience that no matter what the method of oil spill clean-up, fast notification and mobilization of contingency teams are critical. Early action not only can protect shorelines from contamination, but also minimizes it should it occur. Considering crude oil properties, shoreline features and the special "inland sea" characteristics of the study region, it is concluded that mechanical means of clean-up - notably the use of booms, slick-

lickers, and the application of peat moss - are generally less harmful than chemical ones, although not always as effective.

11. We strongly endorse the summary of recommendations incorporated in Part 2 of Volume I of the "Report of the Task Force-Operation Oil (Clean - up of the Arrow Oil Spill in Chedabucto Bay)" as it appears in Appendix E of this report. We particularly endorse the scientific preparedness priorities suggested. Through our own literature research, we have identified precisely the same shortcomings as the Operation Oil team recognized in their establishment of scientific preparedness priorities.

12. While this particular study has dealt with oil transportation on the west coast in isolation, we recognize fully, and stress, that this is only one component of what should ideally be a major international accord between Canada and the U.S. on the manner in which oil is moved from Alaska to U.S. markets.

Ecological imperatives repeatedly point out the artificiality of our international boundary from the standpoint of environmental damage, and this study is an excellent case in point. We have dealt with the impact of a potential oil spill on Canadian shorelines, but the impact on adjacent U.S. coastlines would, of course, be equally devastating. Sooner or later we have to face up to the harsh reality that ecological and environmental imperatives, not man-made imperatives such as national security or arbitrary boundaries, are really going to determine whether or not men and nations are to live in harmony with their environment. It is the environmental imperatives and not the man-made ones which must act as the real constraints on international oil shipments.

CHAPTER VIII - RECOMMENDATIONS

It is not our intention in these recommendations to list the numerous specific items which should be undertaken - these are embodied in the report and have been discussed at various times with people in the responsible agencies on the west coast. As well, the terms of reference did not call for an agency specific study. The recommendations presented here are derived from the broader level of conclusions that we have reached.

1. We recommend that the Canadian government pursue with the utmost vigour every possible avenue to bring about international recognition of the environmental imperatives that must act as the real constraints on international oil shipments.

2. We recommend that Canada proceed unilaterally to establish and maintain an effective contingency plan that is genuinely responsive to local conditions and takes care of the type of oil spills that arise in harbours and shoreline installations as a result of ship-to-ship and ship-to-shore transfer of oil products.

3. We recommend that Canada unilaterally establish on the west coast a contingency force capable of dealing with the type of oil spill that is likely to arise from the spillage of refined products being transported within west coast territorial waters, and of bunker oil that would be spilled as a result of accident to a vessel operating

within the area.

4. We recommend that a third level of contingency planning be initiated in cooperation with the USA for the control of major spills arising from an accident involving a tanker transporting large quantities of crude oil or oil products. Particular emphasis should be placed on preparing for spills on the route to and from Cherry Point.

5. We recommend that any oil spill contingency plan incorporate as its major features: a) the ability to react quickly and effectively to contain and clean-up spills; b) the stockpiling of critical and difficult-to-obtain clean-up materials and equipment for quick mobilization; and c) the documenting of access to other required materials and equipment.

6. We recommend that, in addition to international oil spill contingency planning between Canada and the USA, a fund be created to pay the costs of all contingency forces and clean-up operations in the region. The fund should be financed on a "user pays" basis, most preferably by a tariff on each ton of crude oil or oil products being transported. A value in the order of 17 cents per ton appears to be a reasonable first approximation of the tariff required, and could be used as a basis for more detailed economic and political considerations to arrive at the final levy. Consideration should also be given to paying compensation out of the fund for loss of resource values not adequately covered by other means.

7. We recommend that Canada and the USA jointly establish and operate a comprehensive marine traffic management system for all major vessels travelling in the Strait of Juan de Fuca / Strait of Georgia / Puget Sound inland sea. This system should monitor all communications and vessel locations, and issue either advice or direct orders concerning the routing and speed of all vessels it manages.

8. We recommend that the regulation, surveillance and enforcement of transfer operations be undertaken by one federal agency to prevent chronic long-term pollution of coastal waters and shorelines.

9. Since time constraints and the urgency of dealing with the crude oil movement to Cherry Point prevented the fullest possible examination of internal traffic movement within the study region, we recommend that a more intensive examination of internal barge and tanker movements, and other major vessel movement in the study region, be undertaken in order that a realistic assessment of spill probability of refined products can be made.

10. Since the major purpose in an oil spill clean-up operation is to protect the environment, we recommend that the baseline information on the high hazard zones identified in this study report be further refined and used to dictate the actual level of contingency planning eventually arrived at for the west coast. The information should be developed to the extent that it can be used to determine clean-up priorities and the degree of resource loss in the event of a spill.

11. We recommend that in any oil spill contingency plan a major provision be made for an effective programme of community relations to ensure that individuals who would be affected by the spill are adequately informed of the likely impacts and, equally important, to ensure that uninformed public opinion does not result in politically expedient clean-up measures that simply remove the oil from sight to the long-term detriment of the environment.

12. We recommend that the recommendations of the Operation Oil Task Force which was responsible for the clean-up of the Arrow oil spill in Chedabucto Bay form a significant role in developing Canada's preparedness for oil spills. A summary of those recommendations appear in Appendix E of this volume.

13. Our first twelve recommendations have dealt with the reality of oil transportation as it exists in 1972. However, the threat of oil pollution from supertankers has its origin in problems beyond economics or national security, and we recommend that Canada and the U. S. join in an examination of not only alternatives to the tanker route, but also the fundamental and real question of our exploding energy use.

APPENDIX A - ECONOMIC VALUES

This appendix develops dollar figures for the major economically identifiable resources within the study region. It does not attempt to be completely comprehensive with respect to all the resources discussed in Chapter III, as many of these have value beyond monetary economics. Some of the methods used to determine the figures in this appendix were outlined earlier in Chapter V. As already indicated, extreme caution must be used in interpreting this appendix as none of the values derived here are intended to represent economic losses attributable to an oil spill; rather, they are simply an asset statement in monetary terms of certain resources within the study region.

1. Fisheries

The following section is an inventory and summary of the values of fish caught by commercial fishermen in the oil spill study region. The Fisheries Service of the Department of the Environment reports catch statistics by fishing zones for all Canadian fishing effort. A very close approximation of the study region can be made by using data from zones 13 to 24 inclusive plus areas 28, 29A, 29B, 29C, and 29E. Some caution must be excercised in interpreting data in offshore zones 21, 23, and 24 as the outer limits of these zones reach beyond the study region so that they might give an overstatement of the catch, especially for such species, as tuna, which has been removed from this summary. However, these zones are important because the majority of the salmon caught in them are within the study region.

Area C, which is south of Cape Flattery and outside U. S. protected fishing zones, is outside the study region and has not been included in this inventory. This gives rise to some possible understatement in study region catch statistics because many of the fish caught in this area originate in the Fraser River system, and during some periods of their life cycle could be affected by an oil spill within the study region.

However, neither the statistical problem of the offshore areas or of area C is large enough to enter a 5 percent error in the tabulations. Furthermore, these possible errors are compensatory.

Tables I and II in this section summarize both the gross returns to fishermen and the wholesale market value of seafood taken in the study region. The gross return to fishermen is reflected by the landed value of the fish which is recorded on sales slip receipts. These receipts reflect only the immediate prices paid to fishermen and do not reflect year end bonuses or certain free benefits such as ice and net loft use. The published landed value figures used here would probably be more accurate if they were increased by 10%.

No attempt has been made to indicate the net economic yield of this catch. To do this associated costs of production at both the harvesting and processing levels would have to be measured and deducted. This in turn would bring up further questions of fleet reduction and rationalization, all of which are beyond the scope of the current study.

TABLE I

SALMON

Year	Total Landed Weight in Study Region (lbs)	Landed Value in Study Region	Wholesale Value in Study Region
1971	59,155,700	$19,880,772	$43,737,700
1970	34,826,000	$10,142,100	$22,408,700
1969	32,475,500	$11,429,991	$23,830,400
1968	26,572,200	$ 6,777,937	$15,093,100

Average Landed Value of Salmon in study region over the 4-year period 1968-1971 is $12,057,700

Average Wholesale Value of Salmon in study region over the 4-year period 1968-1971 is $26,267,500

TABLE II

1970 FIGURES

Fish	Total Landed Weight in Study Region (lbs)	Landed Value in Study Region	Wholesale Value in Study Region
Herring	2,665,200	$ 90,770	$ 213,500
Halibut	403,100	$ 148,232	$ 196,300
Sole	1,377,200	$ 85,560	$ 209,200
Red & Rockcod	378,000	$ 21,922	$ 39,500
Ling Cod	2,552,400	$ 335,220	$ 576,100
Grey Cod	2,279,000	$ 187,502	$ 341,400
Black Cod	82,800	$ 18,648	$ 38,000
Non-Food Fish	667,100	$ 16,900	$ 33,800
Flounders	78,500	$ 3,555	$ 9,500
Skate	84,600	$ 4,257	$ 11,800
Perch	709,700	$ 35,955	$ 97,600
Octopus	51,100	$ 9,372	$ 18,700
Sturgeon	18,800	$ 5,170	$ 9,900
Shrimps	979,400	$ 268,814	$ 541,000
Clams	1,087,600	$ 86,480	$ 214,800

Fish	Total Landed Weight in Study Region (lbs)	Landed Value in Study Region	Wholesale Value in Study Region
Abalone	24,000	$ 10,080	$ 25,200
Crabs	984,300	$ 177,560	$ 357,300
Oysters *	80,058	$ 530,000	$ 590,000
Smelt	22,700	$ 4,935	$ 6,900
Eulachons	34,500	$ 4,360	$ 6,300
Other	9,400	$ 228	$ 500
All Fish Except Salmon		$2,045,520	$3,537,300

* Oysters reported in U.S. gallons

The wholesale market value of fish caught in the study region, also included in Tables I and II, reflects the value of the fishery products after they have been processed and are ready for distribution. For each specie the total market value for the various products was extracted from published data. From this, the average value added for each specie was determined and applied to the study region landed values to determine wholesale values. The value added for salmon was developed from an average of 1968 to 1971 statistics. For all other species 1970 statistics were used. For salmon the four year period is illustrated in an attempt to even out some of the cyclical fluctuation in salmon runs.

Of important note is the relative value of salmon to the study region. If the four year average salmon catch figure is compared to the total value of fish taken in this area (average salmon figure plus value of all other fish in 1970) the result indicates that salmon account for 85.5% of the total landed value.

The relative importance of salmon is further enhanced if the future potential for increased salmon production in the study area is considered. Table III indicates the actual and potential average landed values of commercial catches from Fraser River stocks. These potential values are more than purely hypothetical since the International Pacific Salmon Fisheries Commission has recently embarked on a 20 year program to attempt to realize them. In this context, potential values will enhance the current natural resource value of the study region - an exact measure of the current value of the potential is not attempted here, but the magnitude of this increase is indicated.

<u>TABLE III</u>

Summary of Actual and Potential Landed Values
of Commercial Catches from Fraser River Stocks

	Actual Average	Potential Average	
Sockeye	$10,428,000	$29,544,000	
Pinks	1,906,000	9,842,000	(1)
Chinooks	3,682,000	Not Known	
Coho	1,840,000	Not Known	
Chums	1,256,000	1,540,000	(1)
Steelhead	6,000	Not Known	
TOTAL	$19,118,000	$46,454,000	(2)

(1) Potential based on natural production, without artificial enhancement

(2) Where potential for species are unknown, actual average figures have been utilized to reach "Total Potential". In so doing, potential is understated.

Data taken from p. 38, "Fisheries Problems related to Moran Dam on the Fraser River", prepared by the technical staff of Canada Department of the Environment, Fisheries Service, and International Pacific Salmon Fisheries Commission, Vancouver, B.C. August, 1971.

Although it is not possible to predict exactly what proportion of the increased potential would be caught by Canadian fishermen, particularly as international negotiations may modify any estimate, it would appear reasonable to assume they would catch 50% of the total with American fishermen catching the balance. On an average year the Fraser River sockeye run will split with 85% coming through Juan de Fuca Strait and 15% coming through Johnstone Strait. Fraser River pinks will average 70% of their run through Juan de Fuca. It can be seen that the vast majority of the Canadian share of this increased run will be caught in the study regi^n. If one assumes that 75% of the Canadian share of the increase is caught in the study region, the average salmon catch figure would be increased by $10. 25 million in landed value and by approximately $22. 5 million in wholesale value.

In addition to the Fraser system improvements, an increase in the number of hatcheries in other areas could have some effect on the commercial salmon catch in the study area. The Fisheries Service of the Department of the Environment has recently announced that a series of five hatcheries will be built near the Strait of Georgia. However, benefits to the commercial fishery are not intended as the primary objective of the hatcheries program. The program is intended to increase the availability of chinook and coho salmon which are extremely popular as sports catch.

The Fisheries Service has estimated that a moderate sized hatchery of 20 ponds could be expected to increase the combined sport-commercial catch of coho and chinook salmon in the Strait of Georgia region by

51,000 and 14,400 respectively each year. Five such hatcheries could then increase the combined catch of coho and chinook by 225,000 and 72,000 respectively. Because these fish are intended to be resident or "inside" stocks it would appear reasonable to assume that up to half could be caught by sport fishermen. However, the increase to commercial catch is the relevant aspect for this section of the study. If half the increase is harvested by commercial fishermen, and a 1968 to 1971 average price for coho and springs is used, the increased annual landed commerical value would be $550,000 and $450,000 respectively or approximately $1,210,000 and $990,000 respectively in wholesale value.

Although the potential productivity of the Fraser River system and the hatcheries program are both dependent on investment in management and development, the size of this potential should be recognized. It should also be recognized that the current study region landed catch value, just in excess of $14 million dollars, and the corresponding wholesale value of just under $30 million dollars, represents a very conservative estimate of the sustainable catch level in this area, which may through time rise to an average annual landed value of $25 million and an average annual wholesale value of $54 million.

2. Waterfowl Hunting

Migratory waterfowl and shorebirds are numerous in the study region, and are particularly vulnerable to oil spills. A partial measure of their importance and value is the recreation they provide for hunters, and the dimensions of this activity are estimated in this section. Other recreation supported by these species includes non-consumptive activities such as bird-watching and photography and is discussed separately in conjunction with other non-consumptive forms of recreation in the study area.

a) Species Sought and Hunting Seasons

Hunting for migratory game birds is regulated by the federal and provincial governments. The species for which hunting was permitted in the study area during the 1971-72 season, the open seasons, and daily bag limits for each species are given in Table IV. Hunting for waterfowl is permitted in the study area over roughly 5 months (Oct. 9 - Mar. 10), although the majority of hunting takes place during the three month duck hunting season (Oct. 9 - Jan 9.).

b) Waterfowl Hunting Activity

During the 1970-71 season, the most recent for which data are available, there was a total of 62,000 active hunters resident in the Lower Mainland area and on Vancouver Island. Of these, 20,000 purchased the Canada migratory game bird hunting permit, making them eligible to hunt waterfowl. During the 1970-71 season it is estimated that 14,600 of these hunters actually hunted for ducks or geese on at least one day. These hunters spent a total of 105,000 days hunting waterfowl on Vancouver Island and the Lower Mainland, and killed approximately 136,500 ducks and 2,600 geese.

Not all of this hunting activity took place within the study region. Waterfowl are hunted to a limited

TABLE IV

Migratory Bird * Hunting Seasons and Daily Bag Limits, Study Area, 1971 - 1972

Species	Open Seasons: Vancouver Island	Open Seasons: Lower Mainland	Daily Bag Limits
Ducks	Oct. 9 - Jan. 9	Oct. 9 - Jan. 9	8
Snow Geese	Oct. 23 - Jan. 9	Oct. 9 - Dec. 5, & Feb. 5 - Mar. 10	5
Other Geese	Oct. 23 - Jan. 9	Oct. 9 - Jan. 9	5
Coots, Rails	Oct. 9 - Jan. 9	Oct. 9 - Jan. 9	8
Black Brant	Dec. 25 - Mar. 10	Dec. 4 - Mar. 10	4
Wilson's Snipe	Oct. 23 - Jan. 9	Oct. 9 - Jan. 9	10

* Doves and pigeons, migratory upland game birds, are not considered.

extent on northern Vancouver Island outside the study region, and on the southern Island and Mainland Coast waterfowl are hunted both in foreshore areas and inland fields. However, it is felt that from eighty to ninety-five percent of the hunting activity is supported by waterfowl which depend on the salt-water habitat of the study region. Thus, an estimated 84, 000 to 100, 000 hunter days were supported by waterfowl and other migratory birds depending on the habitat of the study region.

c) Hunters' Expenditures

The expenditures associated with hunting activity are discussed in three categories; license fees, payments to landowners, and general expenditures.

i) License Fees

Waterfowl hunters must purchase both the provincial hunting license, costing $4, and the migratory bird hunting permit, at a cost of $2. It is assumed, for simplicity, that the revenues from all migratory bird permits sold in the Lower Mainland and on Vancouver Island and the revenues from provincial hunting licenses sold to those who actually hunted waterfowl (14, 600) can be attributed to the waterfowl and migratory birds depending on the study area. This is a simplifying assumption which probably introduces a small upward bias into the estimate. However, since license revenues are not large in any case this error is not felt to be significant. On this basis the revenue from license fees is approximately $98, 000 annually.

ii) Payments to Landowners

In recent years it has become common for hunters in the lower mainland to pay landowners for the exclusive right to hunt on their lands. A recent report indicated that in 1969 approximately 25,000 acres of land in the Lower Mainland was controlled for hunting purposes by various clubs. Fees are not paid for hunting rights on all this land. In many cases the agreements between hunters and landowners simply call for a restriction on the number of hunters and protection of the property from abuse. In other cases the clubs consist of groups of landowners who have banded together to prevent the general public from hunting on their land. While the data relating to the amounts actually paid to the landowners were not complete, approximately $40,000 was paid to landowners for access fees in 1969.

Not all of this expenditure can be attributed to waterfowl hunting, however, as many clubs are interested in hunting pheasants and upland game and in some cases a signigicant part of the payment is made for habitat improvement and stocking of pheasants. It would appear that at the present time payments in the order of $30,000 per year are made for the rights to hunt waterfowl on private land in the Lower Mainland. No data are available on the extent of such payments on Vancouver Island, although they are probably small.

Despite the lack of good data on this subject, it is noted that some landowners do realize income from this source, a significant part of which is probably directly dependent on waterfowl using the study region. As competition for hunting space in the Lower Mainland and on Vancouver Island becomes more intense such payments can be expected to increase significantly.

iii) General Expenditures

By far the largest category of spending by hunters is for guns and ammunition, transportation, and other goods and services. Recent data on total expenditures by resident hunters indicate that residents of Vancouver Island spent an average of $18 per day on hunting, and residents of the Lower Mainland spent $26 per day during the 1970-71 season. These averages include all hunting activity for the season - both local outings and trips over long distances. The expenditures per day of waterfowl hunting supported by birds using the study region would be much lower, as this hunting would generally be undertaken by area residents on short outings. A more reasonable figure for such spending would be $9 per day. When this figure is used, the total expenditure for waterfowl hunting dependent on the study area is in the order of $756, 000 to $900, 000.

d) The Value of Hunting Activity

Aside from license fees paid to the provincial and federal governments, and such access fees as are paid to landowners, hunters do not pay directly for the opportunity to go hunting. Thus, unlike most resources or commodities, there are no established prices which indicate the value of the "product" consumed. There has been a considerable interest in the evaluation of outdoor recreation in recent years, and several studies have been undertaken which relate directly to British Columbia.

Two of these reports relate specifically to waterfowl hunting: Pearse Bowden (1971), dealing with hunters at Creston, estimate a value of $4.50 per day, while Hedlin Menzies (1967) adopted a value of $6.00 per day for waterfowl hunting on Boundary Bay. After reviewing the background of these reports, and considering the fact that much of the waterfowl hunting supported by birds dependent on the study region is presently not of high quality due to the difficult access and crowded conditions under which most hunting is now done, a value of $5.00 per day is suggested as being appropriate. On this basis the value of waterfowl hunting supported by birds dependent on the study region is from $420,000 to $500,000 annually.

e) Summary

The object of this section is to estimate the amount of hunting activity supported by waterfowl dependent on the salt water habitat of the study region. Although the data which are available do not relate precisely to the study region they permit approximations which should be sufficiently accurate for the study purposes. Roughly 14,600 hunters from Vancouver Island and the Lower Mainland hunted waterfowl during the 1970-71 season. It is estimated that birds depending on the salt-water habitat of the study area supported from 84,000 to 100,000 days of hunting by these hunters. License revenues to the federal and provincial governments from this hunting are estimated at $98,000, payments to landowners at $30,000, hunters' expenditures at between $756,000 and $900,000, and the value of the hunting experience to the hunters themselves at $420,000 to $500,000. Table V presents these data separately for Vancouver Island and the Lower Mainland.

These data relate to present levels of hunting activity, specifically the 1970-71 season. The level of

TABLE V

Waterfowl Hunting Data

	Vancouver Island	Lower Mainland
Days of Waterfowl Hunting	30,000	75,000
Total Number Birds Killed	44,000	92,000
Ducks	500	2,100
Hunter-days attributed to Study Area	24,000 - 28,500	60,000 - 71,250
Value of Hunting	$120,000 - $142,500	$300,000 - $356,250
Hunters' Expenditures	$216,000 - $256,500	$540,000 - $641,250
Payments to Landowners	N.A.	$30,000

License Revenues:	
Federal:	$40,000
Provincial:	$58,000

activity has probably remained fairly constant in recent years. The data can be applied to 1971-72 with little hesitation, and in the future years there is likely to be little, if any, increase. Programs to ensure public access to some hunting areas will be needed to offset habitat losses due to urban encroachment and the prohibition of hunting in other areas. For purposes of this study the data as presented can be accepted as sufficiently accurate for the analysis of both present and future hunting activity.

3. Pleasure Boating and Moorage

Based on available data and functional relationships of boat ownership with population and income, estimates have been derived for 1972.

a) Pleasure Boating

Much of the raw data used in this report have been taken from a survey completed for the Department of Public Works in 1966.

This report attempted to identify the numbers, kinds, and distribution of pleasure boats in the Strait of Georgia area, and also project these findings to 1976 and 1986. In addition to finding the number of boats in particular areas, the survey detailed information as to boat type, length, and number of boats licensed, and indicated that there were 60,900 pleasure boat-owning households in the study area. Of these approximately 57% have licensed craft. When taking into account the fact that many households own more than one boat, the total number of craft was calculated at

72,000 boats. Table VI and VII summarize some of the important results of the survey.

For predictive purposes or to update data from 1966 to the present, one would ideally like to take into account all of the following parameters:

i) Population growth;

ii) Changing population densities;

iii) Changing levels of disposable income;

iv) Changes in taste;

v) Changing technology.

However, the most useful and practical parameters for predictive purposes in this case are those of population growth and increases in disposable income. These factors form the basis of the estimates made in this study.

The population increase was thought to be the most stable predictive factor and forecasts of growth from 2 to 2.7 percent in various areas were used. Added to this factor was a prediction of growth in disposable income of 2 1/4 percent per year in constant dollars. Although boating expenditure is expected to increase at a rate combined from these two factors, the expenditure per boat will also likely increase. This would indicate that the increase in the absolute number of boats would be less than the increase in boating expenditures. This fact is incorporated in the present study.

TABLE VI

Boat Type	Percent
Sailboat	2.7%
Sailboat with auxiliary motor	3.8%
Outboard	50.3%
Inboard	11.2%
Hand operated and other	32.0%
TOTAL (60,900 boats)	100.0%

Source: N.D. Lea and Associates. Analysis of Recreational Boating in the Strait of Georgia Area - British Columbia

TABLE VII

Boats per 1000 population	53
Pleasure boats per pleasure boat owning household	1.18
Pleasure boat owning household per 1000 households	151.5

Estimated Number of Craft by Type in the Strait of Georgia *

Sailboats with motor	2,350
Sailboats	1,650
Outboard motor boats	30,600
Inboard motor boats	6,800
Other	30,500
	72,000

Source: N.D. Lea and Associates. Analysis of Recreational Boating in the Strait of Georgia Area - British Columbia, 1966.

* Takes into account the fact that if a household owns a second boat it is normally a small hand operated boat.

Table VIII estimates the number of boats at present in the areas indicated. For all major population centres a multi-year growth factor was reduced to a compound growth rate to update to 1972. For other areas a 5.3 percent growth factor was used which appears consistent with prediction rates in studies surveyed.

Points to be stressed from this table include the following:

i) The number of boats can be disaggregated by area;

ii) By using the distribution by type of boat illustrated in Table VI an approximation of the kinds of boats in the areas can be obtained.

iii) By using the factor 1.18 as described in Table VII the data can be expanded to include more of the small boats which were indicated by households owning more than one boat.

To determine the value of the pleasure boats in the study area, boats were subdivided by class groups to correspond with the distributional categories listed in Table VI. Several marinas in the Vancouver area were surveyed and market value information was obtained by interviewing boat owners. This was supplemented by information on average size class values obtained from local newspaper advertising for new and used boats. The results of this survey are presented in Table IX. These results are then combined with estimates of boats by class to determine the total value of boats in the study region. The final estimate of value of boats in the study region in 1972 is approximately $250 million dollars.

TABLE VIII - NUMBER OF BOATS

Area	1966 *	Compound Growth Rate Factor	Predicted 1972
Sooke	1,090	.053	1,486
Parksville	460	.053	627
Nanaimo	2,700	.051	3,639
Ladysmith	700	.053	954
Duncan	2,500	.053	3,408
Campbell River	1,070	.053	1,459
Comox	4,800	.054	6,581
Squamish	2,300	.053	3,135
Powell River	1,600	.055	2,206
Victoria	10,000	.054	13,710
Burrard Peninsula	22,700	.058	31,838
North Shore	4,100	.052	5,557
Fraser Valley	2,700	.053	3,681
South Shore	4,180	.046	5,475
TOTAL	60,900		83,755

* Source: N.D. Lea & Associates. Analysis of Recreational Boating in the Strait of Georgia Area - British Columbia

TABLE IX

1972

	Estimated Average Value	Estimated Total Number	Total Value
Sailboat	$ 728	2,261	$ 1,646,008
Sailboat with auxiliary motor	11,058	3,183	35,197,614
Outboard	1,786	42,129	75,242,394
Inboard	14,116	9,381	132,422,196
Hand operated and other	200	26,801	5,360,200
			$249,868,412

b) Moorage

The inventory process for moorage spaces is more straight forward than the updating of the 1966 boating survey. The Lea (1966) study completed a thorough inventory of moorage space in the study region in 1966. The Hedlin Menzies (1971) study updated this inventory to 1971 by surveying the areas Lea listed. The results are illustrated in Table X. When additions to facilities are considered or when a typical or average mooring space is considered it is assumed to be 30 feet long.

The moorage inventory as listed is one year old, but is considered accurate for that date. Any new construction of facilities within the last year would be fairly small and would not noticable affect the results.

The value of the listed mooring facilities is more difficult to calculate accurately. The How (1967) report estimated Department of Transport administered facilities at approximately 56, 500 feet with an estimated replacement cost of $9, 000, 000. For an average 30 foot moorage space this works out to approximately $4, 800 per berth. The Lea study estimated a minimum of $1000 per berth exclusive of land costs if the location is in protected waters. In more likely cases where consideration is given to land costs, breakwater costs, dredging, and berths the Lea estimate works out to $2660 per berth. If both of these estimates are inflated by 4 percent per year to bring them up to equality with 1972 dollars the estimates per berth come out to be $5840 (How) and $3366 (Lea).

TABLE X

Recreational Berthing Spaces in the Strait of Georgia, 1971

Area	Type *	Less than 20 ft.	20 - 40 ft.	More than 40 ft.	Area Total
Juan de Fuca Strait	A	65	4	-	
	B	-	18	-	
	C	-	65		
		65	87		152
Victoria - Esquimalt	A	363	237	40	
	B	-	166	3	
	C	-	469	-	
		363	872	43	1,278
Saanich Peninsula - Saltspring Island - Duncan - Lake Cowichan	A	626	1,001	100	
	B	77	304	25	
	C	-	100	-	
		703	1,405	125	2,233
Nanaimo - Ladysmith	A	312	197	38	
	B	1	167	-	
	C	-	100	-	
		313	464	38	815
Comox - Parksville	A	116	43	4	
	B	-	381	-	
	C	-	100	-	
		116	524	4	644
Campbell River Area	A	50	307	-	
	B	-	297	-	
	C	-	50	-	
		50	654		704

Area	Type *	Less than 20 ft.	20 - 40 ft.	More than 40 ft.	Area Total
Texada Island - West & Lasqueti Island	A	-	-	-	
	B	-	16	-	
	C	-	-		
			16		16
Powell River Area	A	207	96	10	
	B	1	227	-	
	C	-	25	-	
		208	348	10	566
Sechelt Area	A	-	-	-	
	B	1	63	-	
	C	-	130	-	
		1	193		194
Howe Sound	A	1,212	598	-	
	B	3	162	-	
	C	-	-	-	
		1,215	760		1,975
Burrard Inlet	A	722	990	163	
	B	2	336	23	
	C	-	-	-	
		724	1,326	186	2,236
South Vancouver - Richmond	A	425	338	22	
	B	1	111	-	
	C	-	1,000	-	
		426	1,449	22	1,897
Tsawwassen - White Rock	A	60	15	-	
	B	1	10	-	
	C	-	-	-	
		61	25		86
				Total (All Areas)	12,796

* Type: A - Pleasure; B - Combined Pleasure and Fishing; C - Additions, 1966 - 1971

The fairly large difference in these two estimates can be explained in that the How estimate was made for Department of Transport type structures. Many of these facilities are wharves and do not use the finger slip design which is used in most private marinas. This will have a tendency to reduce the number of berths and correspondingly increase the per berth cost. The Lea report was generally considering marina development costs based on the finger slip design. Both of these estimates have appropriate uses for estimating mooring facility replacement costs in the study area. Of the total 12, 796 mooring spaces listed in Table X, 10, 400 are assumed to be private and therefore primarily of the finger slip design and 2396 are assumed to be combination fishermen/pleasure berths and primarily of the Department of Transport type construction. The How estimate in 1972 dollars is then applied to 2396 berths indicating a total replacement cost of $13, 992, 640 and the Lea estimate in 1972 dollars is applied to the remaining 10, 400 berths indicating a total replacement cost of $35, 006, 400. The total replacement value for the entire study area would then be $49 million.

4. Commercial Fishing Vessels

This section determines the numbers, locations, and estimated values of commercial fishing boats in the oil spill study area. The Fisheries Service of the Department of the Environment is the basic source for all data presented below.

Because of the very nature of the fishing fleet it is difficult to keep information up to date. The fleet itself will change in size and investment over time. Furthermore, this change has recently been expedited and directed by the Fisheries Service. In late 1968, the Minister of the then Department of Fisheries introduced a License Control Program which is designed to reduce the number of fishing vessels, particularly in the salmon industry. The effects of this program can be seen by observing the total number of licensed boats from 1969 to 1971 as illustrated in Table XI. Complications can arise when one tries to identify the locations of these boats as the winter or home port locations may vary widely from where fishermen actually fish. This factor must be taken into account when one determines the costs of an oil spill at any particular time.

Table XI also indicates total vessel value for 1969-1971. A word of caution is in order concerning these and other value figures used here. These value estimates are estimates reported to the Fisheries Service by vessel owners. Even though the number of boats is being reduced, the investment in boats is reported to be increasing. This can be explained by any one or a combination of the following reasons. One, the average boat value could be larger because of increased replacement costs as prices in general are rising. Two, fishermen could be replacing present boats with more expensive boats within the confines of the License Control Program. Three, fishermen could be improving their boats by investing in more modern equipment, living accommodations and fittings. Four, fishermen could have a tendency to simply over-estimate the value of their own boats. Only the last reason would give rise to the belief that reported values should be adjusted downward for the purpose of this study.

There is some general feeling among individuals knowledgeable of the fishing industry that the reported

TABLE XI

	Licensed Boats	Value ($1,000)	Average Boat Value
1969	7,064	$ 97,026	$13,735
1970	6,767	100,363	14,831
1971	6,601	104,840	15,882

vessel values are indeed somewhat overstated. Work is currently in progress in the Fisheries Service in an attempt to correlate the reported values with certain aspects of the buy back arrangements of the License Control Program. It is hoped that some relationship can be predicted between reported values and market values when variables such as boat type, age, gear, license and other possible factors are taken into consideration.

At present, it is felt the reported values are appropriate for use in this study. No downward adjustment will be made until such an adjustment can be quantified by statistical means.

Table XII indicates the distribution of fishing vessels in various port areas. Approximately 85 percent of the boats are in the Vancouver, Victoria, and Nanaimo areas and from this it is estimated that 75% of the total boats are within the study region. If one uses the current reported value of the fleet, boat values of $44.7 million for the Vancouver Area, $14.9 million for the Victoria area, and $19 million for the Nanaimo Area are indicated. Thus, the study region contains approximately $78.6 million worth of commercial boats.

It should be noted that a small portion of these boats will be out of the water for winter repairs during off-season periods. Also, more detailed information concerning a break-down in values of boats by gear type in various areas is available. However, the fact that areas for these data do not match the study region indicates that pursuing this increased precision of measurement is not warranted.

TABLE XII

Distribution of Vessel Owners by Each Gear Type, In British Columbia, 1970

(Cross Percentages)

Vessel Gear Type	Vancouver	Victoria	Nanaimo	Prince Rupert	Totals
	%	%	%	%	%
Gillnet	73.7	0.3	9.5	16.5	100.0
Troll	26.5	33.4	31.3	8.8	100.0
Seine	78.1	-	15.6	6.3	100.0
Longline	41.2	-	-	58.8	100.0
Trawl	50.0	33.3	-	16.7	100.0
Other	50.0	41.7	-	8.3	100.0
Gillnet/Troll	57.6	6.6	21.4	14.4	100.0
Longline/Other	58.8	5.9	17.6	17.6	100.0
Other Combinations	47.9	12.3	17.0	22.8	100.0
All Gear Types	48.8	16.3	20.7	14.1	100.0

Lastly, for simulation of an oil spill during the fishing season it is recommended that the catch values for various fishing zones would be the most helpful data to determine how many boats would likely be damaged.

5. Log Booms and Storage

This section describes the value of log booms which may at any one time be exposed to the risk of an oil spill in the Strait of Georgia region. Table XIII summarizes the values of logs both at market and prior to reaching market. It should be noted that these figures represent an average of September and December 1971 stocks at the locations indicated. Although these figures are not a yearly average, the estimate is reasonably representative of average stocks for these locations. Stocks will be drawn down through late spring, and built up during the summer period. This fluctuation will be approximately 30 to 40 per cent from the low in late spring to its high in late summer.

Possible damages to log booms from an oil spill will vary depending on the type of logs in the boom, the type of oil spilled, and the time between the contamination and the processing of the logs. In any case, these possible losses would seldom be the total value of the logs, but would be the loss in value of the logs plus any extra costs of handling and processing them.

Crude oil, which is the major oil type under consideration in this study, would cause a relatively small amount of damage. Much of any possible damage would occur from penetration of the oil into the logs. Since

TABLE XIII

At Camp and In Transit	Volume (Mbm)	Value
Fraser River *	20,000	$ 1,372,500
Section A	3,100	220,000
B	31,000	1,950,000
C	32,850	2,103,500
D	8,700	630,000
E	12,200	838,000
F	46,100	3,769,000
	153,950	$10,883,000
At Market		
Howe Sound	231,800	$15,096,000
North Vancouver	10,080	749,200
Burrard Inlet	24,600	1,784,000
False Creek	9,100	665,000
Fraser River *	114,000	8,806,600
Victoria	41,100	3,107,000
Other Island Markets	183,500	14,395,000
	614,180	$44,602,800
TOTAL	768,130	$54,485,800

* Figures for Fraser River stocks include only those near mouth of River

crude oil has poor penetrating abilities it would not normally penetrate past the bark of most logs for quite some time.

Crude oil would not pose much of a problem for sawmill operations as thebark is removed before the logs are sawed. The bark is normally burned for fuel and in this case a small amount of oil would actually be a benefit to operations. If the ends are badly stained or if there is some penetration we would expect the processed lumber would be reduced in grade. This would affect mainly lumber, but could also affect plywood grade if penetration was deep. The type of production most sensitive to oil damages would be the production of pulp. It would take only a minor amount of penetration to make logs virtually useless for pulp production.

The fact that the logs boomed within the study area may have a very high value at any point in time is no basis for predicting the extent to which they are susceptible to damage from oil spills.

6. Recreation

Both available data and functional relationships have been used to develop the data in this section.

a) Boating

The primary source of boat usage data is a study completed for the Department of Public Works in 1966 by N. D. Lea & Associates. Table XIV was developed from that report and indicates average usage levels

TABLE XIV - USAGE OF LICENSED BOATS

	One Day Outings	Overnight Outings	Vacations	Total
Average Yearly Number of Days Spent on Outings, per Boat	21.96	12.86	15.06	49.88
Average Number of People in Party	3.26	3.41	3.65	3.41
Recreation Days per Boat	71.5	43.9	54.9	170.3

for licensed boats. A recreation day is defined as one person utilizing a boat for a part of one day. Multi-use, which is typical, results in an average of 3.41 recreation days per boat day. Although these figures are over six years old we have no reason to assume a noticeable change in boat usage patterns over this period of time.

Intuitively it might seem that an average of 170 recreation days per boat in a single year would be too large. In an attempt to verify the size of this estimate, data were compared with a study concerned with the Puget Sound region which was completed for the State of Washington in 1970. This study indicates that the average boat in the Puget Sound area accounts for 165 recreation days per year. Taking into account the differences between the two studies, the Puget Sound study still seems to corroborate the estimate of recreation days per boat for the Strait of Georgia region.

It is now possible to utilize these estimates of average boat usage along with data from Table VIII in Section 3 of this Appendix (Pleasure Boating and Moorage) to derive an estimate of total boating recreation days for the study region. Table XV summarizes and breaks down by area this total of 14.3 million boating recreation days per year. Note the areas indicated are of boat ownership, and it does not necessarily follow that the recreation days generally occur in that immediate area. In Table XVI boating is further categorized by activity in the study region. It should be mentioned that although the survey upon which this table is derived was conducted with individuals who lived in close proximity to the waters of Georgia Strait, the possibility

TABLE XV

Area	Predicted 1972 Boat Ownership	Boating Recreation Days
Sooke	1,486	253,100
Parksville	627	106,800
Nanaimo	3,639	619,700
Ladysmith	954	162,400
Duncan	3,408	580,400
Campbell River	1,459	248,500
Comox	6,581	1,120,700
Squamish	3,135	533,900
Powell River	2,206	375,700
Victoria	13,710	2,334,800
Burrard Peninsula	31,838	5,422,000
North Shore	5,557	946,400
Fraser Valley	3,681	626,900
South Shore	5,475	932,400
TOTAL	83,756	14,264,000

TABLE XVI

Activity	Estimated Boat Days, 1972	Estimated Boating Recreation Days, 1972
Cruising	1,213,000	4,136,000
Racing	12,500	43,000
Water Skiing	669,300	2,282,000
Fishing	2,058,000	7,018,000
Sailing	146,400	499,000
Other	79,500	271,000

exists that many of the respondents included boating activity which takes place on fresh water. (There is no way, however of making an adjustment for this factor with the data as presented in the report).

Data concerned with recreation days spent in Georgia Strait waters are not plentiful, and it is not possible to verify all aspects of the data which are summarized in Tables XIV through XVI. However, Table XVII indicates boat days and recreation days spent on salmon fishing in the study area. These figures are for 1970, the most recent made available to us, and were compiled by the Fisheries Service, Department of the Environment. When these figures are compared with data in the Lea report, a wide variance in the estimate of boat days spent fishing is apparent. Even if the Fisheries Service's salt water fishing figures (excluding salmon) were included and the Lea results were reduced to eliminate fresh water fishing by boat owners, the two data sources would still be widely divergent.

While it is not the intent of this study to investigate the reasons for these differences, the discrepancy has been discussed with personnel of the Fisheries Service. On the basis of these discussions, internal checks which the Fisheries Service have made on their estimates, and cross-checks with other data on sport fishing participation, it is concluded that a more appropriate estimate is in the order of 3,000,000 saltwater angler days.

TABLE XVII

Salmon Sport Catch and Effort by Area - 1970 [1]

	Total Fish Caught	Total Boat Days *	Total Recreation Days
Campbell River	43,325	37,900	94,750
Comox-Courtenay	82,100	49,575	123,938
Powell River	26,200	17,430	43,575
Pender Harbour	11,625	17,175	42,937
Nanaimo	31,650	25,275	63,188
Cowichan Bay	27,025	29,050	72,625
Saanich Inlet	42,875	29,650	74,125
Victoria-Sooke	23,325	30,500	76,250
Port Alberni	4,475	9,000	22,500
Vancouver-Howe Sound	50,350	69,700	174,250
	342,950	315,255	788,138

* Includes Efforts by both privately owned boats and rental boats; also includes fishermen days of effort from wharves, docks, shoreline fishing, etc.

1 Source: Salmon Sport Fishing Catch Statistics for the Tidal Waters of British Columbia, 1970 Fisheries Service, Pacific Region

b) Other Recreational Activities

Although boating is the most intensive recreational use of the waters of Georgia Strait, there are other activities relying on water access which should also be considered because of possible disruptions from an oil spill. The most applicable data for these uses was developed by the Lower Mainland Regional Planning Board in 1966. Table XVIII indicates the Board's results under the outings per person column with some refinement to indicate activity of a regional nature. Because of this regional nature of the estimates it would seem that estimates of use in the Georgia Strait region can be obtained by applying the 1966 use data to present population levels for communities in this region.

This has been done, with the estimated amount of recreation activity within the study region presented in the final column of Table XVIII. Note that estimates of waterfowl hunting activity are not mentioned here as they were dealt with earlier in this appendix.

c) Recreation Values

The problems in evaluating non-priced outdoor recreation were alluded to earlier in setting forth the appropriate methodology for assessing the cost of damages resulting from an oil spill study. No attempt is made to derive new or original measures of value in this study, as the purpose is to proceed with existing sources of data and information. Therefore, recreational values have been assigned, based on a review of work completed elsewhere and modified to be appropriate to the study region where modifications were judged to be necessary.

TABLE XVIII

Other Recreation Activities

Regional Activity	Outings per Person	Total Outings * 1972	Estimated Outings in Study Area, 1972
Swimming and Beach Activity	10.5	17,220,000	10,332,000
Strolling	6.0	9,840,000	1,180,000
Picnicking	3.75	6,150,000	1,230,000
Hiking	2.0	3,280,000	Negligible
Sightseeing	1.7	2,788,000	1,394,000
Nature Study	1.25	2,050,000	1,025,000

* By residents of Census Districts 4 and 5 (Vancouver Island and Lower Mainland).

Outings within the study area were estimated on the basis of personal judgement. It was felt that 60% of swimming and beach use would be within the study area, 12% of strolling, 20% of picnicking, a negligible amount of hiking, and 50% of sightseeing and nature study.

These values, estimated for the year 1972, are presented in Table XIX. For consistency in presenting all the recreational values at one point in the report, the estimated value of waterfowl hunting is incorporated in this table. The total value of recreation activity within the study area is estimated, for the year 1972, to be $122 million.

Finally, it should be noted that boating activity estimates are for Canadian residents only. It is known that a considerable number of American boats cruise in the waters of the study area, but no estimates of the amount of such activity are presently available and time constraints prevent the compilation of original estimates.

TABLE XIX

Estimated Value of Recreation Within the Study Area for 1972

Activity	Estimated Outings (1,000's)	Value per Outing	Total Value ($1,000)
Hunting	84 - 100	$5	$420 - $500
Boating	7,231	$5	$36,155
Fishing	3,000	$15	$45,000
Swimming and Beach Activity	10,332	$3	$30,996
Strolling	1,180	$1.5	$ 1,770
Picnicking	1,230	$1.5	$ 1,845
Hiking	Negligible	-	-
Sightseeing	1,374	$1.5	$ 2,091
Nature Study	1,025	$4	$ 4,100

TOTAL VALUE $122,377 - $122,457

APPENDIX B - PREVENTATIVE MEASURES

It is unrealistic to expect to prevent all oil spills from occurring. While the use of sophisticated technology can reduce the number of oil spills, it will not reduce the percentage caused by human error. As human error figures in over 90% of all oil spill incidents, we can therefore reduce the problem only to a level which is socially acceptable; we cannot eliminate it.

In attempting to specify oil spill preventative measures, it is how they perform rather than how they are designed which should be considered. In this way the desired level of safety can be required of a preventative system without restricting the development of its design. It should be a regulation philosophy that any preventative measure - human, mechanical, or electrical - be backed up by at least a second measure performing the same function which becomes operational should the first measure fail.

1. Performance Criteria for Spill Preventative Measures

Measures for the prevention of oil spills divide themselves naturally into three classes - those pertaining to: a) oil transportation; b) the transfer of oil from ship to shore; and c) oil storage on shore.

a) Oil Transportation

The first class of measures can be discussed in two parts, the performance of the vessel itself and of navigation aids.

Items related to vessel performance which are highly relevant to the avoidance of accidents and oil spills are:

i) Stopping distance - A vessel should be able to stop in a predictable distance and manner from any speed. The required stopping characteristics should be dictated by the navigational problems associated with the most restricted waterway which the vessel is expected to navigate.

ii) Manoeuvrability - As with stopping distance, manoeuvrability requirements (i.e., turning circle, response time to instructions for direction change) should be dictated by the characteristics of the most restricted waterway which the vessel is expected to navigate. A vessel should be able to avoid collisions with other vessels given the time constraints imposed by the vessel's speed and the nature of the waterway. While this requirement seems obvious, the number of collisions between vessels in good weather indicates that this capability does not generally exist (as, for example, in the recent collision between a freighter and a B.C. ferry at the entrance to Active Pass).

iii) The resistance to hull damage due to grounding, collision, explosion and fire - Since it is unrealistic to expect that no oil escape as a result of one of these calamities, it should be required that no more than a certain amount of cargo be capable of escaping as a function of the percentage of hull damage. For example, it could be required that, given damage to 40% of the bottom of the vessel, no more than 10% of the cargo be able to escape.

iv) Capability of navigational instrumentation - A vessel must be able to communicate with other ships and shore facilities under any weather conditions. In an age when taxicabs can communicate by radio, it is ridiculous that huge ships of the sea must rely on lights and whistles to talk to each other. It must also be possible to identify any navigation hazards with sufficient accuracy to avoid danger given the vessel's speed and manoeuvrability and the nature of the waterway.

v) On-board facilities to prevent the discharge of oily waste into the sea and to contain and collect accidental spills.

vi) On-board facilities for the removal of oil should the vessel be sunk.

Navigation aids and regulations must reduce the danger of collision or grounding to a socially acceptable level for vessels of significant size (i.e., probably excluding pleasure and small fishing craft). To this end, they should define definite and compulsory rules of the road for all vessels to reduce the collision danger, and should identify fixed hazards to reduce the incidence of groundings. Their operation must not be impaired by poor weather, and should enhance the reliability and usefulness of navigation equipment on-board the vessels using the waterway. A certain minimum capability in navigational aids should be required of all ships. If any ship lacks this capability, it should be reported to the pilot authority before the ship reaches territorial waters so that appropriate measures can be taken to ensure the ship's safety. Any ship not reporting below minimum capability should be subject to the same penalties it would incur if it were involved in a pollution incident.

b) Transfer of Oil from Ship to Shore

Spill preventative measures pertaining to the transfer of oil from vessel to shore tank must regulate the performance and operational procedures of the transfer system. They must ensure that any system malfunction i) is detected immediately by the operators; ii) will not cause a rupture to occur; and iii) will automatically result in a safe shut-down of operations.

c) Oil Storage on Shore

With respect to the storage of oil in shore tanks, measures to prevent spills must i) warn of potential tank overflows or ruptures; and ii) provide for containment of any oil escaping from a tank.

2. What Canada Can Do Alone To Implement Performance Criteria

Without the cooperation of the U.S.A., Canada can do nothing to regulate the operation of tankers bringing crude oil from Alaska to Cherry Point since at no time need these ships enter Canadian waters and thus become subject to Canadian regulations (unless Haro Strait becomes part of the tanker route). While it is not a matter which should cause much concern, she can also do nothing to ensure that transfer operations or storage are carried out safely. Canada must rely on the benevolence of the U.S. governments and the significant concern of the American people for the implementation of adequate performance criteria in these cases.

There is much more that can be done by Canada to ensure the safe transport of oil and oil products in her own waters. The 1971 amendments to the Canada Shipping Act empower the Canadian government to make regulations concerning a wide range of items associated with the pollution hazards of shipping. Such regulations can define pollutants, govern their handling and storage, dictate the capability of on-board navigation equipment, and control the movement of ships in Canadian waters. The act also defines the extent to which the ship and cargo owners are liable for damage and clean-up expenses associated with a pollution incident, and establishes the Marine Pollution Claims Fund. This fund is financed by a tax on imported and exported oil and oil products and pays any claims resulting from a spill which cannot be recovered directly from the owner(s) of the ship or cargo. The regulations implementing the fund came into effect on February 15, 1972, but regulations concerning the navigation and safety equipment of the ships are still forthcoming.

The extent to which this act will in fact militate against pollution damage from oil spills is debatable. It likely goes as far as is possible on a national scale to reduce the incidence of accidents and to provide for compensation for damage and costs of clean-up, but does not approach the problems associated with the first three performance criteria outlined above - ship stopping distance, manoeuvrability, and resistance to hull damage. The fact of the matter is that because of human error, ships will get into trouble. It is certainly not too much to expect that they should be reasonably able to extricate themselves from this trouble. Moreover, should a ship be involved in an accident, its design should be such that the danger of cargo escaping is low. Neither of these capabilities exist in the majority of the world's shipping to any significant extent. They are especially lacking in large oil tankers - vessels which are by far the largest ships afloat. The problem of establishing criteria for these capabilities is one of international agreement. No country can attempt to regulate these criteria on its own without accepting a serious reduction in the number of ships coming to and going from its ports. Therefore, while the act provides for adequate preparedness and compensation to society for oil spills, it will likely not reduce the incidence of spills to an acceptable level.

There are, at present, no regulations in Canada to define performance criteria for the transfer and storage of oil and oil products. The legislation does exist in the Water and Fisheries Acts for the establishment of such regulations.

3. What Canada Can Do in Cooperation with the U.S.A. to Implement Performance Criteria

The situation in which Canada would be should she attempt to regulate too severely the performance characteristics of the ships themselves would not be changed markedly with the added cooperation of the U.S.A.

With respect to navigation aids, the very minimum which should occur is the establishment of a traffic separation scheme in the entire inland waterway. Such a scheme would delineate one-way lanes to and from the sea, provide for traffic routing where lanes intersect, and perhaps make some of the channels through the Gulf and San Juan Islands one-way passages only. It might also be possible to establish "express" lanes for the use of very large ships such as the tankers bound for Cherry Point and the bulk carriers leaving Roberts Bank. These lanes could be effective in allowing these cumbersome ships an unobstructed route to and from port and thus reduce the likelihood of their being involved in an accident.

The most effective preventative measure which could result from Canada - U.S. cooperation is a comprehensive traffic management system for the Strait of Juan de Fuca and Strait of Georgia. From one management centre, such a system would continuously monitor all ship-to-ship and ship-to-shore communications as well as all vessel locations as determined by shore-based equipment. Based on a continuous analysis of this information, it would issue either advice or direct orders to vessels in the management area with respect to their route and speed. Whether or not it would act in an advisory or control role must be decided on the basis of which role is the more effective in preventing accidents. Participation in the management system would be made compulsory for all vessels in the management area.

The U.S. Coast Guard is in the preliminary stages of developing a system of traffic routing and surveillance in the eastern Strait of Juan de Fuca and Puget Sound which could provide for compulsory one-way traffic lanes and one-way passage through Rosario Strait. This system is largely being developed to implement the Vessel Bridge-to-Bridge Radiotelephone Act enacted by the U.S.A. in August 1971. That act requires that every significant vessel in the navigable waters of the U.S.A. have and use the capability for vessel-to-vessel communication on a specified frequency. A similar system, which also incorporates surveillance radar, is being considered by the Canadian Ministry of Transport which would cover the Strait of Juan de Fuca and the Strait of Georgia. While the two surveillance systems would no doubt operate in close cooperation, it is obvious that a greater degree of safety and efficiency would result if they were merged. There is presently no requirement in Canada similar to the U.S. Vessel Bridge-to-Bridge Radiotelephone Act.

4. What Performance Criteria Require International Agreement for their Implementation

International accord is required to realistically attempt to solve any matters concerning ship design and the capability of navigation equipment. Alternatively, it could be possible to establish and enforce these performance criteria via the companies which underwrite shipping insurance, but this method would require international agreement among the underwriters of different countries to be effective. Because the implementation of such criteria require international agreement, it is recommended that Canada lobby vigorously for international discussions to take place on the condition and operating characteristics of the planet's shipping.

5. Costs of Preventative Measures

The costs associated with upgrading the design and operating characteristics of tankers to reflect more stringent performance criteria cannot be estimated given the constraints of this study. Two considerations conspire to make this estimation difficult, the first being that it would be necessary to look at the problem on a global scale since the costs would be spread over many nations. The second and perhaps more important consideration is that such a long period of time would be involved in the upgrading process that present day estimates of costs can easily become outdated with changes in the technology of ship design.

The costs of improving navigational aids in the study area are rather easier to estimate. The U.S. Coast Guard is spending $500,000 to set up the radio surveillance system described above, and the system being considered by Canada is estimated to cost about $1,500,000. The operating expenses of the two systems would likely be about $200,000 per year each. Thus, a combined traffic management system incorporating both radio and shore-based radar surveillance and covering the Strait of Juan de Fuca, Puget Sound, and the Strait of Georgia would cost at least $3,000,000. Its yearly operating expenses would be about $400,000.

In comparison, the total cost of cleaning up Chedabucto Bay after the grounding of the Arrow (a ship of about one-fifth the size of the tankers expected at Cherry Point) was approximately $3,100,000, and even after the expenditure of this large sum much of the oil remained on the shores of the bay. Also, this figure does not include some of the penalties which may arise from taking people away from their normal activities for several months. It is not possible to put a dollar cost on such penalties, but they are real and must be borne by the entire country.

6. Oil Spill Preventative Measures

In this section are outlined some suggested means of achieving the performance criteria for oil spill prevention discussed in the preceding parts of this appendix. As before, the discussion is divided by the class of measures: those pertaining to a) oil transportation; b) oil transfer; and c) oil storage.

a) Oil Transportation Measures

The following is a list of features which ought to be taken into consideration when designing vessels to meet performance criteria for the marine transportation of oil:

i) Communications - In addition to the usual lights, horns and whistles, each ship should be equipped with the appropriate radiotelephone equipment to permit reliable ship-to-ship and ship-to-shore communication on specified frequencies. Every attempt should be made to secure international convention on the type and frequency of communication employed. Equipment of the VHF-FM type appears to be the most widely recommended.

ii) Navigation Equipment - Equipment to aid navigation is available to suit a wide range of accuracy needs. Apart from the usual equipment such as compasses, depth sounders and radar, there are also loran, automatic steering gyrocompasses, speed log indicators, and multiple radar units on the market. For very accurate inshore navigation purposes, Decca and satellite navigators are available though these must be used in conjunction with shore-based equipment and satellites respectively. A Decca navigation system for the study area has been estimated to cost about $6,000,000 by the Canadian MOT. Several new collision avoidance systems are now on the market which use digital computers to process and display radar data. Most of the systems have the capability of plotting the vectors of moving targets and entering trial manoeuvers to determine the proper ship course to avoid collision. Redundancy is extremely important in navigation equipment, especially in the basic tools such as gyrocompasses and radar.

iii) Stopping Ability and Manoeuverability - Numerous gimmicks are available which are supposed to improve the operating characteristics of large ships, but they are all but useless in anything but docking manoeuvers. The only way to significantly improve the operating characteristics of very large ships is to install much bigger power plants in them. Since this method requires much more expense in engines and the carrying of a greater amount of fuel, it naturally affects the economic viability of these ships severely. On the other hand, a case could be made that the only reason that supertankers are economically viable is because society at large accepts much of the costs involved in their running afoul.

iv) Internal Design Features - The sizes of the tanks can be reduced to minimize the volume of oil which could escape should the hull be breached. Double bottoms can be installed, especially towards the bow, to reduce the hazards of hull damage due to grounding (this feature also protects the pipes, pumps and valves located in the hull from fouling by sediments in the oil). The use of the load-on-top system of handling oily tank washings should be made compulsory. Such washings, along with oily ballast, would be discharged into tanks at the loading terminal. Any vessel arriving with clean tanks and no washings should be investigated. It is possible to leave some outside tanks empty both to reduce the chances of a full tank being breached in a collision, and to receive tank washings. There are loading calculators available to indicate when stresses in the ship's hull become potentially dangerous during loading, unloading, or when under way. Equipment to adjust the vessel's trim and eliminate dangerous stresses is also available. Elaborate fire and explosion preventative measures ought to be compulsory. Internationally standard valves and couplings can be installed on the deck so that oil can be removed should the vessel be sunk.

v) On-Board Spill Handling Equipment - A small tender could be carried which would be launched as required. It could carry booms, absorbents and skimming devices. It could also act as an escort vessel in narrow channels.

vi) Crew Training - Since over 90% of all accidents can be attributed in large measure to human error, it is obvious that the crews of tankers are not adequately able to carry out the duties assigned them. Crew members should be carefully trained in the operation of and safety rules pertaining to the equipment which they use, and should have thorough emergency training. This training should be annually updated and reinforced with refresher courses. A school has been established in Grenoble, France, for the training of captains of very large vessels. To this school or one like it, should be sent all personnel who could conceivably be in charge of one of these ships as well as all pilots who are expected to advise on their passage through restricted waterways.

With respect to navigational aids, the most important consideration is the design of a traffic management scheme for the study area. It must involve a traffic separation system and be independent of international boundaries. Narrow channels can be controlled one-way lanes. Where lanes intersect, a roundabout or traffic circle system can be used to reduce the possibilities of collision.

The surveillance part of a management scheme should be jointly run by Canada and the U.S.A. In addition to the basic features outlined previously, it should be tied directly into contingency plans so that any accident can be immediately investigated and salvage and clean-up operations can be instantly mobilized to minimize possible environmental contamination.

b) Oil Transfer Measures

In any transfer operation, there should be one transfer operation centre to which information on the status of the entire transfer system is automatically relayed. It should be possible to automatically monitor, issue alarms for, and shut down any part of the system. The pressure and flow rate in all pipes, valves and couplings, and the levels of all tanks (ship and shore) can be subject to such control. A barrier boom can encircle any vessel from the moment it docks until just prior to its departure. All valves should permit both power and manual operation. Transfer equipment can be designed to allow for differential movement of the vessel with respect to the pier, for quick release without spillage in the event of an emergency, and for complete drainage of all oil in the lines after transfer operations have been completed and before the line is disconnected.

The execution of a detailed checklist of items which must be inspected for safety and readiness to begin pumping operations, such as valve closings and the security of all fittings, should be mandatory. The checklist should also control the sequence of starting and stopping pumping in order to avoid overloading any transfer equipment. While one would think that these procedures are standard practice, in fact they are not. It would also be advisable for the major transfer operations to be monitored by a member of an oil spill contingency agency.

c) Oil Storage Measures

Tanks should be dyked to contain the contents from a ruptured or over-filled tank. The capacity of a dyked area should at least equal the total capacity of all tanks within the area. It should not be possible for liquid to seep under the dyke. Tanks can be fitted with controls which automatically shut off inlet valves should the level in the tank get too high, and outlet valves should the the line pressure become too great.

APPENDIX C - CONTINGENCY PLANNING

Although contingency planning is one of the most relevant aspects of marine oil pollution preparedness, our terms of reference precluded any detailed discussion of it. As the scope of this study places greater emphasis upon the economic, social and aesthetic impacts of oil spills, contingency planning has been relegated a minor role and therefore included in this appendix form.

For the same reason, detailed references to specific agencies and site locations are also avoided. Because some costing of contingency planning was required to give a comprehensive perspective of the economics of oil spills, we have included an order of magnitude estimate. However, for each of the figures arrived at, we added sufficient qualification to indicate their generality.

Inevitably, through literature reviews, contacts, and field experiences, we discovered the degree to which contingency planning was actually being carried out in the study region, and consequently realized what contingency options were realistically feasible. Although this information does not form a part of this report, it is available should future reference to it be required.

We have assessed documents concerning action taken on past oil spills caused by damaged vessels (Arrow and Torrey Canyon) and offshore drilling rigs (Santa Barbara). While this review has provided valuable information, in many cases the data were not pertinent to the lower B.C. coast. For example, in the Torrey Canyon case, chemicals were used to disperse the oil, a practice not tolerated in most Canadian waters as many dispersants are toxic to marine life. Experience gleaned from the Arrow incident is perhaps the most applicable to the B.C. area as it occurred in cold waters which are similar to B.C.'s and the agencies involved in that spill would likely be deployed in a west coast one.

We also supplemented the information retrieved from the literature with field trips to actual petroleum product spills on this coast, as referred to in the introduction.

1. Contingency Force Mobilization

From both our literature review and field experiences we have observed that rapid systematic deployment of equipment and personnel is of utmost importance in mobilizing combatant forces. In all cases, it was ascertained that an oil spill must be hit hard and fast if it is to be contained.

The B.C. Forest Service, an agency which has long been involved with emergency situations, maintains that to effectively combat forest fires they must "hit hard and fast" also. In other words, all fires are treated as potential major conflagrations. Consequently, the equipment necessary to contain a large fire is mobilized immediately. If the forest fire is contained before it develops into major proportions and the large force mobilized is not required, the cost of the "over-reaction" can be regarded as inexpensive insurance when compared to the astronomical damage and expenses which could have occurred if the fire had become large.

In this respect, oil spills are very similar to forest fires. In both cases there is an exponential increase in adverse effects and costs as the spill or fire becomes larger. It is obvious, therefore, that all components of an oil spill contingency plan must be geared for quick action within short notice. The following deployment schedule could be adopted to ensure that this quick action is taken (Refer to Table XX).

a) Alert

An initial critical time response could be established similar to the B.C. Forest Service 10 o'clock forest fire concept which directs initial attack forces to control a forest fire by 10:00 a.m. the day after it is detected. A similar concept could be adopted in hazardous materials spill contingency plans with the object of controlling small to medium spills within 24 hours after detection. As early oil spill detection is critical if this concept is to be adhered to, airborne units and patrol boats could be used to ensure that tanker traffic is closely monitored at all times. Spot inspections of tankers could be carried out to check that they are properly equipped and maintained.

TABLE XX

CONTINGENCY FORCE MOBILIZATION

ACTION	SECTIONS MOBILIZED	
	OPERATIONS	SERVICES
Alert	(a) Detection	
Initial Response	(a) Reconnaissance and Classification (b) Suppression Force	
Major Response (Large Oil Spill)	(a) Containment (b) Floating Oil Clearance (c) Debunkering Salvage (d) Beach Clearance (e) Disposal	(a) Communications (b) Scientific Sector (i) Environmental (Physical - Oceanography & Meteorology) (ii) Environmental (Biological and Assessment of Damages) (iii) Oil Characteristics (iv) Clean-up Technology (c) Administration (i) Contracts, Legalities, Finances (ii) Manpower, Accommodation, and

ACTION	SECTIONS MOBILIZED	
	OPERATIONS	SERVICES
		Catering Services (iii) Purchasing (iv) Damage Assessment - Human Values (d) Logistics and Transportation (e) Documentation and Public Relations (f) Library and Outside Advisors
Post-Clean-Up	(a) Demobilization (b) Post-Clean-Up Surveillance (c) Rehabilitation	

b) Initial Response

Upon receipt of an oil spill report, the agency responsible for hazardous material clean-up would immediately put all support agencies on alert. Many departments of the federal, provincial, municipal and industrial sectors would be involved. The responsibilities of each department should be established well beforehand in a master contingency plan. Since a large spill could easily involve both Canadian and American response, it would be important at this point to establish a continuous reporting schedule informing each country what procedures were being followed on each side of the border so that subsequent decisions and actions could complement each other.

Initial action would then commence. Hovercraft equipped with a small laboratory could be despatched to take samples, conduct reconnaissance and deploy booms carried on the tankers. An aircraft with a trained On-Scene-Coordinator would fly the area and classify the spill, using criteria such as spill size and oil type. This officer would report his findings and suggest action to be taken. A full complement of oil spill clean-up would then be brought to full alert if the spill warranted such action.

c) Major Response

Cargo planes loaded with peat moss would commence bombing the spill following the On-Scene-Coordinator's directions. Bombing operations would take place at the periphery of the spill, with peat moss bales designed to burst upon impact. Tugs with booms, skimmers, slick-lickers and barges loaded with peat moss would set sail to the scene with salvage and oil recovery equipment. A large naval vessel would be despatched from Esquimalt loaded with landing craft and launches to be used for later shoreline clean-up. Canadian forces would begin troop mobilization and setting up camp at a field command site close to the oil spill area. Concurrently, the oil spill task force would be meeting to decide detailed plans of action based on field reports and facts presented by local specialists such as oceanographers, meteorologists, biologists and geomorphologists. The following are examples of subjects which would be under consideration:

i) Priorities of shoreline protection and clean-up;
ii) Public involvement;
iii) Equipment requirements and availability;
iv) Procedures for releasing information to the public;
v) Biological and physical shoreline control sampling requirements.

Within the first 24 hours, the following would occur:

- The spill would be surrounded by booms, conditions permitting. In most instances, however, ocean and weather conditions would dictate that the booms be positioned in V-configurations in an effort to deflect the slick to slick-lickers or skimmers situated in the apex of the V.
- A series of short booms would be deployed along the shoreline by small tugs to intercept some of the oil-soaked peat. Any oil escaping under these booms could be bombed with peat moss.
- Additional peat moss would be applied to the slick by aircraft during daylight hours or by vessels

during the night.

- Collecting barges would be located near the spill site to take on oil-soaked peat moss, fish boats might be used to net floating peat moss in seine nets, and a laundromat could be established to clean the nets at a later date.
- Helicopters would be positioned, especially in large tidal flats areas, to transport people to the tideline and to pick up oil-soaked peat moss when it washed ashore.
- Reconnaissance would identify areas which would be contaminated first. Critical sections such as marinas and estuaries would also be pinpointed.
- Detailed reconnaissance would continue to establish areas of shoreline where heavy equipment could not work due to soft conditions.
- Biological and physical sampling stations would be established for monitoring baseline information throughout the duration of the spill.
- Oil containment booms would be located around critical areas. Pneumatic booms would be placed around wharf facilities so that boats could still utilize the docks, but floating oil containment booms would also be positioned nearby as a back-up measure if the facility were threatened by a heavy slick.
- The availability of equipment would be noted and additional supplies (clothing, gloves and peat moss) would be rechecked and reordered.
- Caterpillar tractors could construct roads to the shorelines where necessary and possible. Crews with chain saws would buck some of the driftwood logs on beaches while caterpillar tractors would lift

the logs to higher ground to facilitate later beach clean-up.

- Road access routes to the spill area would be cordoned off and parking lots would be designated for public use. Transportation could be provided to enable volunteers to be moved to the shoreline, and procedures to systematically utilize these people for clean-up might be initiated by the Environmental Committee of the B.C. Petroleum Association.
- The large naval vessel at the spill site could act as a marine oil recovery headquarters to coordinate marine clean-up efforts. An equipment marshalling area complete with maintenance facilities and fuel dumps could also be established with a weather ship as its floating headquarters.
- The armed forces would establish a field headquarters and communication centre. At least two radio frequencies should be used by them - a short range FM one for field crews, and a long range FM or AM frequency for units outside the immediate spill area. All vessels and vehicles not on these frequencies could be provided with short wave FM portables. A citizens' band switchboard might also be used to facilitate the use of private vehicles, as would a telephone switchboard to monitor equipment with radio telephones.
- Command posts would be erected at strategic locations along the shore, as would kitchen, sanitation and first-aid facilities, bird de-oiling stations and absorbent material stockpiles.
- Heliports would be designated at the command posts, absorbent material stockpiles, and disposal sites.
- The disposal sites would be located and routes to them from the shoreline would be cordoned off. A wharf would be designated where barges with oil-soaked peat moss could be unloaded.

- News releases would be given every hour to inform the public on the progress of the spill and clean-up activities, and to clearly indicate how the public could assist in clean-up operations.

. . . . . .

Although activating these procedures within a 24 hour concept would be difficult in the case of spills in remote areas, gearing contingency plans to this policy would mean that a realistic possibility would exist of having all equipment and personnel in position before oil from a large offshore spill hit the intertidal zone and beaches.

2. Financing a Contingency Package

An exact cost estimate of contingency plans is outside the terms of reference of this study because of such undefined variables as government departmental responsibilities, degree of preparedness desired, and whether some of the men and equipment might also be on standby for other purposes as well. We have therefore attempted to indicate only the major areas of expense as follows.

a) Administrative Expenses

We estimate that ten full-time personnel would be engaged in such duties as liaison with participating oil companies and various levels of government, plus clean-up research and clean-up training and practice.

Assuming a monthly wage of $1200 (with no additional remuneration for overtime), an annual expenditure of $144,000 would be required. Assuming that office overhead would cost a minimum of $50,000, total annual administration expenses would be approximately $200,000.

b) Oil Spill Equipment Acquisition Costs

The capital cost of equipment which is unique to oil spill clean-up, including the value of special frequency portable radios which cannot be obtained quickly, is developed for both scenarios in Chapter VI. These figures show where it would be advantageous to purchase equipment outright. For example, in the Boundary Bay scenario, the cost of renting hand tools is three times as great as outright acquisition. It must be noted that capital costs indicate the value of units only and do not include attendant maintenance and storage costs. The rental rates do, however, take these other costs into consideration.

Both capital and replacement costs are shown for peat moss to encompass the option of either purchasing the material prior to the spill or at the time of the spill. In both cases the cost of transporting the material is not represented in the figures given. As noted in both scenarios, a capital expenditure of $2.5 to $4.0 million could be involved in acquiring oil containment booms, slick-lickers, skimmers, peat moss and portable radios.

Although it appears that a number of government agencies plus some private companies already have a substantial quantity of equipment which could be used in oil spill clean-ups, it is likely that much of it could not be mobilized quickly enough in the event of a major spill. The alternatives to this situation are either to set us the channels whereby that equipment can be made readily available, or to purchase some equipment ahead of time and keep it on standby. We recognize that the latter option is extremely costly compared to the first and therefore recommend that the former be acted upon. No costs are included for either option.

c) Materials Replacement Costs

The costs under this heading would be for those supplies which would need replacing after every major oil spill. For example, substantial peat moss stockpiles would have to be replaced. This material may not have to be purchased prior to a spill if arrangements are made for peat moss distributors to maintain certain quantities of absorbents at their warehouses. However, with this system an unacceptable time delay of several hours may result before peat moss can be transported to airfields and docks. This time delay may prove critical when flying weather is deteriorating such that peat moss may not be applied to the slick by air in time to avoid foul weather. A more practical solution might be to purchase peat moss and stockpile it at key airports and marine facilities.

Certain hand tools such as rakes and shovels which are susceptible to being broken or lost, and also clothing, would have to be replaced after each spill. According to the scenarios outlined in Chapter VI, these costs might be from $500,000 to $1,000,000 for a large spill.

APPENDIX D - CLEAN-UP METHODS

The recent public concern with the problem of oil pollution on land and water has stimulated a broad and intensive research effort on the practical problem of combatting pollution created by oil spills. A bewildering number of solutions have been presented: some are practical, some are simply zany; some methods have been marketed, others exist only on paper.

The following summary of clean-up methods is a condensation of those reviewed in available literature. We have given consideration to major categories of techniques rather than to discussion of the relative merits of specific methods. It has been quite difficult to evaluate the efficiency of many of the methods in the literature since few have been tested in operational situations, and if they have, there is little documentation presented on their success or failure.

We suggest that agencies directly involved with the treatment of oil pollution should maintain current files on new anti-oil pollution technology. During the course of our study, new literature arrived almost daily, changing and improving our understanding of the practical technology for cleaning up oil spills.

We were obliged to understand the behaviour of oil on water and on various types of shorelines before we were able to discuss clean-up methods. Our summary is presented in the sequence that we came to understand the problem.

1. THE BEHAVIOUR OF OIL

There is a wide variety of liquid petroleum products that, when spilled on water, have been termed "oil spills" by the media. The behaviour of each is obviously quite different depending on volume, density, viscosity, volatility, and chemical composition. There are, however, some rather obvious general characteristics which are common:

(i) Oil usually floats on water but in some cases may sink in lens or droplet form if it is dense enough.

(ii) The layer of spilled oil will be thickest at the source of the spill and thinnest at the perimeter.

(iii) Oil slicks gradually spread over a wider surface area in time unless contained by artificial or or natural barriers.

(iv) Crude and bunker oils emulsify reasonably rapidly forming very stable water-in-oil emulsions.

(v) Oil degrades: lighter fractions evaporate; all fractions will slowly oxidize; organisms can metabolize some of the hydrocarbons in the original liquid or in various stages of decomposition.

The behaviour of water borne oil spills when they are carried on to the shoreline by wind, tide or current depends on the configuration, slope and composition of the shoreline. The behaviour of heavy oils generally exhibits the following characteristics:

(i) Wind, wave and tidal action tend to concentrate the oil at the high water mark of the shoreline.

(ii) Oil will coat the surface of rocks in the intertidal zone. It will penetrate cracks, fissures and interstices; the depth of penetration will increase with high ambient temperature and with energy expended on the shoreline by water and tide action.

(iii) Oil deposited on cobble beaches will tend to stabilize the movement of beach material.

(iv) Oil which is deposited on sandy beaches will divide and become covered with a surface layer of sand. These nodules act as discrete particles but can be broken up by the mechanical action of tide and waves. In sand beach exposed to surf action, the oil will become "mixed" with the beach material to greater depths than in sheltered beaches.

(v) Oil which has been deposited on sandy beaches may form an impervious layer at varying depths below the sand surface. Percolating water will flow along the surface of this impervious layer, causing erosion of the upper beach layer.

2. Clean-Up Methods on Water

There are a number of mechanical devices which can be used to remove oil from the water. Their effectiveness depends upon the thickness of the oil slick and weather conditions. Another method of treatment is by the application of chemicals to break up the oil slick into globules which, because of a great increase in surface area, can be more easily degraded by natural processes. Finally, oil spills can be sunk or in some cases burned. A brief description of each of these methods is presented below.

a) Mechanical Methods

The first and most effective method of cleaning water borne oil spills is to pump oil directly from the source of pollution and transport it to shore. This is frequently possible in the case of stricken tankers, weather conditions permitting. Collapsible containers have been developed which can be quickly transported to the site of the accident, filled with oil, and towed to safety.

A variety of mechanical devices, variously termed "skimmers" and "slick-lickers" have been developed to remove oil films from the surface of the water. The devices known as skimmers simply collect the surface layer of oil and water and transfer it to tanks where the oil-water mixture undergoes gravity separation. Slick-lickers incorporate a conveyor belt principle where the belt itself is an oleophilic material which attracts oil but will not conduct water into the container holds of the floating craft. A number of variations on this principle have been designed and attached to barges that are towed to the site of an oil spill. The main problem of collecting oil films with skimmers or slick-lickers is that their actual intake areas are relatively small. Where oil spills are thin and dispersed over a wide area, a means of concentrating the oil is necessary for efficient recovery. A number of booms have been developed for this purpose.

Booms usually consist of a floatation chamber with a skirt below the water and an above-water barrier to contain the oil. Most booms will not contain oil in currents that exceed two knots, as above this speed the surface layer of water and oil starts to pass under the skirt and re-emerge behind the boom. This fact limits the use of stationary, anchored booms to the protection of waters with very low velocity currents. Free-floating booms can be manipulated into position with tugs to contain oil spills or they can be towed in a V-shape with a skimmer or slick-licker at the apex of the V to collect the concentrated oil-water mixture.

Experiments done on bubble "curtains" produced by bubbling air through the water have shown that oil spills in protected waters can be contained by this method. Its usefulness is limited to situations such as estuaries and harbors.

b) Chemical Methods

Chemicals have been used to treat water-borne oil spills in a number of ways: dispersants promote oil-in-water emulsification and increase surface area; sinking agents increase the specific gravity of oil to sink it below the water surface; burning agents are added to increase the combustibility of oil.

Oil spills which are dispersed or sunk undergo biodegradation. The rate of natural degradation depends on numbers and types of organisms, nutrient levels in the water, oxygen content and water temperature. Several nutrient-organism mixtures have been developed which purportedly degrade oil more quickly than natural processes. These may be useful as a long-term treatment method but will not remove oil spills quickly enough to remove the threat of shoreline pollution.

i) Dispersants - Chemical dispersants vary considerably in toxicity. Some have been found more toxic to marine and inter-tidal organisms than the oil itself. However, organizations are producing a wide variety of new chemical dispersants. In many cases the toxicity ratings produced by different laboratories are not comparable and consequently quality comparisons are difficult. It would be instructive to conduct bioassy programs using organisms and environmental conditions from the area where application of chemical dispersants was under consideration. Chemical barriers to contain oil slicks have been suggested but to our knowledge, none have been tested in operational situations.

ii) Sinking Agents - Chemical sinking agents have proved effective in removing oil spills from the surface of the water, but are subject to a number of drawbacks. Sinking the oil does not remove the pollutant;

it merely transfers it from one environment to another. Sunken oil is toxic in varying degrees to bottom organisms and can easily smother them. It is not stationary, but will move with bottom currents to be redeposited perhaps in a productive bottom environment or even on the shoreline.

Sinking agents should not be employed in areas which support commercial fish or shellfish operations or in areas which support large populations of aquatic organisms.

iii) Burning Agents - Burning oil slicks is very difficult except in cases where the product is particularly volatile and has a low flash point, as the heat loss across the oil-water interface generally prevents combustion. Various processes have been designed to overcome this phenomenon. Most popular has been the deployment of materials to "wick" the oil above the water surface where it can be burned without extensive heat transfer. From the information available, it appears that burning oil is feasible only if the slick is relatively thick, if it is not emulsified, and if water temperatures are relatively high.

3. Clean-up Methods on Shore

The restoration of shorelines that have been polluted with oil is difficult at best, and in many cases, impossible. The existing technology is both labour and capital intensive. At present there are only three methods for cleaning shorelines; physical removal of the contaminated matter, chemical removal, and processing.

a) Physical Removal

Physical removal of contaminated material can be done with standard road-building equipment where access and the type of beach permit movement of the equipment. Obviously, this method is limited to level beaches composed of relatively fine material. The polluted beach sand or gravel is then usually buried above the high water mark.

In many cases, hand labour must replace machinery. Absorbent materials are usually applied to the polluted area to concentrate the oil and to speed removal. Peat moss, straw, and other organic compounds have been found useful as they are inexpensive and their long fibre length allows them to be handled with rakes and forks. However, relatively large volumes of absorbents are required.

b) Chemical Removal

Chemical dispersants, often called detergents, have been used to clean both sandy beaches and rocky shorelines. Most of these chemicals are toxic to intertidal life. On occasion, the surface oil has been carried by the chemical down into the beach so that erosion of the upper layer has resulted.

At the Santa Barbara oil spill, talc, an oleophilic substance, was applied to the rocky shoreline and then the encrustation was blasted off with a high pressure jet of water. This method proved quite successful.

c) Processing

In the case of processing, beach material is actually removed, treated and replaced. A number of schemes have been proposed to process contaminated sand. The thermal processes are promising. To date, these schemes are experimental and have not been used under the actual conditions of an oil spill. Their expense may preclude any practical application.

4. Costs of Clean-Up Methods

Due to the time and site specific nature of oil spills and consequent clean-up procedures, we have not attempted to assess clean-up costs on a regional basis. Instead, we have chosen to determine equipment and manpower unit costs at the 1972 level for southwest British Columbia in this appendix, and then apply those base values to the selected scenarios in the main text.

As illustrated in Table XXI, equipment can be sub-divided into marine equipment and supplies, aerial equipment, vehicles, and heavy and miscellaneous equipment. Specific items in the table are evaluated by either capital costs or rental rates (by hour or day). Capital costs are only noted for equipment which is unique to oil spill clean-up, except in the case of portable radios which would require a special preset emergency frequency setting.

TABLE XXI

EQUIPMENT & MANPOWER COSTS

ITEM	CAPITAL COST	RENTAL
MARINE EQUIPMENT		
Booms:		
Heavy	$30,000 / 1000'	$1.00/ft/8 hour day
Light	$10,000 / 1000'	$0.50/ft/8 hour day
Skimmers	$30,000 / unit	$30 / hour
Slick-lickers	$10,000 / unit	$18 / hour
Hovercraft	-	government
Tugs:		
1500 HP +	-	$135 / hour
1000 - 1500 HP	-	$ 95 / hour
800 - 1000 HP	-	$ 65 / hour
Landing Craft	-	military
Small Work Boats	-	$6.00 / hour
Barges:		
Oil Recovery	$40,000 + $300/day for barge	$400 / day
Deck Barge	-	$300 / day
Work Barge (with crane)	-	$350 / day
MARINE SUPPLIES		
Peat Moss Absorbent	$3.50 / cu. yd.	-
AERIAL EQUIPMENT		
Cargo Planes	-	military
Helicopters:		
3 place	-	$155 / hour
4 place (jet)	-	$240 / hour
cargo	-	$500 / hour
Light Planes	-	$ 70 / hour

ITEM	CAPITAL COST	RENTAL
VEHICLES		
Tank Trucks	-	$20 / hour
Vacuum Trucks	-	$65 / day
Dump Trucks	-	$15 / hour
Lowbed Trucks	-	$20 / hour
Buses	-	$30 / hour
4 Wheel Drives	-	$20 / day
Pick Up Trucks	-	$10 / day
Dune Buggies	-	$10 / day
Trailers	-	$ 5 / day
HEAVY EQUIPMENT		
Caterpillar Tractors	-	$25 / hour
Rubber-Tired Skidder	-	$15 / hour
Front-End Loader	-	$30 / hour
Tracked Vehicle	-	$15 / hour
Grader	-	$24 / hour
Self-Elevating Scraper	-	$40 / hour
Crane	-	$20 / hour
MISCELLANEOUS EQUIPMENT		
High-Pressure Pump	-	$75 / day
Steam Cleaner	-	$20 / hour
Portable Power Generator	-	$20 / day
Conveyor	-	$15 / hour
Portable Radio	-	$65 / month
Hand Rakes and Shovels	$3.00 / unit	$5.00 / day / dozen
Bird Scarer	-	$10 / day

ITEM	CAPITAL COST	RENTAL
MANPOWER		
Organization Personnel	$1, 200 / month	$60 / day
Field Supervisors	-	$12 / hour
Consultants and Advisors	-	$15 / hour
Skilled Personnel (Machine Operators)	-	$10 / hour
Military	-	government cost
Additional Manpower	-	$2.00 / hour
Accommodation for Additional Manpower	-	$20 / man / day

APPENDIX E - REPORT OF THE TASK FORCE - OPERATION OIL

(PART 2 - SUMMARY OF RECOMMENDATIONS)

INTERNATIONAL ACTION

We recommend that

consistent with the initiatives taken by the Government with respect to Arctic pollution and at the IMCO special conference on pollution in 1969, Canada take a parallel initiative to convene a conference of all those concerned to write a new international convention for the operation and control of shipping throughout the world and that this convention be patterned on the principles of the Convention on International Civil Aviation.

the convention should ban all deliberate pumping of oil, oily waste or tank cleanings, or bilge cleanings into the oceans or any other body of navigable waters

Canada should take the initiative with the appropriate international bodies to seek agreement on a series of definitions and descriptions that will permit the reporting of spills in an orderly and understandable manner.

NATIONAL ACTION

We recommend that

extensive pollution control zones be established to cover the rest of the coast of Canada consistent with the position taken by the Government in the Arctic

the law should make it clear that those who pollute pay the complete cost of clean-up, including the cost of any Canadian federal or provincial personnel used in the clean-up, that the ship concerned be impounded until this has been accomplished or assured and that the legal penalties be in addition to this liability for the complete cost of cleaning up the pollution.

We recommend that

1) with respect to tanker operations, in order to enter Canadian waters, they provide evidence that they are fitted with adequate and serviceable navigation equipment

2) Canadian pilots be required on all vessels entering Canadian waters unless the ship and its captain have been given special clearance by the federal authority

3) standards of competence of crews of ships entering Canadian waters should conform with our national standards

4) the same principles as in 2) and 3) above should apply to Canadian ships in Canadian waters

5) there should be a complusory filing of samples of all petroleum products loaded on ships and a requirement that any spillage of petroleum products, regardless of whether they originate from a shore

tank or a ship, be immediately reported and sampled

6) the federal government establish one or more central laboratories capable of "finger-printing" petroleum products in a manner acceptable to the courts

7) until a better scheme is developed, the tankers and barges used in the petroleum trade be fitted with the Madsen valves.

We recommend that

1) all bulk storage tanks holding petroleum products or other hazardous substances be protected by dykes capable of containing the entire contents of the tank

2) pipelines running along water courses be similarly dyked.

ORGANIZATION AND PREPAREDNESS

1. Governments

We recommend that

1) the federal government should have the operational responsibility and authority for all major spills at sea and should reach agreement urgently with the provincial governments concerning the responsibility for all other major spills

2) with respect to moderate spills within provincial jurisdiction, agreements be reached with each province

3) with regard to minor spills agreements be reached between the provincial government and municipalities, with the provincial government having someone on site to take over in case the municipality is unable to cope.

We recommend that

the Minister of Transport have the responsibility for dealing with pollution arising from oil spilled in water when the extent and nature of the spill makes it a federal responsibility.

2. Ministry of Transport

We recommend that

this responsibility of the Minister of Transport be focused in a small team at the headquarters level and comprising a minimum of one physical scientist, one biological scientist and one operations expert, with the physical scientist being the leader

very careful attention be given to the community relations aspects of contingency and operation plans and that those information officers who are capable of effectively operating in a community relations setting be identified, involved with the headquarters team in the planning, and be immediately available when operations are mounted to deal with a pollution incident stockpiles of material be located at strategic ports. These would include peat moss or other absorbents, booms and boom components, and a variety of equipment not readily available, which will vary with each location

at least one slick-licker be placed at each major port on the Canadian coast and that at least two others be held in a central contingency packet

the Canadian Coast Guard have primary responsibility for the recovery of oil floating on the water, which will include slick-lickers, containment booming and all other ramifications

the Canadian Coast Guard be responsible for steam cleaning operations.

3. Department of National Defence

We recommend that

HMCS Cape Scott and Cape Breton be maintained operationally ready to fulfill primary roles in the national contingency plan

the Department of National Defence take on the responsiblity of developing an operational communications plan so that in an emergency all segments of the federal government in the field can communicate with one another.

4. Industry

We recommend that

the oil industry reach agreement among themselves to provide on immediate call from a Federal Government Task Force suitable oil recovery vessels

industry be heavily involved in research, development and production of equipment and material needed for the contingency packages on the one hand and the actual clean-up operations on the other, as well as devices to assist in the prevention of pollution incidents.

5. Department of Public Works

We recommend that

the Department of Public Works provide engineers to supervise the beach cleaning operation

6. Department of Energy, Mines and Resources
Department of Indian Affairs and Northern Development
Department of Fisheries and Forestry
Department of National Health and Welfare

National Research Council
And Support of Research

We recommend that

the scientific advice required by the headquarters team in the Ministry of Transport be provided by a group actively concerned with a portion of the research themselves. This advice will include assessment of research done in other countries, assessment of proposals for research to be carried out in Canada, and advice on grants to universities and industry to involve them in research, development and innovation in this area of pollution and its prevention. We feel that at the present time the best group to perform this function is the group that came together in Halifax on an ad hoc basis for Operation Oil headed by Dr. W. L. Ford, Director of the Atlantic Oceanographic Laboratory.

money for the support of relevant research at universities and in industry should be made available to the Ministry of Transport and disbursed on the recommendation of the headquarters team with the assistance of their scientific advisers

the initial funds to support the Canadian research effort on oil pollution problems in universities and industrial laboratories be $250,000 per annum

the National Science Library be the central repository for literature dealing with oil pollution and that there should be no proliferation of library holdings in the various federal government departments.

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