EPILOGUE ENVIRONMENTAL SAFETY

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There has been much speculation and public concern about the effects of offshore petroleum exploration activity on the plants and animals that comprise the biological component of the marine environment. Offshore exploration is normally conducted in areas of relatively shallow water, areas which are often productive fishing grounds. As exploration, and, ultimately, production increase, so too will the risk of pollution and public concern about its consequences.

Under normal operations an exploration drilling activity is relatively clean, compared with other maritime activities. A minimum of pollutant materials are released into the environment and these are generally of negligible consequence. Modern drilling units are equipped with sewage treatment facilities, and kitchen wastes and other garbage are usually transported to shore for proper disposal. The cuttings from the actual drilling, soaked in the drilling mud that is used in most offshore drilling programs, are disposed of over the side. Only in exceptional circumstances have drilling muds produced any measurable effect on the environment. In most other regards the exploration drilling activity is no more disruptive of the natural environment than is fishing or merchant shipping activities. The major environmental threat is posed by the hydrocarbons themselves which are the object of this drilling activity.

Should there be a catastrophic failure of the devices and procedures used to control the pressure in the well, a blowout will occur and reservoir fluids will make their way to the surface. These could be water, gas, oil or condensates. There have been some notable blowouts, such as occurred on the Ekofisk field in the North Sea in 1973 and at the Ixtoc well in the Gulf of Mexico in 1979. Blowouts are unusual events, rare in the offshore. The threat posed by them is real, however, and to date there have been two such losses of well control on the Scotian Shelf. Fortunately, as yet no environmental damage has resulted from these incidents. A blowout carries with it the threat of an uncontrolled release of oil for a protracted period of time until well control can once again be obtained; the Ixtoc blowout, for example, lasted for nine months.

It has been said that "the advance of technology carries within it the threat of destruction" but it is equally true that advancing technology will lead either to more effective means of minimizing the effects of pollution or to more efficient and advanced means of preventing it. As both industry and government improve their monitoring systems, and as new technologies in well control are developed, risks to the environment become progressively minimized. In a more global context, as the exploitation of oil takes place closer to its point of consumption, the reduced tanker traffic may, in fact, result in less rather than greater pollution from oil spills. Even with present technology, the occurrence of blowouts can be minimized and their

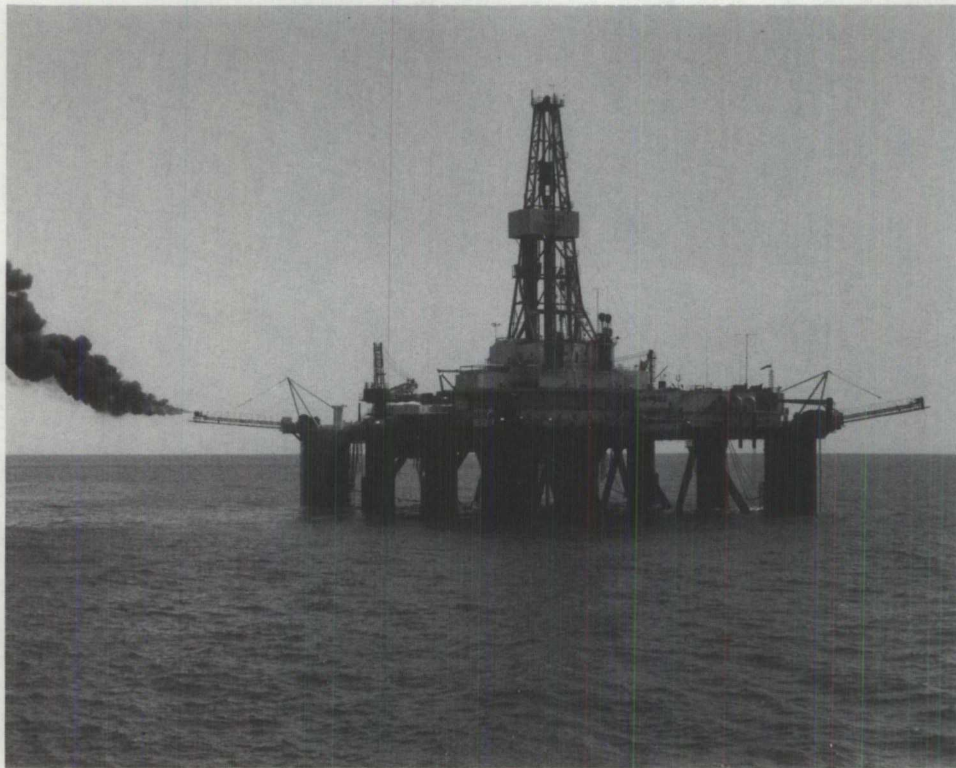

FIGURE 1. A semisubmersible drilling rig engaged in well testing on the Grand Banks. Oil, gas and condensate which flow from the well during testing are disposed of by burning.

effects controlled to some degree through various methods. Some of the equipment used in response to an oil spill such as booms to contain the oil, skimmers and absorbants to recover it, and dispersants to break up the slick have been used with varying degrees of success in different locations and under various circumstances. Nonetheless, the ability to contain and recover spilled oil in the open ocean under any but relatively calm conditions is minimal. Research and development have led to improved devices and products based on earlier experiences, and the toxicity that was characteristic of the previously used dispersants has been vastly reduced in the new products.

In many locations off eastern Canada, an oil spill could very well be driven offshore into deeper waters by the prevailing wind and currents. If the oil were to come ashore, however, its effects would vary with the nature of the coastline. In high-energy areas where the coastline is exposed to wave action, oil is weathered relatively quickly and its effects are transient. On low-energy beaches and marshes, however, oil is persistent and its effects are prolonged. Oil will also foul fishing gear, fishing vessels and wharfs. The public perception of the disastrous effects of oil spills has been almost exclusively associated with the shoreline damage created by the release of a huge volume of oil over a relatively short period of time and close to shore, as occurs with the loss of an oil tanker. This review, however, addresses the environmental risks and biological effects of a different type of oil spill, one that occurs at sea and involves a prolonged release of oil, albeit at a much lower rate than can occur from a supertanker spill.

The relationship between different forms of marine life can be described as a food web made up of many connectors, or, it may be likened to a pyramid, with a broad base representing many individuals supporting fewer individuals above it, the numbers decreasing at each level until finally the apex is reached, which may represent, for example, seals. All levels of the web or the pyramid are supported by a larger base beneath, forming a food and energy source for the levels above. Break the web, or destroy the pyramid and the entire community is disturbed, distorted or destroyed. At the base of the pyramid are the bacteria, then the microscopic, planktonic plants or phytoplankton (the producers of organic material in the sea), above which are the consumers which are basically incapable of producing organic matter and must gain it at the expense of the producers (the phytoplankton), for example the planktonic animals (zooplankton) upon which the fish and birds feed.

The consequences of an oil spill on the phytoplankton off eastern Canada, particularly on those forms suspended or drifting in the upper water column, will likely be undetectable and negligible. The worst effects will be restricted to definite areas of high level contamination. In the open sea, the effects on fish stocks of the suppressed production of primary organic material resulting from the mortality of phytoplankton will be slight, if indeed detectable. Not all primary organic producers are planktonic, however, nor are they adrift in the water column. Some are found on the seabed in relatively shallow water as well as on submerged structures. The effects of oil spills in these cases will be local.

At the next level in the food web are the microscopic animal drifters or zooplankton. The same generalizations concerning the effects of oil spills on phytoplankton will apply to them as well. Fish eggs, larvae and juveniles are much more vulnerable to oil than are the adult fish. Investigations have shown that they are less capable of detoxifying petroleum hydrocarbons, and are insufficiently mobile to escape and thereby avoid contamination. Many eggs and larvae are buoyant and, as a consequence of their immobility, they can be exposed to oil at the surface long enough for high mortalities to occur. This effect is obscured because at these stages of the life cycle fish have a natural mortality rate in the order of up to 10 percent daily. As in all other cases, the impact of oil on these forms of fish life is influenced by a multitude of factors, including the configuration of the water basin itself, its depth and the pattern of the water currents. On mature fish the effect will probably be insignificant. Fish have the ability to swim and move about, and they can therefore escape areas which come under the influence of pollutants. Further, there is evidence that adult fish have the ability to detoxify hydrocarbons. Nonetheless, biochemical evidence does exist indicating that there are effects from exposure of some adult fish species to oil, which are not measurable in terms of mortality. Pollutant-induced pathological changes in their gills, liver or eye-lens tissue have been reported and these could, in time, take their toll.

Information on the effects of oil on marine mammals is extremely limited, as there have been very few definitive experimental studies conducted to date. Their lifestyle, their habits and their rearing of young cause both adults and young to be potentially liable to come into contact with oil. The colonial habits of most seals and of some other marine mammals expose whole populations rather than just individuals to the effects of discharges of oil. It has been learned through short-term experimentation that exposure to relatively high concentrations of oil causes a loss of thermal insulation and of waterproofing as well as causing irritation to the eyes and the exposed mucous membranes. The long-term effects of a seal being coated with relatively large concentrations of oil are not known. Biochemical information indicates that, unlike fish or marine invertebrates, marine mammals have efficient mechanisms to permit the mammals to metabolize the hydrocarbons and it is unlikely that the ingestion of small quantities of oil would seriously harm these animals. It is not known, however, whether marine mammals possess the ability to avoid areas of oil spills since field observations have indicated that they do not necessarily navigate away from areas of oil contamination.

The highest biological risk factor involves sea birds. The coast of eastern Canada supports several million breeding pairs of marine birds comprising the majority of the western Atlantic population of all marine bird species except Dovekies and Roseate Terns. Ornithologists have concluded that the Grand Banks are the single most important feeding area for marine birds in the North Atlantic. For this fact alone oil

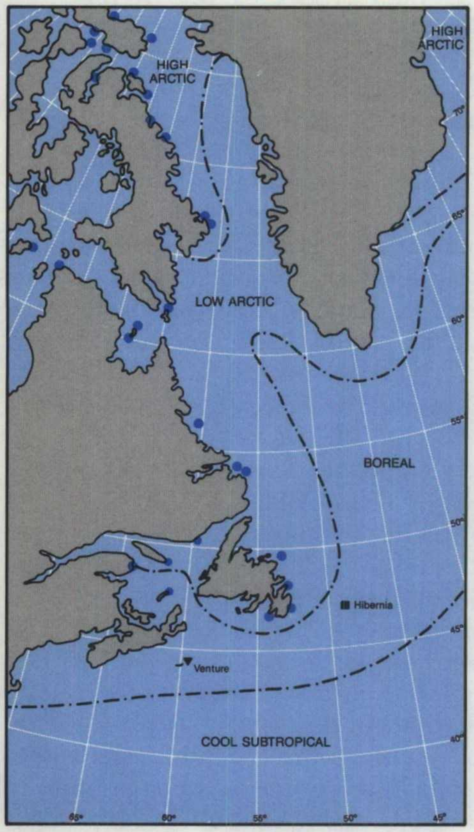

FIGURE 2. The major sea bird colonies of eastern Canada.

spills offshore take on their greatest biological significance. It is also recognized that the sea bird colonies assume a great importance in the public consciousness since the effects of oil spills on bird populations are readily apparent, even to the most casual observer.

A summary of marine bird populations breeding in four areas of eastern Canada (Nova Scotia, Newfoundland and the Gulf of St. Lawrence; Labrador; Hudson Strait and Hudson Bay; and the High Arctic) is presented in Table 1. Reference to this table will indicate that the vast majority, about three million birds, are concentrated in eastern Newfoundland. The major sea bird colonies in eastern Canada are shown on the map in Figure 2.

Information on the distribution of birds foraging away from these colonies during the breeding season is only partially known. A high proportion of Atlantic Puffins and Common Murres from the colonies in eastern Newfoundland are believed to feed within a few kilometres of the shore during capelin spawning periods. On the other hand, pelagic species such as Leach's Storm Petrel and the Northern Fulmar range widely, and reportedly cover extensive portions of the continental shelf. Thick-billed Murres breeding in Lancaster Sound and in Hudson Strait are known to forage up to 120 kilometres from their colonies. In Labrador, Atlantic Puffins, Common Murres, and Razorbills forage up to 40 kilometres from their colonies on the Gannet Islands. From these observations, it is evident that these species venture to sea and may enter areas of oil spill.

In addition to the breeding birds, the numbers of avian species and individuals are augmented in the summer months by visitors from the southern hemisphere spending the austral winter in Canadian waters. The most important of these is the Greater Shearwater, of which several million visit the Grand Banks annually from July to September, extending as far north as Greenland. Smaller numbers of Sooty Shearwaters come north to Newfoundland, and substantial numbers of pre-breeding Northern Fulmars from the eastern North Atlantic populations also visit the Grand Banks and even further north.

In addition to all these, the marine birds from the high Arctic, from eastern Canada and from western Greenland are supplemented in winter by emigrants from the eastern Atlantic, with birds coming to Newfoundland and to the Labrador Sea from as far away as Spitzbergen and northwest Russia. Although it is difficult to determine their populations precisely, these winter visitors have been estimated to be more than 19 million birds in addition to the large numbers of Common Eiders and other ducks which stay throughout the winter.

The avian population placed in risk by oil pollution is therefore very large indeed. Relatively little is known about the actual migration corridors or the important staging areas of pelagic birds. What is known, however, is that a large proportion of them, whether native or visiting, would be potentially exposed to pollution if an oil spill should occur. Many would be young-of-the-year, compelled to spend much of their migration time on the water, and thus most susceptible to the pollution.

Sea birds have very few predators other than man. That man does prey upon sea birds is confirmed by the fact that between one-quarter and one-half million murres, mainly Thick-billed Murres are shot annually in Newfoundland and Labrador.

Sea birds die from a combination of causes when they come into contact with oil. Oil may mat their feathers to such an extent that they become incapable of movement. Soiled plumage loses its insulating properties and the bird must expend more energy than usual on thermal regulation. The oil can also be transferred to incubating eggs with a consequent reduction in hatching rates. At lower intensities of oil coverage, birds swallow oil while preening and suffer from a variety of toxic effects including increased metabolism and decreased digestive efficiency. It is not

TABLE 1
Summary of Marine Bird Populations (Individuals x 1000) Breeding in Four Areas of Eastern Canada

SPECIES	NOVA SCOTIA NEWFOUNDLAND GULF OF ST. LAWRENCE	LABRADOR	HUDSON STRAIT HUDSON BAY	HIGH ARCTIC
Northern Fulmar *(Fulmarus glacialis)*	(1)	(1)	—	720
Leach's Storm Petrel *(Oceanodroma leucorhoa)*	1600	(1)	—	—
Northern Gannet *(Sula bassana)*	51	—	—	—
Cormorants *(Phalacrocorax carbo, auritus)*	22	—	—	—
Common Eider *(Somateria mollissima)*	76	40	200	50
Large Gulls *(Larus argentatus, marinus)*	>50	>10	>5	>10
Black-legged Kittiwake *(Rissa tridactyla)*	219	(1)	10	180
Arctic Tern *(Sterna paradisaea)*	>1	>1	>10	>5
Razorbill *(Alca torda)*	8	38	(1)	—
Common Murre *(Uria aalge)*	1023	112	—	—
Thick-billed Murre *(Uria lomvia)*	5	19	1340	1280
Black Guillemot *(Cepphus grylle)*	>5	>5	>40	>20
Atlantic Puffin *(Fratercula arctica)*	511	153	(1)	(1)
TOTALS	3571	378	1605	2265

NOTE (1) Present, but fewer than 1000 individuals.

Source: *Environmental Risks from Offshore Exploration*
Fisheries and Oceans Canada, Newfoundland Region Environment Canada, Atlantic Region January 1984

possible to predict the exact effect of oil on any given species of birds. Some species have been shown to clean themselves without ill effects, while others have succumbed after only a very light soiling with oil.

The species that are most vulnerable to oiling are those which spend most of their time on the surface. Oil in heavy concentrations, as indicated earlier, would affect the birds' food supplies either by destruction or by contamination of lower levels in the food web. Eider Ducks are particularly vulnerable since they feed predominantly on bottom-dwelling animals which filter their food from the water and which may thereby concentrate toxic substances.

It has been estimated that a major oil spill at the Hibernia site can be expected to move across areas on the continental slope at the edge of the Grand Banks, which support large concentrations of marine birds throughout the year. Species particularly at risk would be, in winter, Common and Thick-billed Murres and Dovekies and, in summer, Northern Fulmars and Greater Shearwaters. A worst case scenario, one involving a slick of oil covering 1,000 square kilometres, could kill as many as one-fifth of Dovekies and Murres wintering off Newfoundland. Of equal significance is the fact that a spill of that dimension would probably be felt in all transient populations, and that at best they would take several years to recover.

A major spill in the Labrador Sea would have greatest effect on sea birds in September to October when large numbers of Thick-billed Murres, Northern Fulmars, Black-legged Kittiwakes, and Phalaropes pass through the area. At worst, a

FIGURE 3. Drilling in the Labrador Sea is possible only during the summer and early fall, when the area is relatively ice-free. The drilling season coincides with the arrival of vast numbers of migratory sea birds.

large proportion of the young and flightless as well as the adult Thick-billed Murres from colonies in Hudson Strait would be drastically affected.

The use of dispersants to combat oil spills would benefit sea birds in a polluted situation. Dispersants, however, enhance the release of toxic properties of the oil until it is incorporated into the water column and place other forms of marine life in greater danger than that posed by a spill alone. Where sea birds are not greatly at risk, the benefits of the use of dispersants would have to be weighed against possible adverse consequences for fish larvae and marine invertebrates.

Oil pollution in the offshore environment will have an effect upon all levels of life within the marine ecosystem from bacteria, plants and lower animals, fish and mammals to birds. The mode of life of some marine forms will cause greater exposure and result in greater susceptibility than for others. Commercial species of fish will be the least exposed and sea birds the most endangered. Greater threats to marine life and the marine environment are posed daily from the activities of ships passing through the areas in question, and particularly the discharge into the water of their oily bilges. The potential harm from bilge exceeds that from oil spills.

The potential for oil pollution, whether due to exploration, production or maritime activity, is likely to increase with an escalation in activity along the East Coast. The negative consequences of future oil pollution will depend on a number of factors including the chemical and physical properties of the oil, the volume spilled, the location of the spill, the prevailing weather conditions at the time of the spill, and the nature of the segment of the biota affected. It can be expected that oil pollution may have serious, though temporary, local consequences for most populations on the lower ends of the food chains, with a consequent reduction in primary productivity. Particularly vulnerable, and obviously so, are the millions of sea birds that characterize our immediate coastal areas which they must now share with offshore oil exploration and production.

Knowledge of individual organisms, species, and populations at all levels of productivity in the marine environment is needed. The study of the effects of pollutants on the living components of the marine environment is a proper and desirable investigation for biologists and ecologists to undertake. The risk of environmental disaster is a challenge for them to solve by providing the information needed to assess the results of offshore operations, and thus to calculate appropriate limits for those operations.