ENVIRONMENTAL EFFECTS OF OIL POLLUTION IN CANADA

An Evaluation of Problems and Research Needs

A Brief Prepared for The Canadian Wildlife Service

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TABLE OF CONTENTS

Summary and Recommendations

Introduction

Oil Pollution: A Global Problem

Offshore Oil Drilling: A New Pollution Problem

Determinants of the Biological Impact of Oil Pollution

- Greater Snow Geese in the St. Lawrence River, Canada; A Case History
- The Cape Penguin of Cape Province, South Africa; A Case History
- The Razorbill of Quebec and Newfoundland; A Case History
- Oil Transporting Mechanisms
- Effects of Temperature

Biological Aspects of International Activities

Canadian Problems of Special Relevance

- Oil Exploration and Exploitation in the Arctic
- Tankers in the Northwest Passage : An Additional Hazard
- Oil Released From Ships: A Major Problem

Oil Pollution Costs, Responsibility, and Contingency Plans

International Cooperation and Communication

Recommendations

Summary and Recommendations

Oil pollution has been a serious biological problem in the coastal regions of Canada for many years owing principally to the dumping of oil at sea by tankers and other vessels. With the advent of the recent "oil boom", the magnitude of the problem has grown enormously. Offshore drilling is now taking place in the Canadian Arctic, and is expected to begin soon in Hudson Bay and off Newfoundland. A substantial body of evidence is at hand clearly demonstrating the high degree of risk of environmental contamination from such oil exploration and exploitation activities.

The proposed use of the Northwest Passage as an oil shipping route represents another high risk venture where an accident could produce massive environmental damage. Canadian waters and coastlines would bear the brunt of the resulting oil pollution, which would persist for decades, perhaps centuries.

Canada has as yet no effective contingency plan in case of accident, has not yet developed a national policy relative to liability of the polluter and badly needs effective policies with respect to a) protection of environmental quality during oil development activities, and b) promotion of the necessary biological and other research requisite to a clear understanding of the complex oil pollution phenomenon.

A series of recommendations is presented (see below and pp. 23-28) which, if implemented, will go far toward placing the country in a position to intelligently resolve what is now a serious yet imperfectly understood problem.

Recommendation 1: instigation of a biologically and oceanographically oriented research program in the North Atlantic and the coastal regions of eastern Canada with special reference to seabirds and other important marine species.

Recommendation 2: instigation of a research program into the biological effects of marine oil pollution upon the hyponeuston, or the surface and immediate subsurface biotic community which is so critical to the continued productivity of the oceans.

Recommendation 3: instigation of a research program into the biological effects of oils in arctic and subarctic waters.

Recommendation 4: carrying out of a national survey to identify sites of special importance, leading to development of critical area protection programs.

Recommendation 5: instigation of a research program into the biological effects of present and proposed refinery and petrochemical plant operations (e.g. at Holyrood and Come-by-Chance).

Recommendation 6: development of a truly effective national system for locating, reporting, and identifying the sources of oil pollution circumstances.

Recommendation 7: development of a National Contingency Program.

Recommendation 8: development of national criteria for environmental protection, to be included in all oil leases, construction contracts and other agreements where the activity presents some probability of risk to the environment.

Recommendation 9: improvement of international coordination and communications.

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Introduction

This review of oil pollution problems as they relate to Canada is intended to cover several areas. First, it examines the present global oil pollution situation, with special reference to Canada's principal current problem, namely coastal oil pollution. Second, it evaluates the special problems which Canada now faces, or will face in the immediate future due to the press of circumstances. Third, based on a recent review of current oil pollution research in Western Europe, Canada, and the U.S., it recommends a series of programs which if implemented, would enable Canada to intelligently come to grips with what is a rapidly growing problem of national significance.

Data utilized in the report were derived from a variety of sources. Those on the current status of European research were obtained from on-site discussions with scientists in England and mainland Europe during the period 18 December 1968-1 March 1969; for which I acknowledge with sincere thanks the financial assistance of the Canadian Wildlife Service. Documentation of other sources may be found in the "Literature Cited" section at the end of the paper. I am indebted to colleagues throughout the world for generously providing much useful information on a subject which has as yet no unifying world effort, and whose literature is as a consequence now scattered in scores of scientific journals, popular scientific magazines, and other periodicals and unpublished reports. I am also indebted to Dr. Marshall Laird and Dr. Leslie Tuck, who critically reviewed the manuscript and provided many useful suggestions.

That there is an oil pollution problem of national significance will become clear from the following documentation. Whether Canada can successfully deal with this problem depends ultimately upon the awareness of Government, and it is toward this end that the present report is prepared and respectfully submitted.

Oil Pollution : A Global Problem

The magnitude of global oil transport activities is difficult to comprehend. Tankers come and go, our only contact with them usually being brief glimpses in harbours or as white-plumed dots in the ocean far below the window of our jetliner. They seem, for the most part, to be a minor and unobstrusive part of the contemporary scene.

It is only when we consider the data on oil transport activities that the awesome magnitude of the enterprise becomes clear, and it requires an examination of the historical record to appreciate the trends. The arrival of the Industrial Age brought with it the "Oil Age". Relatively large volumes of oil were transported and consumed during the first half of the century, especially during the period immediately preceding 1945.

However, during that time refineries were generally built near the fields supplying the crude oil, and as a consequence generally only refined oils and oil products were transported. These products (gasoline, kerosene, diesel oil, etc.) are referred to an "non-persistent" materials, which, if accidentally released into the environment tend to evaporate quickly, and until recently it was presumed with minimal environmental damage. More recently the trend has been to locate refineries remote from the crude oil source, resulting in ever increasing quantities of crude oil being transported vast distances by sea. Crude oil is a "persistent" oil, and its effects on the environment can be profound.

By late 1967 an average of nearly 19 million barrels, or 2 3/4 million tons of oil were being moved by sea every day in the free world (18). At the present time half the world's ocean cargo weight is oil; according to Darling (10) some 700 billion tons of it in 1967 in 3218 tankers. Seventy to eighty percent (70 - 80%) of all oil traffic, including coastal traffic, is crude oil. The transporting tankers are generally huge-up to 200,000 tons, with 250,000 ton (12) and even 350,000 ton tankers slated for use in the near future. In addition, the total number of tankers is rapidly increasing. Some 800 were added to the world's fleets in the past three years alone.(2).

The world tanker fleet produces oil pollution in two principal ways: 1) the deliberate discharge of oily wastes in bilge pumpings and tank washings, and 2) through accidents either at sea or while loading or unloading in port. Had the historic practice of unrestricted dumping of dirty ballast and tank washings been continued to the present moment, we would now be experiencing a marine oil pollution problem of enormous proportions. Kluss (18) estimates that the amount of crude oil which would be released into the oceans under these circumstances would today amount to about 6000 tons per day, or 2,190,000 tons per year. Fortunately, largely because of the intense pressures brought to bear by ornithologists and conservationists (see Proceedings of the 3rd International Conference on Oil Pollution of the Sea, Rome, 7 - 9 October 1968) investigations were undertaken to find alternate means of disposing of this oil.

As a result Shell Oil Co. in 1962 developed the so-called "load-on-top" method of handling tank washings, which materially reduced the amount of oil deliberately dumped into the sea. Despite the current acceptance of this technique by many oil transport companies, Barclay-Smith (5) estimates that because of accidents and deliberate illegal release of waste oil some 400,000 tons of oil are still released into the world's oceans each year. One may confidently expect that this figure will continue to increase for at least the next two decades for a variety of reasons, some of which are discussed beyond.

The problem of oil contamination from leakages while loading or unloading tankers, or from mistakes by oil-using shorebased operations such as electricity generating stations, is significant. While the volumes of spilled oil from any single accident are generally relatively small, the impact upon the environment is aggravated by 1) the immediate proximity of vulnerable habitats such as bays, estuaries, and marshes; and 2) the physically confining effect of the harbours in which most such activities are located. As a consequence, a few thousand gallons of spilled oil can have an enormously destructive impact on the immediate environment, where the same quantity released far at sea would tend to be dispersed with presumably only nominal ill effects.

The oil pollution experiences of the Medway Estuary, a major British oil port, serve well to illustrate the situation (17). In 1967 there were no less than 34 minor oil spills in the Medway Estuary. The biological effects of these spills were significant but not catastrophic. However, on the 18 September 1966 the West German tanker Seestern accidently discharged 1,700 tons of Nigerian light crude oil into the estuary (an underwater sea valve had been inadvertantly left open). During the following 36 hours an immense sheet of oil, trapped within the estuary, was swept through the area by the tides. A total of 2778 birds were found dead or incapacitated; an unknown additional number were affected. The invertebrate life was devastated; hundreds of millions of molluscs were killed by the oil and the detergent used to clean up the spill; the local shrimp (Crangon vulgaris) and the Dover sole (Solea solea) disappeared completely after the pollution. The intertidal vegetation was badly damaged. Migratory bird utilization of the area dropped by as much as 95% for some species. The overall ecological change was profound. While certain components of the ecosystem recovered relatively rapidly, the effects on overall productivity of the area were extensive.

One has but to examine the geography of Placentia Bay, Newfoundland, to see what a similar accident at the proposed oil port would do. Placentia Bay is one of the largest bays in Newfoundland, and is the basis for important inshore fishery. Water currents and wind effects in the bay would actively transport the oil, depositing it along extensive stretches of shoreline. And as Placentia Bay is long and relatively narrow, the toxic, water-soluble components of the polluting oil would have a protracted influence on the bay's marine life.

Offshore Oil Drilling : A New Pollution Problem

In recent years a new source of environmental contamination by persistent oils has developed. It has been reported that there are now over 9000 oil wells pumping from submerged areas of the world's continental shelves. There are today over 150 mobile oil drilling rigs, representing about 1 billion dollars worth of equipment, actively involved in exploring for offshore oil. And the rate of oil exploration on the continental shelves is increasing. Ocean Industry (4) lists 29 offshore areas in almost as many countries where exploration and/or exploitation is now underway. The report was apparently not intended as a complete review of activities offshore, for it does not include the present intensive exploration in Arctic Canada and off the coasts of Newfoundland and British Columbia, nor that along the Santa Barbara coast of California, nor the impending drilling in Hudson Bay.

Reports now available indicate that in the Baltic and Caspian Seas oil leakage from drilling and pumping activities is resulting in grave losses to wildlife, principally the migratory waterfowl and seabirds, and to the commercial fisheries. The widely reported (eg. 3;20) recent catastrophic blowout of an offshore oil well on the Santa Barbara coast, where crude oil under pressure leaked through fissures in permeable sedimentary strata, has graphically illustrated what can happen during such underwater operations.

While the industry claims that such operations are quite "safe", an engineer presently employed by one of the companies heavily involved in offshore drilling stated privately that the life expectancy of such offshore platforms was less than ten years, owing principally to the damaging effects of storms, collisions from ships, and other environmental hazards. It has, for example, been reported that an entire drilling rig was carried away by ice in Cook Inlet, Alaska. If one adds to this the problem of breaks in the submerged pipelines serving these offshore units, the magnitude of the potential for environmental contamination becomes clear. Such underwater pipelines have been broken by ice action at a water depth of 250 feet.

Determinants of the Biological Impact of Oil Pollution

The severity of impact of any particular oil pollution circumstance is contingent upon a variety of circumstances. One significant determinant, the confining effect of bays and estuaries, has been mentioned. Other determinants include, for example, a) the presence of especially vulnerable life forms; b) the presence of transporting mechanisms, such as river flow, wind, and tidal current; c) environmental conditions, especially temperature and presence of ice; and so forth. The discussion which follows attempts to characterize the nature of these determinants using in part documented pollution case histories.

Greater Snow Geese in the St. Lawrence River, Canada: In August, 1963, an unknown ship illegally dumped about 1000 gallons of Bunker C fuel oil into the St. Lawrence River. The oil drifted onto the Cap Tourmente Marshes, which lie about 20 miles east of Quebec City. While marshes are not yet rare ecological entities in Canada, this particular marsh is of special significance, for it supports during the fall and spring months most of the world's remaining population of the Greater Snow Goose (*Chen Hyperborea atlantica*). Some 70,000 birds regularly use the area as a resting and feeding ground during their migrations to and from the Arctic. About 1000 birds were in the area at the time of the oiling, and more were arriving daily.

Fortunately, the oil was discovered shortly after it reached the marshes, and by a vigorous and concerted effort by the Canadian and Provincial Wildlife Service, together with members of the Biology Department of Laval University, most of the oil was removed and burned before it contaminated the geese. Had the spill not been discovered for a few days, and had it occurred a few days later in the year, most or all of this single remaining Greater Snow Goose population would have been destroyed.

The Cape Penguin of Cape Province, South Africa: Oil pollution off the southern and south-western coasts of Cape Province, Republic of South Africa, has been growing steadily worse in recent years. The oil comes from a) ships pumping tanks off the coast while rounding the Cape; and b) periodic shipwrecks. While the highly pelagic bird species (e.g. petrels and albatrosses) have not suffered heavily, those forms which feed in the intermediate zones (cormorants, gannets, penguins) are seriously affected.

Extreme concern is now being expressed for the future of the endemic Cape or Jackass Penguin (Spheniscus demersus), a species found only in South Africa and adjacent islands, whose total population was estimated in 1960 to be 103,000 (28). More recent studies have indicated that the population is diminishing alarmingly (29). In one oiling incident alone in April, 1968, 1700 dead or dying penguins were collected along the beaches. This figure represents but an unknown fraction of the total numbers affected, since there are no data available on the numbers which were oiled and perished immediately at sea, or were debilitated and carried out to sea by winds and currents. However, one study of oiled birds at sea (different species in a different area) indicated that for every oiled bird which reaches shore and subsequently perishes in the normal course of events, between eight and eleven perish and are lost at sea (35).

Because of its high vulnerability to the chronic oil pollution of its environment, there is mounting concern that this endemic species of penguin may, within a decade or two, become extinct.

Razorbill of Quebec and Newfoundland: The Razorbill, Alca torda, is a member of the family Alcidae, and is presently found throughout the North Atlantic. Bédard (6) has provided a summary of colony censuses and estimates which indicates an approximate population of 40,000 birds for the Canadian Atlantic region. The species is widely dispersed, with 33 of the 42 reported colonies apparently having populations numbering less than 1000 individuals. The reproductive potential is low as is typical for the alcids, a single young being produced during the summer breeding season. Mortality from embryo to fledgling age has been estimated by Bédard(5)to be around 34%, further reducing the effective reproductive potential of the species.

While quantitative data are still being gathered, it appears that at least the Western Atlantic population is diminishing in size. It is uncertain whether climatic and/or ocean environment changes are contributing to this reduction in numbers. The possibility that marine oil pollution may be playing a major role in the apparent decline cannot be ruled out, and some students of the problem feel that it may be a major contributor.

It is clear that a prompt and thorough study of the situation is necessary to ascertain the causative factors and, if possible, to recommend actions which can be taken. The Razorbill population is now so small that special care must be taken to assure its survival under as near optimum conditions as possible.

Oil Transporting Mechanisms: The phenomenon of oil slick transport by river, tidal, and ocean currents, is well enough known not to require special elaboration. Reference can be made to the numerous instances of polluting oils travelling for many miles on rivers of the United States, Canada and elsewhere; and the Medway Estuary disaster, where tidal flow played an important role, has been mentioned. Transport by winds has been well demonstrated in the "Torrey Canyon" incident, where huge quantities of oil were carried principally by wind action first to the coasts of England and then to the coasts of France.

The chronic coastal oil pollution situation of Newfoundland is in part the consequence of onshore winds bringing oil from the sea lanes to inshore waters. The dynamics of wind action are not yet well understood, but it has been found that oil movement is in the same general direction as that of the wind, the rate of oil slick movement averaging between 2.5 and 4% of wind velocity (20).

Effects of Temperature: The influences of such environmental factors as temperature and the presence of ice are much less well understood. However, it is now established that the rate of biochemical decomposition (bacterial decay) of oil in seawater is temperature dependent. At higher environmental temperature (25-30°C., 76-87°F.) crude oil breaks down rather rapidly (11), and it is at these temperatures that most experiments have been conducted. However, the decomposition rate slows markedly at lower temperatures, and at 0°C is drastically reduced, some components of the process stopping altogether. Over half the earth's surface has mean temperatures well below those necessary for the optimal biochemical decay rate of crude oil. And decomposition in the Arctic oceans, whose temperatures are at 0°C (32°F.) or below throughout the year, would be very slow indeed. Where oil is exposed to still lower temperatures, for instance when carried onto shore lines and ice floes, biochemical decay would be virtually nonexistent, and the oil would persist for decades, perhaps centuries.

Crude oil is principally a complex mixture of hydrocarbons, some of them highly volatile, some of them very stable compounds with high boiling points. These highly volatile, "lighter fractions" are the components chiefly responsible for the high initial toxicity of fresh crude oil to marine organisms. Fortunately, in tropic and temperate environments the "lighter fractions" rapidly evaporate, leaving on the water's surface the more inert and persistent "heavier fractions", which over time develop the consistency of tar and which are seriously damaging only to seabirds, shore biota, and amenity values, although they may also interfere in a most objectional way with fishing operations by coating nets, lines, and other equipment.

It must, however, be clearly recognized that the phenomenon may be much more complex than here-to-fore realized. Biochemical decay of crude oil produces a variety of metabolic by-products and hydrocarbons of unusual nature. Suspicions are growing that there may be toxicity problems resulting from the products of biochemical decay which seriously compound the known environmental degrading effects of oil per se.

In cold Arctic waters, evaporation rates of the highly toxic "lighter fractions" of crude oil slicks are believed to be greatly slowed. The net effect is to significantly prolong the time during which sensitive marine organisms are exposed to the toxic influences of the lighter hydrocarbons. Mirinov (23) has recently shown that such surface films of oil are especially toxic to the hyponeuston, that special marine community found in the surface layer of water (from 0 to 5 cm depth) and which is composed in part of the embryonic and larval stages of many pelagic and bottom dwelling forms. Many of the species inhabiting the hyponeuston during their early stages are of great value to commercial fisheries (33). Mirinov reported, for example, that the development of fecundated spawn of the plaice (Rhombus maeoticus) was extremely sensitive to the influence of oil products in sea water. Injury was noted at oil concentrations of 10^{-4} to 10^{-5} ml/L. At these concentrations, 40 to 100% of the hatched pre-larvae showed various signs of degeneration during development and perished. Planktonic algae have also been found sensitive to the toxic components of such oils, exhibiting retarded cell division and direct mortality(22).

Thus, environmental temperature plays a highly relevant role in the dynamics of marine oil pollution. Based on current knowledge, the principal effects appear to be:

1) determination of rate of biochemical degradation;
2) determination of rate of evaporation of toxic "lighter fractions";
3) ice formation with its unknown consequences.

In arctic and subarctic environments these three determinants are acting together, each augmenting the other. The consequences of these cumulative actions are not at all well understood at present, but they are clearly of great significance to ecosystems of colder environments.

To summarize, it does appear possible to make some predictions concerning the effects of a specific oil pollution event, although at the outset we must admit that we know relatively little about the dynamics of much of the problem. Accepting this, then it is possible to conclude that the biological impact of a given oil pollution circumstance depends largely upon:

1) the nature and quantity of oil released;
2) pattern of release over time;
3) general geographical location and immediate topography of area;
4) environmentally determined patterns of biochemical decomposition;
5) relative vulnerability of the exposed biota;
6) climatic conditions, especially temperature;
7) transporting mechanisms, e.g. tides and winds;
8) presence of ice (extent of influence presently unknown);
9) aesthetic or human amenity values of area.

Using these criteria, it becomes possible to evaluate the probable impact of oil pollution on areas of special interest. Certain regions, such as the Arctic and Subarctic of the U.S., Canada, and Russia, can thus be expected to be especially sensitive to oil pollution of any kind. Tropical seas, on the other hand, may suffer less from a pollution experience. Nevertheless, considerable care must be exercised in attempting any predictions. Certain habitats, such as the coral flats of the Great Barrier Reef of Australia, while tropical (10^o to 23^oS.) are exceedingly vulnerable owing to the thorough and repetitive exposure to floating oil of the substrate by tidal fluctuations. It is therefore not difficult to understand the great alarm currently being expressed by Australian conservationists over the impending oil drilling activities on the Great Barrier Reef. Either chronic leakage or catastrophic blowout could seriously degrade and possibly destroy completely the reefs over hundreds of square miles.

Biological Aspects of International Activities

The historical evidence relative to international action concerning marine oil pollution is of great interest. It clearly demonstrates, for example, that it has been neither national governments nor elements of the oil industry which have pioneered and catalysed the present global effort toward alleviation of oil pollution. Rather, the movement owes its origin and its present rapid state of progress to private individuals and conservation groups who became alarmed over the rapidly deteriorating environmental conditions (see the proceedings of the 3rd International Conference on Oil Pollution of the Sea, 7-9 October, Rome).

A classic demonstration of this mechanism in action is found in the activities of the Advisory Committee on Oil Pollution of the Sea, an independent, non-governmental group which was formed in England in March, 1952. This Committee, a coalition of conservation groups and concerned individuals, was formed to provide a united front in the struggle to halt the massive oil pollution which was then inflicting serious damage to the world's ocean ecosystem. The Advisory Committee organized a series of "informal" international conferences on oil pollution of the sea (London, 27 October 1953; Copenhagen, 3-4 July 1959; Rome, 7-9 October 1968), the latter conference was sponsored jointly by the British Advisory Committee on Oil Pollution of the Sea, the Italian National Committee on Oil Pollution of the Sea, and the Nordic Union for the Prevention of Oil Pollution of the Sea, all independent groups. These "informal" international conferences have led directly to such conservation milestones as:

1) the formal Intergovernmental Conference on Oil Pollution of the Sea (London, April-May 1954);
2) the International Convention concerning marine oil pollution, and more recently;
3) in catalysing the establishment of IMCO (Intergovernmental Maritime Consultative Organization, a Specialized Agency of the United Nations) and in promoting marine conservation activities by that organization.

While many of the mechanisms required to curb oil pollution of the world's oceans are administrative and technological, the need for greater biological knowledge concerning the phenomenon is urgent. In the absence of such knowledge there is no guarantee that well intentioned administrative efforts will have the desired effects. The point is made clear in the following example.

The proposal has recently been made, and is now under active consideration by IMCO, to permit the release of relatively small quantities of waste oil by ships while in transit. The present proposal calls for a convention to allow ships to dump up to 60 liters of oil per nautical mile of travel, this rate having been established by preliminary observations as not normally producing a discernible oil slick (24). By releasing the oil into the turbulence of the ships' propellers, it is presumed that the material will be sufficiently dispersed to permit bacterial decomposition within a reasonable period of time.

Unfortunately, there are several important biological factors which remain unresolved. First, no studies have ever been made of this practice when conducted in arctic and subarctic waters, hence no predictions can be made concerning its effectiveness in significant portions of the world's oceans. Second, no studies have been made to determine the effects of the quantities of oil involved upon the neuston and hyponeuston. Data presented in an earlier section of this report indicate that the plant and animal communities comprising the hyponeuston are a) of critical importance to the productivity of the world's oceans, and b) extremely sensitive to the toxic properties of such waste oils. The proposed oil dumping scheme, by advocating the mixing of waste oils with seawater immediately upon their release into the environment, effectively eliminates their detoxification by the previously described surface evaporation of the highly toxic "lighter fractions". Waste oils introduced directly into the ocean under these circumstances may well prove to be many thousands of times more toxic to hyponeuston organisms than if left as surface films. The biological consequences of such an activity are difficult to gauge, but should the practice become universally accepted through international agreement, they could well be profound.

Canadian Problems of Special Relevance

Many of the oil pollution problems presently confronting Canada are similar or identical to those with which any industrialized nation has to cope. Fuel oil leaked into rivers and lakes by accient or design; accicental discharge of oil from loading or unloading tankers; waste oil from industry or shipping, dumped into bodies of both fresh and salt water; these are some of the recognized hazards of large scale use of oils throughout the world. Their ubiquity does not render them any less undesirable, nor does it justify the disregard and irresponsibility which commonly leads to contamination. But it does provide a background of previous experience from which Canada can learn much, both in terms of control and of impact on the environment.

There are, however, other conditions and situations which are to varying extents peculiar to Canada. Some of these situations have little historical precedent, rendering difficult any firm predictions or a priori guide lines for Canadian activity. Three situations are detailed below, in part because such evidence as is available strongly suggests the need for immediate study and decisive action if Canada is to avoid extensive and longterm damage to significant portions of her natural environment.

Oil Exploration and Exploitation in the Arctic: The Canadian Government is of course well aware of the intensive programs of geophysical and drilling exploration for oil currently underway in the American and Canadian Arctics. Oil has recently been discovered offshore in Prudhoe Bay, Alaska, with the reserves for that area now being variously estimated at between 25 billion and 300 billion barrels (the latter an oil industry estimate). For comparison, some 118 billion barrels have been discovered on the entire North American continent over the past century (1). Still more recently, an exploratory well on Melville Island, Northwest Territories, struck gas; it is expected that soon oil will be discovered in the same area. Geophysical exploration and possibly exploratory drilling is now underway in Hudson Bay and Hudson Strait, as well as off the coasts of Newfoundland and British Columbia. While the two latter areas are not Arctic or Subarctic, many of the comments which follow, although directed toward the developing problem in the Arctic, are pertinent to them as well.

It is desirable to demonstrate, before going further, the extreme urgency of the problem in the Canadian Arctic. The Toronto Globe and Mail recently reported (16 July 1969) that the first of a proposed series of 15 exploratory wells on Melville Island being drilled by Panarctic Oils Ltd. of Calgary, had suffered a gas blowout (from a split in the casing) about midnight of Sunday, 13 July and had been out of control ever since. According to that source, the specialist brought in by the company to stop the blowout reported that a routine approach would not be feasible because of the almost impossible working conditions on and around the rig. Had this blowout been oil instead of gas, Canada would at this very moment be deeply embroiled in the most massive case of oil pollution in her history. One has but to reflect on the widely documented recent oil blowout of a well offshore of Santa Barbara (16,33) to realize the potential magnitude of such a disaster. And since the Canadian Government owns 45% of the stock of Panarctic Oils Ltd. (3) the Government may therefore find itself in the most unenviable position of becoming a major polluter of the environment while simultaneously trying to curb pollution by others.

The pattern of oil pollution of Cook Inlet, Alaska, can be utilized to evaluate some of the potentials of Canadian Arctic oil development activity. Oil was discovered in Cook Inlet in 1962. Today there are 13 giant drilling platforms in upper Cook Inlet, each one valued at $12 to $15 million. Wells are drilled through the platform legs, and the oil subsequently pumped from them passes through concrete-encased underwater pipelines to storage tanks on land. Tankers then receive the oil and transport it south. Approximately 116 miles of these underwater pipelines are now in operation, some of them extending for several miles on the floor of Cook Inlet. There are conflicting reports from the oil industry as to whether the lines are equipped with automatic shut-off devices, but apparently they are not. It will be recalled that a report is at hand indicating destruction of such pipelines by ice action at a water depth of 250 feet.

An extraordinary series of oil pollution incidents followed the discovery of oil in Cook Inlet. These incidents now average 1-2 every fortnight; their severity ranges from modest to extremely destructive. Tens of thousands of seabirds and waterfowl have been killed by this pollution, and even the commercial species of fish and bottom-dwelling crabs have been affected. Concern is growing for the welfare of the mammal populations of the region, including the beluga whale, seals, sea otters, bears and furbearers (25).

In April 1968, the then U.S. Secretary of the Interior Stewart Udall called for an emergency control program for Cook Inlet oil operations, and for more conscientious efforts by industry. The comments he made at that time are most appropriate to the present discussion. He stated, in part:

> "During recent months I have received well-substantiated evidence that exploration and development activities in Cook Inlet have resulted in a recurring series of pollution incidents. Between June 1966 and December 1967 there were some 75 incidents of oil pollution in Cook Inlet reported by federal and state agencies responsible for the conservation of natural resources in the area."

One report available to the Secretary revealed that:

"Nearly 100 oil pollution incidents have been recorded in Cook Inlet, Alaska, between March 1966 and April 1968."(19)

This unenviable record of environmental contamination produced by the oil industry in Cook Inlet is in part the result of inadquate controls, in part the result of attempting to exploit oil resources in a difficult and poorly understood environment. Cook Inlet is, climatically, no more difficult - and probably considerably less difficult - than the Canadian Arctic Slope and Beaufort Sea. And since Canadian environmental protection legislation and regulations governing oil activities are considerably more lax than those of the U.S., there is every reason to expect that Canadian Arctic oil activities will be at least as destructive as those in Cook Inlet. Add to this probability the results of ancillary terrestrial activities - roads, pipelines, settlements, storage facilities and their relevant construction and maintenance activities - and the prediction of impact upon the fragile arctic environment is not an encouraging one.

Present oil leases issued to oil companies by the Canadian government do not contain environmental protection clauses, in contrast to DEW - line construction contracts for the military. The Cook Inlet example detailed above, illustrates what can happen even in the presence of relatively well regulated oil development activity. The evidence is thus unequivocal that Canada must act decisively and soon if she is to avoid the wanton destruction of her arctic environment, including its wildlife, on an unprecedented scale.

Tankers In the Northwest Passage - An Additional Hazard: The United States has recently been refitting the tanker Manhattan, its largest merchant vessel, for travel in Arctic waters. The Manhattan's deadweight tonnage is 106,500 and it can carry 38,220,000 gallons of crude oil; according to one report enough to fill nearly 4000 railway tank cars. The immediate goal of this exercise is to explore the feasibility of transporting crude oil, obtained from oil fields on the Arctic Slope, east through the Northwest Passage and hence to refineries on the New England coast of the U.S. The proposed route is through the Canadian Arctic islands to Davis Strait between Baffin Island and Greenland. Half of the 4500 mile route would be covered by ice. The first trip is scheduled for the summer of 1969.

A cursory glance at a map of the region is sufficient to confirm that virtually all of the hazardous part of the journey will be through Canadian waters, or waters which, although due to international agreements are considered "high seas" are immediately contiguous to Canadian waters and lands. To date, Canadian and American icebreakers have been the only large vessels to traverse this route with any predictable degree of success.

Of all international oil transporting ventures undertaken to date, this proposed Northwest Passage plan is clearly far and away the most hazardous. It is extremely hazardous not only for the ships and their crews, but for the Arctic environment along the route of the tankers. The sinking - or even serious damaging - of but one large tanker in these waters could have catastrophic and longterm effects on the arctic coastal environment. In the present absence of even rudimentary data on the behavior of oils in ice-filled arctic waters, no sensible contingency plan in case of accident can be developed. Canadian resources will bear the brunt of any such accident, whose impact is at present virtually unpredictable, but known to be great.

Oil Released From Ships: A Major Problem: The available evidence, while incomplete, strongly suggests that the greatest current environmental damage from oil contamination results from the dumping of oil by ships at sea. Several principal sea lanes converge off the Eastern coast of Newfoundland, and there are significant shipping routes through such coastal waters as the Gulf of St. Lawrence and the Strait of Georgia. Tuck (36) has stated the situation well:

> "Most traffic routed from Northern Europe, the Mediterranean and Africa to Halifax, the Great Lakes and New England ports, converges south of Cape Race on the Grand Banks of Newfoundland, while the more northerly shipping route during the summer months passes through the Strait of Belle Isle into the Gulf of St. Lawrence.
>
> Oil dumped south and east of Newfoundland is carried toward the coast by prevailing winds and currents. There is an infamous current setting towards Cape Race which has been the cause of hundreds of marine disasters during the past three centuries. That same current brings oil-slicks toward the coast and thousands of dead and dying murres and other sea birds are found along the shores of both sides of the Avalon Peninsula in the fall, winter and early spring."

Field studies by Tuck (37) have indicated that there are several principal areas off Newfoundland where heavy mortality to sea-birds by oil pollution occurs. The shores of both sides of the Avalon Peninsula have been mentioned. A second area, the north side of Bonavista Bay, southwards from Cape Freels, and a third, the Newfoundland side of the Strait of Belle Isle, have also been identified. Mortality from oil contamination, while continuous, appears to be far more serious in winter, when the Eider ducks concentrate inshore and the murres offshore. Tuck (and others) are convinced from the available evidence that:

> "...far more murres - and possibly Eider ducks - have been killed annually off the coast of Newfoundland by oil than have been utilized for food." (37 p.191).

The scattered and fragmentary data on Newfoundland seabird destruction by oil have been well summarized for the period 1949-1968 by Gillespie (15). The winter of 1959-60 was apparently one of the worst in history; Gillespie reported of this interval:

> "It was estimated that several hundred thousand sea birds were destroyed between January and March 1960. The first report during the winter of 1959-60 was from the Avalon Peninsula in January but apparently an earlier kill was registered along the northeast coast. The kill was highest on the Alcids (murres, puffins, dovekies, black guillemots, and razor-billed auks). It was calculated that of the 4,000 birds handled by Dr. L.M. Tuck, 97% were murres. The source of the pollution was not detected."

He cites, in addition, several other instances of oil pollution during the same period.

Livingston (21) has described the important concentrating effect upon alcid and eider populations of the North Atlantic caused by the seasonal southerly movement of the arctic ice pack. The net effect of this ice pack movement is to compress these populations into a relatively small area ("something less than 400 miles square - relatively small in terms of the great numbers of birds coming from large breeding colonies throughout our eastern Arctic."), which coincides with the shipping lane convergences described above.

I have recently investigated another serious Canadian oil pollution circumstance, of a sort not previously reported in the literature with the exception of the recent Santa Barbara catastrophe. In mid-April 1969 reports were received of migrating harp seals in the Gulf of St. Lawrence being found covered with a heavy oil. This incident, which was neither widely reported nor widely known to either authorities or the general public, involved 3000-5000 and possibly more juvenile harp seals which were following their traditional migration route northwest through the Strait of Belle Isle after leaving the whelping grounds along Eastern Quebec shores. The animals apparently contacted a large oil slick somewhere in the Gulf of St. Lawrence north of Prince Edward Island. Eye witness reports indicated that thousands of them were completely coated with the viscous material, and many eventually perished. Death was especially gruesome, for the animales'flippers stuck to their bodies making swimming difficult or impossible, while the heavy, tarlike coating irritated the skin; the combination eventually stressing the afflicted animals to the point of exhaustion and death. Dead oiled seals were found on ice floes, along the beaches of the Strait of Belle Isle, and some were observed dead in the water. It has not yet been established whether the contaminating oil came from a ship or a shore facility, but because of the location and circumstances it is believed to have come from the former.

Discussions and correspondence with officials of the Canadian Wildlife Service, Department of Fisheries, and Department of Transport over this seal oiling issue have indicated that under the existing circumstances they are not adequately equipped to deal with such oil pollution problems. Their duties are diverse, and control of oil pollution constitutes only a fragment of their overall responsibilities. Authority to investigate and act is scattered among a variety of laws and regulations, none of which are ideally suited to the existing conditions of the area. Attempts at coordination and improved communications have been made, especially by the Canadian Wildlife Service, but substantial improvements will be needed before any truly effective coordination can be achieved. One of the greatest needs is for ministerial level direction leading to effective integration of the various, now-separate efforts.

Equally important is the need for biological studies of various aspects of this phenomenon. Some progress is being made toward understanding the ecology and phenology of the North Atlantic seabird populations, but there has been no concerted attempt to date to relate the findings to the oil pollution problem.

It is well known that exploration for oil is actively underway on the continental shelf off eastern Newfoundland. Since we now have at hand considerable evidence of the myriad problems which can beset such offshore development activities (the Baltic Sea; Santa Barbara; Gulf of Mexico; etc.), it would be naïve indeed to assume that the eastern Canadian offshore development activities will be completed without serious oil pollution incidents. The consequences of such incidents are now well known to many, if only through the exhaustive documentation of the Santa Barbara catastrophe. Seabirds would suffer enormous losses; marine mammals would be affected, but to an unknown extent. If onshore winds prevailed at the time of an accident, extremely serious damage could result to the inshore fisheries as a consequence of a) the biological deterioration of the shoreline itself, b) the killing and rendering unfit of fish and other commercially important marine species, and c) oil damage to fishing gear. These effects would be augmented by the destruction of aesthetic values of the shorelines, a point of considerable significance to an economy actively interested in promoting tourism.

Oil Pollution Costs, Responsibility, and Contingency Plans

The cost of oil pollution incidents can be high. The British Government is presently sueing the owners of the 61,263 ton American-owned 'Torrey Canyon' for $8,156,000 to pay for the cleaning operation subsequent to its being grounded off the southwest coast of England (2). Lawsuits resulting from damage due to the blowout of one of Union Oil Co.'s offshore wells near Santa Barbara now total more than $2 billion (the value of the oil lost during the first 12 days of the blowout was estimated at something less than $1 million(16).

One reason for the potential extensiveness of damage from an oil pollution incident is the quite large area that even a modest quantity can cover. The thickness of an oil slick is never very great, the actual thickness being determined largely by its viscosity and existing environmental conditions. One British report indicated that 15 tons of oil (type unspecified) dropped into a calm sea covered eight square miles in less than a week (14). Another report of a patch of jettisoned oil found off the coast of Denmark stated that the slick covered an area of 772 square miles, threatening not only the bird life, but also the beaches of both England and coastal Europe.(31). Calculations made by Blokker (7) indicate that 1000 cubic meters (about 1000 tons) of crude oil would spread to cover 78.5 million square meters of water surface in 90 minutes and about 235.5 million square meters (about one square mile) in 10 hours. Thus even a relatively small spill can jeopordize large areas of water and damage extensive coastal shore-lines.

At the present time there is no information available indicating that the Canadian Government has developed contingency plans for the inevitable coastal oil pollution resulting from activities in the Arctic and on the continental shelves, nor for the problems consequent to damage to or destruction of a tanker attempting to negotiate the Northwest Passage. It should be pointed out that neither Britain nor the other coastal countries of Western Europe had contingency plans at the time of the Torrey Canyon disaster; and it was largely the absence of effective contingency plans which resulted in so much uncertainty and confusion both in Great Britain and France concerning leadership and best approaches at the time of the accident. Some appreciation of the need for intelligently conceived contingency plans can be obtained from study of the book 'Torrey Canyon Pollution and Marine Life' (34), and the White Paper on Coastal Pollution prepared for the Home Department of the U.K.(32), both of which carefully document and examine many aspects of the 'Torrey Canyon' disaster.

The extent of damage in several well documented recent cases of catastrophic oil pollution was shown to be materially compounded by the absence of adequate scientific information on the physical behavior and biological effects of oil pollution and upon the chemical dispersants used to control it. An example of the possible consequences of this lack of knowledge was the use of nearly 2 million gallons of detergents by the British Government during the Torrey Canyon episode which, on final analysis, were concluded to be of questionable overall value (27). It would thus seem short sighted indeed for a country as dependent upon its natural resources as Canada, to postpone planning for the inevitable until it was in the process of happening.

The question of ultimate responsibility for the consequences of oil pollution is a difficult problem needing immediate consideration in Canada. The most basic question is: who will pay for the damages resulting from an oil pollution incident? Thomas A. Clingan, Jr., Professor of Admiralty Law and International Law of the Sea at George Washington University, in a recent article in the U.S. Naval Institute Proceedings, May 1969(9) observed:

> "....In view of the enormous damages resulting from a massive spill, the usual channels of the law in such cases, namely the Admiralty courts, may not be adequate to deal with the problem. This is becoming more and more apparent as the size of tankers increases, with the Japanese-built 312,000-ton Universe Ireland leading the way toward the inevitable 500,000-ton - and larger - ships. The prospect of huge tankers carries with it mixed consequences. As size and speed increases, the energy needed to stop the vessel in a given space increases exponentially, and, should a casualty occur, the losses could be five times larger than that incurred by the Torrey Canyon...."

Professor Clingan then argues in favor of the concept of "limited liability", as the best means of shipowners avoiding ruinously high insurance costs.

> "....Assuming that a shipowner is to be asked to be absolutely liable for any oil spillage, and assuming further, that we are to require him to insure to assure payment, then it is only fair to place a reasonable ceiling on his potential liability acts and treaties that are designed to protect shipowners from disastrous claims for damages...."

I find that I am in strong disagreement with Professor Clingan concerning the basic concept of "limited liability" as opposed to that of "strict liability" where the injuring party is fully responsible for his own acts. Application of the concept of limited liability would place a significant portion of the burden of risk for the activities of a profit-oriented special interest group upon the government and/or the general public. To abrogate the rights of the government or the individual, by treaty or any other means, to just compensation for incurred damages seems unethical and, probably, unconstitutional. It is difficult to see how it would contribute to a greater sense of responsibility for the environment, a need so clearly demonstrated and documented in the petroleum industry's recent activities in Cook Inlet, Alaska. It is also worth noting that U.S. Secretary of Interior Hickel has recently proposed that there be no dollar limitation on liability for U.S. oilmen, for reasons essentially similar to those provided above.

In any event, there are serious questions yet to be resolved concerning liability for the environmental, and individual property, damage which will inevitably result from oil exploitation activities in Canada. The decisions reached on this question will have important bearing on the development of contingency plans and, indeed, on the overall Canadian policy concerning environmental protection from destructive oil pollution events.

International Cooperation and Communication

At the present time Canada has but one official contact with IMCO, through the Department of Transport. Partly because of this, and partly because of the largely technological and administrative orientation which DOT has historically had toward marine oil pollution, Canadian promotion of scientific investigations of oil pollution at the international and national level has been singularly lacking. It has proven difficult to obtain information relevant to international scientific activities through the Canadian DOT, and information flow from IMCO and other international bodies to potentially interested Canadian governmental agencies and research institutions has been poor.

The National Research Council of Canada maintains in London a Scientific Liaison Office, whose normal functions include the fostering of information exchange and program coordination at the international level. This Scientific Liaison Office is admirably equipped to carry out the kind of liaison between scientists and scientific groups of different countries, and between Canadian scientists and international organizations such as IMCO, UNESCO, and FAO which is so badly needed at the present time. Delegation of responsibility for the scientific aspects of oil pollution to the Canadian Scientific Liaison Office in London would appear to be an effective solution to the problem.

Communication between interested scientists and organizations has also been hampered by the lack of a suitable international forum for reporting research results, proposed projects, and circulating other information which could materially improve research coordination and reduce duplication of effort. One constructive attempt to correct part of this deficiency is to be found in the Bulletin of the North East Marine Pollution Programme, under the editorship of Prof. R. B. Clark, University of Newcastle upon Tyne, England. This useful periodical, which has been experiencing serious financial problems because of inadequate support from government and industry, reviews ongoing and proposed pollution research programs, and provides a forum for discussion of current problems of significance in environmental biology, with special reference to pollution. This important effort constitutes the only significant attempt at present to promote communication between scientists in this field, and despite the financially imposed limitations on scope and readership, is proving of great value in reducing duplication of research programs and facilitating coordinated research effort.

Recommendations

The following series of recommendations arises from detailed consideration of the broadly biological problems associated with oil pollution in Canada. In developing these recommendations, careful study was made of current and proposed research programs in Western Europe, the United Kingdom, and the U.S. The British activities in this field are of special interest, for the 'Torrey Canyon' episode sensitized the U.K. to the magnitude of oil pollution problems and catalysed a substantial research effort into the problem. The British government is at the present time clearly the world leader in oil pollution research. In 1968 it appropriated a total of $395,900 (Canadian equivalent) for the various phases of its program, which include investigation of:

1) effects on marine life and waterfowl;
2) burning of oil in stranded tankers and on the sea surface;
3) effects of natural factors on movement, dispersal and destruction of oil on the sea surface;
4) oil sinking, scavenging and gelling agents;
5) less toxic detergents and improved equipment for application;
6) mechanical removal and inexpensive booming methods;
7) cargo transfer from disabled tankers.

Clearly, actions of a more purely administrative and technological nature will also be required if Canada is to effectively deal with the issue. However, these areas are beyond my sphere of competence. Certain of the following recommendations can be implemented by a redeployment of existing manpower and resources. In some cases, however, new programs will have to be instituted in order to achieve the desired ends.

With respect to the financing of proposed new programs, it can be pointed out that ultimately the petroleum industry itself will be a major recipient of the benefits, through reduced insurance costs, improved public relations, and assistance in the solution of industry-wide problems. It is thus considered only appropriate that some of the cost for such programs be borne by the petroleum industry, via direct contribution or an appropriate tax mechanism. Segments of the industry have already demonstrated their concern and sense of responsibility by supporting research activities, and the enlargement of this activity on a more formal basis is believed a very desirable goal.

The successful resolution of Canada's oil pollution problem will come only if a maximum integration of total effort is achieved. Especially important is the need for industrial/government/university collaboration in all facets of the endeavor. By working together - in the sharing of resources, the allocation of research activities, and most important the recognition of joint responsibility to society for providing a prompt and intelligent solution to the problem - can we expect to achieve the desired goals of preservation of environmental quality and sustained viability of the oil industry.

Recommendation 1: instigation of a biologically and oceanographically oriented research program in the North Atlantic and the coastal regions of eastern Canada with special reference to seabirds and other important marine species. Its purposes are to:

1) determine the present causes and patterns of oil pollution;
2) evaluate the influences of ocean currents and winds upon such pollution;
3) analyse the consequences of seasonal movements and distribution of seabirds, seals, and other important species which are subject to oil pollution;
4) determine the present magnitude and nature of seabird oiling at sea;
5) determine the relationship of shoreline data (oiled birds, oil, etc.) to events at sea;
6) study and predict the pollution potentials from offshore oil exploitation activities, with special reference to the development of pollution control mechanisms and functional contingency plans;
7) recommend, ultimately, ways in which marine oil pollution and its deleterious effects in the study area can be alleviated.

Recommendation 2: instigation of a research program into the biological effects of marine oil pollution upon the hyponeuston, or the surface and immediate subsurface biotic community which is so critical to the continued productivity of the oceans. This program would study the:

1) dynamics of oil dispersion in the upper ocean layers with special reference to the proposed 60 liters per nautical mile oil dumping convention;
2) toxicity of various hydrocarbons to hyponeuston organisms;
3) toxicity of oil spill removers to hyponeuston organisms;
4) effects of oil slicks (as opposed to dispersed oil) upon the neuston and hyponeuston communities;
5) evaluate the overall biological effects of the phenomena under study so as to provide a sound biological basis for conventions, treaties, or other administrative approaches to the disposal of oil at sea.

Recommendation 3: instigation of a research program into the biological effects of oils in arctic and subarctic waters. This study, of critical importance at the present moment, should investigate the following aspects of the overall problem:

1) seasonal biochemical decay rates for various types of polluting oils;

2) physical behavior (distribution, dispersion, mixing, etc.) of oils released in arctic and subarctic coastal environments;
3) influence of ice on dispersion and evaporation of oil fractions;
4) biological effects and ultimate fate of "beached" oils;
5) effects of oils upon wildlife species of interest and importance, including the marine mammals, with special reference to a) damage to food sources, b) direct physical effects, c) physiological or toxicological effects, d) effects upon habitat (e.g. breeding areas) of ecological significance.

Recommendation 4: carrying out of a national survey to identify sites of special importance, leading to development of critical area protection programs. The criteria for evaluating sites of special significance should include:

1) ecological significance to wildlife and/or man;
2) aesthetic (recreational, scenic) values;
3) presence of highly susceptible life forms (e.g. Atlantic seabirds and inshore waterfowl);
4) presence of rare or endangered species (e.g. Razorbill, Greater Snow Goose);
5) uniqueness of area as representative of Canadian habitats.

This survey should definitely be linked with the present Canadian activities in the International Biological Programme (IBP). There is now underway throughout Canada a national effort, coordinated through the National Research Council, to identify, describe, and delineate areas of special ecological significance and which represent samples of the natural diversity of the Canadian environment. This ongoing program could readily be enlarged to encompass the proposed critical site survey, or to facilitate its completion with advice and technical assistance.

Recommendation 5: instigation of a research program into the biological effects of present and proposed refinery and petrochemical plant operations (e.g. at Holyrood and Come-by-Chance), with special reference to;

1) effects on shoreline biota;
2) effects upon hyponeuston (e.g. lobster larvae, herring and cod eggs and larvae);
3) development of means for containing oil contamination (booms, etc.) to avoid contamination and to minimize its damaging effects once a spill has taken place.

This study has special relevance to such commercially significant areas as Placentia Bay, where a major oil port is in process of development. It should be undertaken prior to design and construction, providing important baseline data.

Recommendation 6: development of a truly effective national system for locating, reporting, and identifying the sources of oil pollution circumstances. Implementatio of such a system must begin at the ministerial level to assure interdepartmental and interagency cooperation and integration. One or more "Coordination Centres" should be established, which would receive reports of oil pollution and coordinate investigations. Resources of the following groups should be utilized to locate oil pollution situation:

1) Department of Transport (ships, planes and field personnel);
2) Department of Fisheries (ships and field personnel);
3) Canadian Wildlife Service (field personnel);
4) Provincial Governments (field personnel);
5) natural history and conservation organizations;
6) Canadian Armed Forces (field personnel);
7) Department of Energy, Mines and Resources (field personnel).

This program could be effectively implemented through a high level directive to these government agencies listed above, providing for the prompt reporting to Coordination Centres of any oil pollution circumstances. Cost would therefore be limited to that necessary to establish one or more Coordination Centres. It is desirable that the first Coordination Centre be established in a region where oil pollution is an existing problem, preferably at a university. A pilot program of 2-4 years should be run by the university either independently or in cooperation with Government, to develop the most effective means of coordination. At the end of this time the Coordination Centre could, if Government desires, be turned over to an agency of Government for permanent operation. Both the Memorial University of Newfoundland and Dalhousie University are well situated geographically to conduct such a pilot Coordination Centre program.

The principal functions of such a Coordination Centre would be to:

1) establish contact with field observers and to promote prompt and accurate reporting of oil pollution circumstances;
2) to coordinate investigations and to provide relevant data to those agencies responsible for natural resource protection and prosecution of pollution regulation violations;

3) to provide chemical analyses of polluting oils;

4) to advise government of existing pollution trends or incipient pollution conditions which may threaten the natural resources of the country, and to provide information on new developments in oil pollution control as it becomes available.

Recommendation 7 : development of a National Contingency Program, with special reference to :

1) blowouts and other accidents to offshore oil drilling and pumping facilities;
2) pipelines and storage facilities, both on land and underwater;
3) tankers and other oil-carrying vessels inshore and at sea;
4) Northwest Passage tankers (a special case requiring special treatment);
5) bay and estuary oil handling sites (Come-by-Chance; Holyrood, etc.);
6) shoreline sites of special significance;
7) rivers, lakes, and other freshwater locations;
8) the Arctic environment, an especially vulnerable region.

In every case contingency plans should include thorough consideration of:

1) wildlife and fisheries values;
2) protection of valuable plant and animal communities;
3) human safety and aesthetic or amenity values;
4) the several alternate "best means" of alleviating the pollution while minimizing damage;
5) ultimate responsibility and liability for damage, both to property and to the environment;
6) regulations and legislation which will minimize the likelihood of damage from recognized sources of danger.

The present British effort toward development of a National Contingency Program for the U.K. should be studied and where applicable its procedures adopted by Canada.

Recommendation 8 : development of national criteria for environmental protection, to be included in all oil leases, construction contracts and other agreements where the activity presents some probability of risk to the environment. Such criteria should include:

1) the provision for unlimited liability of the developer;
2) utilization of best available environmental protection devices and procedure
3) careful policing of activity sites during and after development activities;
4) designing of development programs which would maximally harmonize with other uses and values of the environment.

While the need for rational criteria applied to development relates most immediately to the oil exploration and development activities in Arctic Canada, it is clear that most development programs would profit from such criteria and activity guidelines.

Recommendation 9 : improvement of international coordination and communications. This is critically important during the coming decade of rapidly expanded research activities in oil pollution, and can be significantly upgraded by:

1) delegation of responsibility for all international aspects scientific research on oil pollution to the Canadian Scientific Liaison Office, London;
2) financial and other assistance to the Bulletin of the North East Marine Pollution Programme, with the explicit aims of promoting the enlargement of its scope and readership.

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