The Arctic Oil Rush

and

Attendant Conservation Problems

by

A. H. Macpherson

and

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Introduction

Oil, as the cheapest, most easily obtained and transported, and most convenient of energy sources, is a major economic fact of life throughout the world. Oil as much as any single factor has enabled humanity to perform the technological wonders of today. As the basis of the modern agricultural revolution, the fuel for tractors and the source of agricultural chemicals, oil has enabled human populations to soar far beyond the limits of sustained resource yield. Some people believe that the using up of world oil reserves will presage the fall of man from his pre-eminence in nature, by forcing him to return to a less dominant position in the biological community. Others have warned that the rapid burning up of these huge fixed carbon reserves may have catastrophic effects on our environment: sulphur dioxide from the chimneys of Western Europe is already believed responsible for acidity in rainfall and decreasing growth rates in Swedish forests.

The oil consumption of the world is rapidly rising. Coal mines close, finding it impossible to compete with oil wells, even thousands of miles away. A part of the increased consumption is due to human population increase:

more people mean more cars to run and more houses to heat. But per capita energy use is also rapidly increasing. In developing countries, oil needs increase as agriculture is modernized and industrialization proceeds: in developed countries oil consumption increases as standards of living rise. In 1967, it was estimated that world consumption of oil was about 12 billion barrels, up 2 billion barrels from the 1964 estimate of 10 billion. The free world consumption was 22 million barrels a day, and is expected to reach 50 million barrels a day in 1980. In the U.S. alone, daily consumption in 1968 was estimated to be 13 million barrels, and in 1980 predictions are that it will reach 18 million. We are now using every year the equivalent of about 1/12th of the entire world consumption of oil in the last 100 years.

How long can world reserves last? In the United States, the level of reserves has been steadily falling, and the deficit of consumption over production growing steadily from its present level of some 4 million barrels per day. However, the world's total proven recoverable reserves

amount to 420 billion barrels, enough for thirty years or so at the present rate of increase, and oil exploration activity is increasing them at the rate of some 30 billion barrels a year, or by over twice as much as consumption.

There are doubtless very large volumes still to be found, and others that will be recoverable as market demands influence the economics of recovery. The Athabasca tar sands, for example, are believed to hold some 600 billion barrels of recoverable oil, and the Canadian Petroleum Association recently estimated a total Canadian recoverable reserve of 120 billion additional barrels. Exploration activity is not merely a response to falling reserves: its intensity and location respond also to geopolitics, and doubtless the present interest in oil from the Arctic stems in part from fears for the continued accessibility of oil from the Middle East, Africa and South America for the huge market of the developed world. Military power and political independence depend on secure oil supplies as never before, and arctic oil exploration owes much of its impetus to this fact. The Middle East, with its 300 billion barrel reserve and cheap production, still dominates a large proportion of the world's petroleum market.

Arctic Oil Production and Exploration

Huge reserves of oil are suspected to be present in all the large sedimentary basins of the Arctic. These quantity ~~figures~~ can be roughly estimated from the volumes of sediments. For the Canadian arctic islands estimates range from 50 to 150 billion barrels. The arctic extension of the sedimentary basin of Western Canada may contain some 35 billion barrels: adjacent areas of Alaska are believed to hold about the same amount again. The Hudson Bay sedimentary basin may hold another billion barrels or so. Altogether it has been suggested that 100 to 300 billion barrels of oil will be found in the Canadian Arctic and Alaska.

Exploration for oil has been held up in Greenland until recently by law which made it impossible for a company to obtain extraction rights until deposits had been located. The oil companies are now showing interest in the continental shelf off Western Greenland, and it is expected that leases will soon be negotiated. There is an active exploration program on Svalbard. In the U.S.S.R., the great oil-fields of the Pechora, and of the Ob and Taz river basins are being developed. Gas has already been found

near the mouth of the Ob near the Arctic Ocean, but the oil-fields south to the Kuznetsk Basin east of Novosibirsk appear to be satisfying current Siberian demand and placing central U.S.S.R. in an oil export position.

The arctic environment presents enormous problems for oil exploration and drilling, and costs are necessarily very great. Oilmen say that it has cost them $1.5 million a well, or five times the industry average, to drill in Alaska. The three wildcat wells drilled in the Canadian Arctic islands have cost considerably more - $1.5 to nearly $2.2 million. Remoteness is very costly; labour costs are high (productivity in extreme weather may be only 30% of normal), transport is expensive, and the lack of services means that the companies must make provision for all eventualities on site. The lack of the services that are taken for granted farther south is illustrated by transport to the Alaskan North Slope. Cargo planes are so scarce in the region that the companies are said to have had to use land transport even at considerably greater costs per ton delivered. Transport by sea is possible to the Mackenzie River and the eastern half of the Canadian arctic islands, but insurance costs are high and the season is very limited.

Another major problem, and one that greatly concerns the public and the scientific community, is the fragility of the arctic landscapes. The Minister responsible for northern development in Canada, the Hon. Jean Chrétien, has pointed out how easily the landscape is marred by vehicles and how long it takes to recover. Part of the problem lies in the slow growth and regeneration of the vegetation. Another is in the slow rate of decomposition of junk and organic refuse. A third part is due to the small annual precipitation and run-off.

This problem of landscape damage is universal in the arctic lands. Where it is most evident and serious, however, is in the areas of deep, unconsolidated sediments, and here it reaches dramatic proportions. Unfortunately, in the region of the Mackenzie River delta and on the Alaskan Arctic Slope, where oil companies are most active, the landscape is least able to endure heavy use. Imperial Oil Limited has quickly brought the problem to public attention. Officials of this company have reported on their experience in detail at the Third Canadian Conference on Permafrost in Calgary (January, 1969) and at the Canadian Transportation Research Forum in Toronto (May, 1969).

Briefly, the problem is that the material near the surface of such unconsolidated sediments is composed to a great extent of ice. In summer, the ice in the upper layers turns to water, until the wet blanket of vegetation and soil attains a depth great enough to insulate the remaining ice. When some of this material is bladed off with a bulldozer to obtain a firm surface, melting will continue into the permafrost, water will run into the hole, the sides begin to slip, and a large gully begins to develop. Any damage to the terrain will begin the process: damage by construction, tracked vehicles, fires and seismic lines included.

Drilling also presents particular problems. If the drill pipe is withdrawn, unconsolidated material from the sides tends to fall into the drill-hole. British Petroleum Company Ltd., and other companies also, are experimenting with new drilling muds and new drilling techniques.

Because of the lack of solid rock, the well must literally hang on the layer of permafrost, 800 to 1200 feet thick, near the surface. The operators are forced

to protect this vital junction, using insulation and even refrigerating plants. When large volumes of oil begin to flow, the difficulty will be enormous. Oil leaves the ground at a high temperature, perhaps 150° or 200° F, and some very efficient methods of carrying off the heat and of insulating the pipe, will be required.

The Arctic presents also great difficulties and hazards in transporting oil to market. The preferred bulk carriers are ships and pipelines. Shipping at present is confined to a very brief season. Very large ships may offer efficiencies of scale in the ease of ice navigation as they do in the costs of bulk transported, and the S.S. Manhattan, a specially strengthened tanker of 115,000 tons deadweight, is being tested on the Northwest Passage route this summer by a consortium of oil companies. If she is successful, it is planned to build a fleet of six 250,000 ton tankers for year-round service to arctic loading facilities. Ships of whatever size and power will, however, always be vulnerable to collision with ice, ice pressure and damage by collision or shipwreck in the narrow channels of the Arctic. Pipelines also

present enormous problems. If the permafrost is not protected from the heat which they give off, experiments indicate that the ground upon which they rest, or in which they are buried, will rapidly subside, leaving sections of pipe suspended and liable to breakage. Hanging the pipelines, the only obvious solution, will require the building of immense numbers of pilings. As is well known, an 800 mile, 48 inch, $900 million pipeline is planned to carry Alaskan North Slope oil to Valdez on the Gulf of Alaska. A break in such a pipe would release oil at the rate of nearly half a million gallons per mile drained.

These are a few of the problems faced by the oil industry and public interests in arctic lands. There are others for which solutions will be required, for example before off-shore drilling can be considered possible in the zone of arctic pack-ice, which is prevalent in all the waters of the Canadian Arctic and off the Alaskan north coast. Studies have been made of submarine tanker feasibility, but the capital costs would probably be two to three times those of surface vessels of similar speed and capacity. So far this problem appears to have daunted the industry.

The problems of oil pollution are obviously worse in the northern part of the U.S.S.R. than they are in Northern North America. Priroda last year carried an article by a fisheries official, B.G. Burdiyan, who attributes a drastic decline in the huge fisheries resources of the Ob-Irtysh river basin to pollution, largely from the oil and gas industries, which in 1964 dumped some 5 million M^3 of effluent per day into the Ob basin. Burdiyan believes that the damage done has been very considerable, one effect being a decrease of about 8 million kg of fish per year, or 16 per cent, of an average annual catch of some 50 million kg. Mr. Burdiyan seems to have spoken to some effect: a year later, according to a news report of February 17, 1969 a western Siberian court sentenced two oil-well operators to prison for polluting a river and killing its fish. The engineer was sentenced to three years and the foreman to two years for criminal negligence.

Waste oil from drilling sites flowing into the Volga River is so abundant that ten giant purification plants have been constructed to remove it.

The problems of landscape degradation in the U.S.S.R. are probably very similar to those faced in Alaska and

Canada, except that in addition to permafrost, the drillers in the Ob basin have to contend with extensive seasonal floods.

Oil is at present being extracted from a second arctic area in the Soviet Union, the Pechora River basin west of the Urals.

Conservation Problems in the Arctic

The Arctic is a region of low biological productivity. Each growing season is short: the snow cover, which persists well into June in most areas, hides the vegetation from the sun for eight months or more each year, and reflects back much of the insolation which reaches the arctic lands in spring. The winds, which carry with them an abrasive hail of drifting snow, dessicate and abrade the vegetation of exposed areas. Hence vegetation is scanty and meagre, and annual production is very low. The arctic fauna is of course correspondingly scant.

Chemical processes also are slowed by the low heat regime. Junk degrades imperceptibly; recent explorers report that cans of food left in the Arctic in the last century are palatable, or at least as much so as they

were originally. The living decomposers are equally slow to degrade materials such as wood and paper, and organic wastes such as garbage and sewage. Last year a party dug up the body of Charles Francis Hall, left buried in a shallow grave at Polaris Harbour in 1871: his body had undergone surprisingly little decomposition.

What would happen if a major oil spill were to occur in the Arctic? It seems probable that much greater harm would result than from a similar occurrence in a warmer climatic zone. Much less of the spill would presumably be absorbed in the shallow, sodden arctic soils than would be in more temperate areas. Run-off is comparatively weak because the annual precipitation is under 10 inches in parts of the Canadian Arctic where exploration is active. Ice cover would presumably tends to slow the dispersion of oil floating in the sea by preventing it from being washed onto beaches or emulsified in rough waters. Worse, the degradation of spilled oil will be much slower. The evaporation of the more volatile components, the oxidation of heavier residues, and the biological decomposition of crude oil, all proceed at temperature-dependent rates.

Microbial oxidation seems to be far more important in the destruction of oil at sea than spontaneous oxidation. This is a complex process: many of the responsible organisms attack only particular constituents of the crude oil. An article by D.N. Pilpel in Endeavour (January, 1968) includes the remark, "Below about 5° C it (microbial oxidation) is rather slow and thus hardly proceeds at all in latitudes beyond 75° N or S." The latitude passes to the south of the area of interest in the Canadian arctic islands. More significantly, surface temperatures remain below 5° C the year round in arctic waters, except where large volumes of floating river water raise them locally, as in southern Hudson Bay. For most of the year, they remain at or below 0° C. This problem is clearly an important subject of concern.

The likelihood of pollution is compounded by a number of factors. One may be the public interest in encouraging industry into remote and economically distressed parts of the arctic countries. Another is possibly the indifference that exploiters/industry typically have to wilderness/values, when undefended ~~particularly~~ by strong public pressures ~~wilderness that has few defenders~~. Again, there are not

many areas in which people are more nomadic: in the Arctic there are few of us who have to live with our mistakes. In addition to the hazards posed by environmental conditions and human attitudes, the arctic fish, birds and mammal populations share an Achilles heel: a vulnerability to calamity that seems rare among the animal populations of more equable zones.

Evidence accumulating from several sources, including studies of the Fisheries Research Board of Canada and the Canadian Wildlife Service, suggests that several fish, bird and mammal populations of the Canadian Arctic, and perhaps many of them, experience comparatively frequent reproductive failure. That is, whole cohorts or year-classes fail to survive to breeding age. Consequently several of the best studied vertebrate populations appear to depend inordinately on a very few year-classes. Obviously the recognition of this weakness is basic to management practices, and in particular to the avoidance of catastrophic mortality such as might be caused by a large oil spill.

The Biological Values at Hazard

Direct mortality of wildlife from a large oil gush or a tanker accident could be enormous. Arctic wildlife has a dangerous tendency to concentrate: King Eider drakes, after the hens begin to lay, concentrate in enormous rafts in Baffin Bay: scoters and ~~Old Squaws~~ Old squaws do so as well. Old Squaws are known, from reports of the Baltic population, to be very vulnerable to oil at sea.

We must remember too that many birds are restricted at migration times to narrow flyways. The great autumn outrush of waterfowl and seabirds along the Barrow coastline has been described by such observers as Bailey. In spring heavy oil pollution in open water off the floe-edge in the Beaufort Sea or Hudson Bay would unquestionably trap very large proportions of swan, duck, goose, gull, guillemot, murre, fulmar, jaeger and phalarope populations.

The storm-wrack, thrown onto exposed beaches in fall, often covering a thick accumulation of wave-piled brash ice, is among the first sources of food for returning birds. On Coats Island, I have seen mixed flocks of Purple Sandpipers, Sanderlings, Semi-palmated-Sandpipers,

Turnstones and Knots feeding in proximity to Pintails, jaegers, terns, gulls, longspurs, pipits and Whistling Swans on piles of storm-wrack in early June. An oil spill could coat this food source and make it a lethal trap.

Crude oil is toxic to many birds, and would presumably be also to mammals attempting to remove it from their pelts with their tongues. Polar bears and arctic foxes might suffer on the sea-coasts: muskrats, beavers, mink, otter and lesser species would doubtless be affected by a major oil spill in the delta of the Mackenzie River. I am unaware of how the pinnipeds would fare.

The most permanent potential casualty, and what appears the major value at immediate hazard, is the arctic landscape. A traveller returning from a recent tour of the Canadian Arctic, when asked for his impressions, said "The face of the moon". My first reaction, visualizing the many beautiful arctic environments in which I have travelled, was incredulity, until I realized that he had probably never been off the disturbed ground around airstrips and settlements. If people are to live in and enjoy our

Arctic, as surely they will increasingly find cause to as resources come into production and as the recreation boom expands, we must find ways to preserve its landscapes. And it is not only a question of amenity. Wildlife and fish resources are still worth some $10 million a year in the Northwest Territories, and immeasurably more culturally and socially. These resources depend on productive landscapes.

Present Regulation and Present Needs

Legislation for the protection and conservation of environment and biological values during oil exploration, drilling, production and transport comprises a large, multijurisdictional, complex field in which I have no specialized knowledge. In Canada there are regulations, both federal and provincial (the Minister of Indian Affairs and Northern Development acts in the place of the territorial authority in the Northwest Territories) governing the drilling and production of wells - off-shore and land-based. Guidelines are issued to exploration lease-holders in the Territories urging them to respect the environment, but so far there appear to no mandatory provisions in force to govern the operation of tracked vehicles or the

running of seismic lines and other potentially destructive machines and techniques. A new bill, "An act respecting the production and conservation of oil and gas in the Yukon Territory and the Northwest Territories" contains provisions authorizing the Governor-in-Council to prescribe the measures necessary to prevent pollution of air, land and water as the result of handling or producing oil or gas, but no mention is made therein of landscape damage. It is understood that the Northwest Territorial Lands Act, now in process of revision, will include such provisions, and it is to be hoped that these will be proclaimed in time to prevent more damage. This revised act will fill a very urgent need.

In Alaska, both state and federal authorities are making careful studies. The pace of development has been tremendous and much damage has already been done. The Wildlife Management Institute reported in May that the U.S. Secretary of the Interior had recently appointed a special task-force under the Chairmanship of Russell E. Train, Under Secretary, to prepare guidelines for development on federal lands on the Arctic Slope. A staff team of

Bureau of Land Management specialists is also at work developing safeguards to be written into any permit issued to the oil industry for the construction of the planned 800-mile pipeline from the Arctic Slope to Valdez on the Gulf of Alaska. It is expected that the permit will be applied for in mid-summer.

At present, four agencies govern land-use in various parts of the Alaskan tundra: the U.S. Navy on Petroleum Reserve No. 4, the Bureau of Land Management on public federal lands, the Alaska Department of Natural Resources on lands selected by the state, and the Bureau of Sport Fisheries and Wildlife in the Arctic Wildlife Range.

Petroleum Reserve No. 4 is ~~so far~~ at present closed to exploration, but may not ~~be~~ remain so for long. The Bureau of Sport Fisheries and Wildlife has shown its effectiveness in protecting surface values on the Kenai National Moose Range: so far the Arctic Wildlife Range still remains closed.

The Bureau of Land Management has established guidelines for companies operating on public lands, which include the provision that a B.L.M. District Manager can specify detailed protective stipulations which are mandatory, but surveillance may not in all cases by possible.

Finally activities on state selected lands are governed by restrictions which are based on the authority of the States' Anadromous Fish Act, which is perhaps stretched somewhat in the process. In January of this year additions to the State Laws of Alaska were proposed to minimize surface damage, and there is some expectation that these will pass in their original or perhaps amended form.

Thus in both Alaska and the Northwest Territories, the environmental problems are recognized and appropriate legislation is being framed. The Canadian Committee for the International Biological Program, the Canadian Wildlife Federation, and other groups with interests in environment and wildlife, are doing much to ascertain the exact nature of the problems we face and to bring them to the attention of the responsible Minister and officials. The oil industry itself is being frank and co-operative. Alaska is ahead of us in one respect - in a much more highly developed land classification system, which assigns "highest use" values, doing much to ensure the preservation of uniquely valuable habitats. Canada still seems hesitant to assign priorities and values in her sparsely-settled Arctic, yet every year the public at large makes greater

investments in social capital, railways, etc., to foster extractive industry in the North. The same public is becoming very sensitive to pollution and other forms of environmental degradation. It seems ~~obvious to us~~ unlikely that it ~~won't~~ will be long before development becomes subject to planning based on exact knowledge not only of mineral and fuel resources but also of surface resources, whose very considerable and rising values we now dismiss lightly as intangible. We must work for a whole scale of natural reserves, for the satisfaction of all comers: parks, wilderness areas, scientific reserves and sanctuaries; we must encourage action on legislation for the prevention and the mitigation of surface and pollution damage; and we must encourage and sustain the environmental scientists who will be needed in the future to recognize and preserve what we have left, and restore to us what we need.

ELITE TYPEWRITER

NATURAL HISTORY MAGAZINE Author copy Page 1

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World oil consumption is rapidly rising. Part of the increased consumption results from human population increase: more people mean more cars to run and more houses to heat. But per capita energy use is also rapidly increasing. In developing countries, oil needs increase as agriculture is modernized and industrialization proceeds; in developed countries oil consumption increases as standards of living rise. In 1967, world consumption of oil was estimated at 12 billion barrels (1 barrel = 42 gallons), up 2 billion barrels from the 1964 estimate of 10 billion. The free-world consumption was 22 million barrels a day, and is expected to reach 50 million barrels a day in 1980. In the U.S. alone, daily consumption in 1968 was estimated to be 13 million barrels, and predictions are that in 1980 it will reach 18 million. We are now using every year the equalivalent of about 1/12th of the entire world consumption of oil in the last 100 years.

How long can world reserves last? In the United States, the level of

AQ: Are the 1968 estimates out yet?

reserves has been steadily falling, and the deficit of consumption over production has been growing steadily from its present level of some 4 million barrels per day. The world's total proven recoverable reserves amount to 420 billion barrels, however, enough for thirty years or so at the present rate of increase, and oil exploration activity is increasing them at the rate of some 30-billion barrels a year, or by over twice as much as consumption.

There are doubtless very large volumes still to be found, and others that will be recoverable as market demands influence the economics of recovery. The Athabasca tar sands, for example, spread over an area of some 30,000 sq. miles near Fort McMurray in northern Alberta, are believed to hold some 600 billion barrels of recoverable oil, and the Canadian Petroleum Association recently estimated a total Canadian recoverable reserve of 120 billion additional barrels. Exploration activity reflects not only falling reserves but also geopolitics, and doubtless the present interest in oil from the Arctic stems in part from fears for the continued accessibility of

A.Q. Has the 1968 estimate come out since you wrote this?

A.Q. Do you know of any theoretical estimates of the total world oil supply?

A.Q. Could you locate the Athabasca sands and summarize the difficulties (& costs) of extracting the oil?

and exploitation of part of the deposit has been underway for the past two years. The extraction process involves heating with steam, centrifuging and coking, and is probably marginally competitive with liquid oil production in Alberta.

oil from the Middle East, Africa and South America. Military power and political independence depend on secure oil supplies as never before, and arctic oil exploration owes much of its impetus to this fact. The Middle East, with its 300-billion-barrel reserve and cheap production, still dominates a large proportion of the world's petroleum market.

Arctic Oil Production and Exploration

Huge reserves of oil are suspected to be present in all the large sedimentary basins of the Arctic. For the Canadian arctic islands estimates range from 50 to 150 billion barrels. The arctic extension of the sedimentary basin of western Canada may contain some 35 billion barrels; adjacent areas of Alaska are believed to hold about the same amount again. The Hudson Bay sedimentary basin may hold another billion barrels or so. Altogether it has been suggested that 100 to 300 billion barrels of oil will be found in the Canadian Arctic and Alaska.

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Oil and natural gas are found in geological permeable strata ~~underground~~. They ~~probably~~ are probably derived from the remains of living things, as they are usually closely associated with fossiliferous formations of marine origin.

A.Q. Could you add a sentence or two explaining what the presence of oil implies about the geologic past?

A.Q. Is this part of Alaska the North Slope? Yes

by a law which made it impossible for a company to obtain extraction rights until deposits had been located. The oil companies are now showing interest in the continental shelf off western Greenland, and it is expected that leases will soon be negotiated. There is an active exploration program on Svalbard. In the U.S.S.R., the great oil-fields of the Pechora and of the Ob and Taz river basins are being developed. Gas has already been found near the mouthof the Ob near the Arctic Ocean, but the oil-fields south to the Kuznetsk Basin east of Novosibirsk appear to be satisfying current Siberian demand and placing central U.S.S.R. in an oil export position.

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very costly; labor costs are high (productivity in extreme weather may be only 30% of normal); transport is expensive; and the lack of services means that the companies must take provision for all eventualities on site. The lack of the services that are taken for granted farther south is illustrated by transport to the Alaskan North Slope. Cargo planes are so scarce in the region that the companies are said to have had to use land transport even at considerably greater costs per ton delivered. Transport by sea is possible to the Mackenzie River and the eastern half of the Canadian arctic islands, but insurance costs are high and the season is very limited.

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¶ The potential benefits of arctic oil production are indisputable. They range from increased economic opportunity in remote areas of our continent to more objectivity in attempts to settle international disputes. However, there are also dangers inherent in arctic oil exploration and production, in particular the danger to ~~these~~ the landscape and wildlife amenities of ~~this~~ the fragile ~~type~~ tundra biome.

A.Q. Seems to need more transition to this section.

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A.Q. Where was Hall from, and who left him there?

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Worse, the degradation of spilled oil will be much slower. Evaporation of the more volatile components, oxidation of heavier residues, and biological decomposition of crude oil all proceed at rates dependent upon temperature. Microbial oxidation seems to be far more important in the destruction of oil at sea than spontaneous oxidation. This is a complex process: many of the responsible organisms attack only particular constituents of the crude oil. D.N. Pilpel of the University of London has noted that microbial oxidation is rather slow below about 40 degrees, and thus hardly proceeds at all in latitudes higher than 75° N or S. The area of interest in the Canadian arctic islands is north of 75° N and the Alaskan North Slope? More significantly, surface temperatures remain below 40 degrees the year round in arctic waters, except

A.Q. Can you place Pilpel for the reader?

where large volumes of floating river water raise them locally, as in southern Hudson Bay. For most of the year, they remain at or below 32 degrees.

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species would doubtless be affected by a major oil spill in the delta of the Mackenzie River. We are unaware of how seals, walruses and other marine mammals would fare.

though crude oil is known to be destructive to a multitude of marine organisms, including algae, plankton, fishes and molluscs, important components of the food chains upon which all higher animals depend.

A.Q. What about fish, plankton, etc. You have mentioned fish populations above.

Danger to the Arctic Landscape

Another major problem is the fragility of the arctic landscape. The minister responsible for northern development in Canada, Jean Chretien, has pointed out how easily the landscape is marred by vehicles and how long it takes to recover.

This problem of landscape damage is universal in arctic lands. Where it is most evident and serious, however, is in the areas of deep, unconsolidated sediments, and here it reaches dramatic proportions. Unfortunately, in the region of the Mackenzie River delta and on the Alaskan Arctic Slope, where oil companies are most active, the landscape is least able to endure heavy use. Imperial Oil Limited, a subsidiary of Standard Oil of New Jersey, has quickly brought the problem to public attention. Company officials have reported their experiences in detail at the Third Canadian Conference on Permafrost in Calgary ~~(last January) and at the~~

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Briefly, material near the surface of unconsolidated sediments is largely composed of ice. In summer, the ice in the upper layers turns to water, producing the wet blanket of vegetation and soil. When some of this material is bladed off with a bulldozer to obtain a firm surface, melting into the permafrost begins again, water runs into the hole, the sides begin to slip, and a gully develops. Any damage to the terrain will begin the process, whether caused by construction, tracked vehicles, fires or seismic lines.

Drilling also presents special problems. If the drill pipe is withdrawn, unconsolidated material from the sides tends to fall into the drill-hole. British Petroleum Company Ltd., and other companies, are experimenting with new drilling muds and new drilling techniques.

Because of the lack of solid rock, the well must literally hang on the layer of permafrost, 800 to 1200 feet thick, near the surface. The operators are forced to protect

Geol. map of arctic basin showing sedimentary rocks

AQ: A simple cross section might help the reader here ☺

this vital junction, using insulation and even refrigerating plants. When large volumes of oil begin to flow, the difficulty will be enormous. Oil leaves the ground at a high temperature, perhaps 150 or 200 degrees Farenheit, and some very efficient methods of carrying off the heat and of insulating the pipe will be required.

The Arctic also presents great difficulties and hazards in transporting oil to market. The preferred bulk carriers are ships and pipelines. Shipping at present is confined to a very brief season. Very large ships may offer efficiencies of scale in the case of ice navigation as they do in the costs of bulk transportation, and the S.S. Manhattan, a specially strengthened tanker of 115,000 tons deadweight, navigated the Northwest Passage route this summer. If ~~she is successful~~ the trip is judged a success, it is planned to build a fleet of six 250,000-ton tankers for year-round service to arctic loading facilities. Ships of whatever size and power will, however, always be vulnerable to collision with ice, to ice pressure, and to damage by

collision or shipwreck in the narrow channels of the Arctic.

Pipelines also present enormous problems. If the permafrost is not protected from the heat which they give off, experiments indicate that the ground upon which they rest, or in which they are buried, will rapidly subside, leaving sections of pipe suspended and liable to breakage. Hanging the pipelines, the only obvious solution, will require the building of immense numbers of pilings. As is well known, an 800-mile, 48-inch, $900-million pipeline is planned to carry Alaskan North Slope oil to Valdez on the Gulf of Alaska. A break in such a pipe would release oil at the rate of nearly half a million gallons per mile drained.

These are a few of the problems faced by the oil industry, and public interests, in arctic lands. There are others for which solutions will be required; for example, offshore drilling is not now possible in arctic pack-ice. Studies have been made of submarine tanker feasibility, but the capital costs would probably be two to three times

those of surface vessels of similar speed and capacity.

The present extent of oil pollution may well be obviously worse in the northern parts of the U.S.S.R. than they are in northern North America. Priroda last year carried an article by a fisheries official, B.G. Burdiyan, who attributes a drastic decline in the huge fisheries resources of the Ob-Irtysh river basin to pollution, largely from the oil and gas industries, which in 1964 dumped some 6.5 million cubic yards of effluent per day into the Ob basin. Burdiyan believes that the damage done has been very considerable, one effect being a decrease of about 17.6 million pounds of fish per year, or 16 per cent, of an average annual catch of some 110 million pounds. Burdiyan seems to have spoken to some effect: a year later, according to a news report of February 17, 1969, a western Siberian court sentenced two oil-well operators to prison for polluting a river and killing its fish. The engineer was sentenced to three years and the foreman to two

The problem of avoiding future oil pollution is everywhere under study. The responsible Minister in Canada has already outlined publicly an Act that will soon be debated in Parliament. He has stated that the bill will lay the responsibility for water quality on the user, though the standards to be maintained have not yet been revealed.

A.Q. Can you list major species affected??

years for criminal negligence.

Waste oil from drilling sites flowing into the Volga River is reported to be so abundant that ten giant purification plants have been constructed to remove it.

The problems of landscape degradation in the U.S.S.R. are probably very similar to those faced in Alaska and Canada, except that in addition to permafrost, the drillers in the Ob basin have to contend with extensive seasonal floods.

Oil is at present being extracted from a second arctic area in the Soviet Union, the Pechora River basin west of the Urals, but we have not seen any accounts of the pollution problems there.

The most permanent potential casualty, and what appears the major value at immediate hazard, is the arctic landscape. A traveller returning from a recent tour of the Canadian Arctic, when asked for his impressions, said "The face of the Moon". My first reaction, visualising the many beautiful arctic environments in which I had travelled, was incredulity, until I realised that the visitor had probably

never been off the disturbed ground around airstrips and settlements. If people are to live in and enjoy our Arctic, as surely they will increasingly find cause to, we must find ways to preserve its landscapes. And it is not only a question of amenity. Wildlife and fish resources are still worth some $10 million a year in the Northwest Territories, and immeasurably more culturally and socially. These resources depend on productive landscapes.

Present Regulation and Present Needs

Legislation for the protection of environment and biological values during oil exploration, drilling, production and transport comprises a multijurisdictional and complex field. In Canada there are regulations, both federal and provincial (the Minister of Indian Affairs and Northern Development acts in the place of the territorial authority in the Northwest Territories) governing the drilling and production of wells - off-shore and land-based. Guidelines are issued to exploration lease-holders in the Territories, urging them to respect

the environment, but so far there appear to be no mandatory provisions to govern theoperation of tracked vehicles or the running of seismic lines and other potentially destructive machines and techniques. A new bill, "An act respecting the protection and conservation of oil and gas in the Yukon Territory and the Northwest Territories" contains provisions authorizing the Governor-in-Council to prescribe the measures necessary to prevent pollution of air, land and water as the result of handling or producing oil or gas, but no mention is made therein oflandscape damage. It is understood that the Northwest Territorial Lands Act, now in process of revision, will include such provisions, and it is the hope that these will be proclaimed in time to prevent more damage. This revised act will fill a very urgent need.

In Alaska, both state and federal authorities are making careful studies. The pace of development has been tremendous and much damage has already been done.

At present, four agencies govern land-use in various parts of the

A.Q. Is this bill now law?

A.Q. When will the revision take effect?

of the Alaskan tundra: the U.S. Navy on Petroleum Reserve No. 4, the Bureau of Land Management on public federal lands, the Alaska Department of Natural Resources on lands selected by the state, and the Bureau of Sport Fisheries and Wildlife in the Arctic Wildlife Range.

Petroleum Reserve No. 4 is at present closed to exploration, but may not remain so for long. The Bureau of Sport Fisheries and Wildlife has shown its effectiveness in protecting surface values on the Kenai National Moose Range; so far the Arctic Wildlife Range still remains closed.

The Bureau of Land Management has established guidelines for companies operating on public lands, which include the provision that a bureau district manager can specify detailed protective stipulations which are mandatory, but surveillance may not in all cases be possible.

The Wildlife Management Institute reported in May that the U.S. Secretary of the Interior had recently appointed a special task-force under Russell E. Train, under secretary,

to prepare guidelines for development on federal lands on the Arctic Slope. A staff team of Bureau of Land Management specialists is also at work developing safeguards to be written into any permit issued to the oil industry for the construction of the planned 800-mile pipeline from the Arctic Slope to Valdez.

Finally activities on state-selected lands are governed by restrictions which are based on the authority of the States' Anadromous Fish Act. In January 1969 additions to the State Laws of Alaska were proposed to minimize surface damage, and there is some expectation that these will pass in their original form.

Thus in both Alaska and the Northwest Territories, the environmental problems are recognized and appropriate legislation is being framed. In Alaska, many groups have presented the case for conservation at public hearings. In my country, The Canadian Committee for the International Biological Program, the Canadian Wildlife Federation, and other groups with interests in environment and wildlife, are doing much to ascertain the exact nature of the problems we face and to bring them to the attention of the responsible officials. The oil industry

itself is being frank and cooperative. Alaska is ahead of Canada in one respect - it has a much more highly developed land classification system, which assigns "highest use" values, doing much to ensure the preservation of uniquely valuable habitats. Canada still seems hesitant to assign priorities and values in her sparsely-settled Arctic, yet every year the public at large makes greater investments in social capital; railways, and so on, to foster extractive industry in the North. The same public is becoming very sensitive to pollution and other forms of environmental degradation. It seems unlikely that it will be long before development becomes subject to planning based on exact knowledge not only of mineral and fuel resources but also of surface resources, whose very considerable and rising values we now dismiss lightly as intangibles. We must work for a whole scale of natural reserves, for the satisfaction of all comers: for parks, wilderness areas, scientific reserves and sanctuaries; we must press for action on legislation for the prevention

and the mitigation of surface and pollution damage; and we must encourage and sustain the environmental scientists who will be needed in the future to recognize and preserve what we have left, and restore to us what we need.