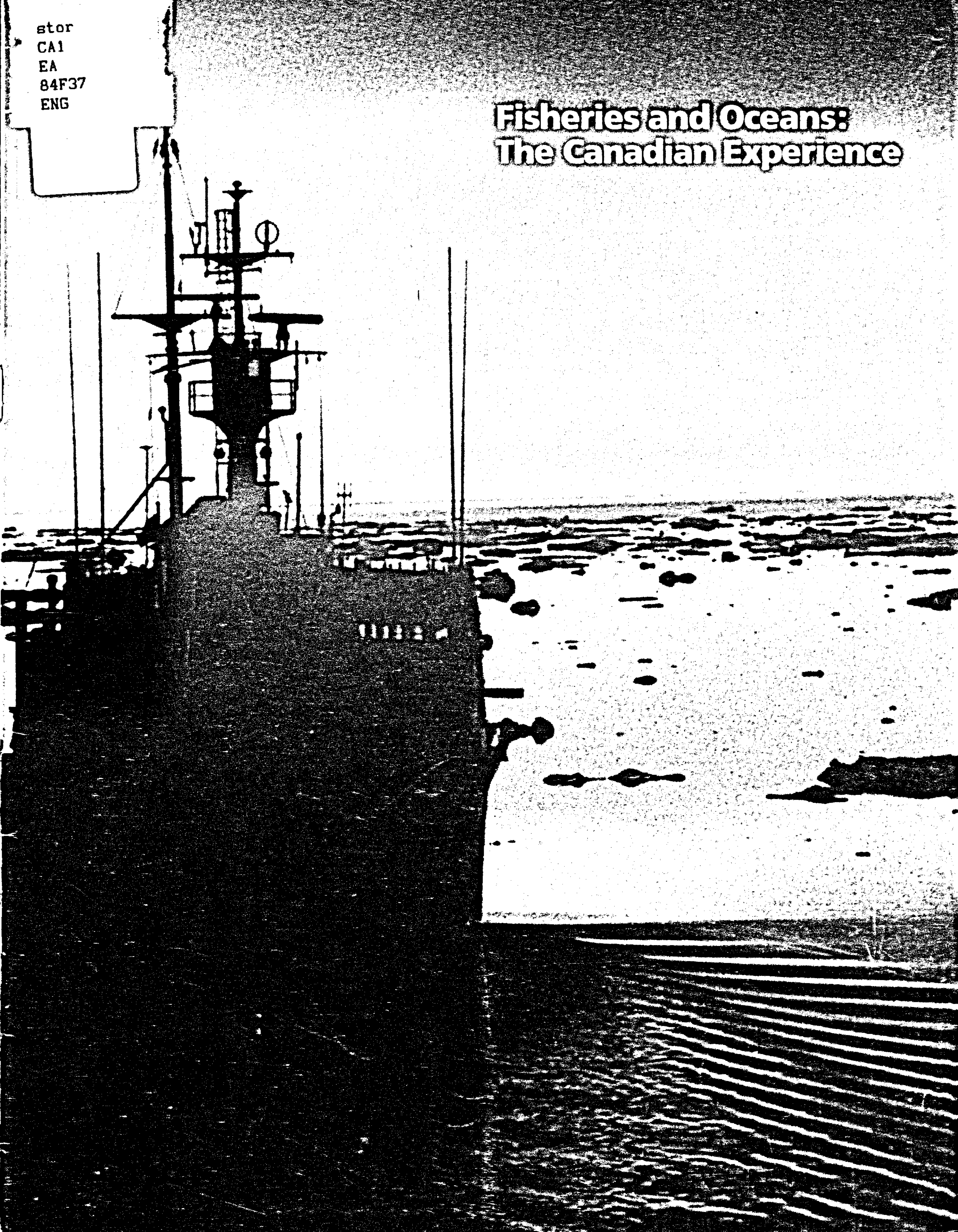
Fisheries and Oceans: The Canadian Experience



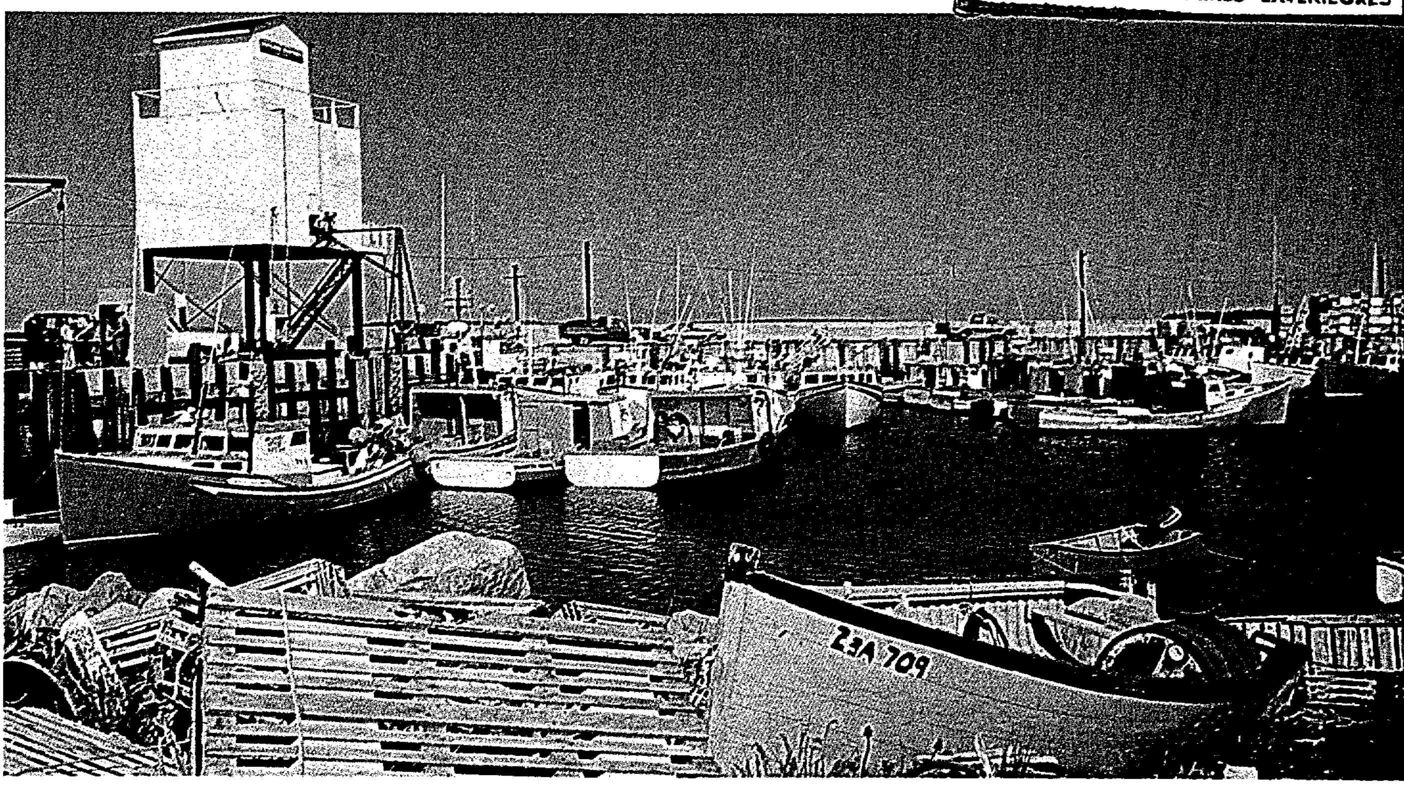
Fisheries and Oceans: The Canadian Experience

Canadian scientists working in ocean research are engaged in frontier exploration and not merely in a metaphorical sense. For Canada, the ocean is the frontier — or more accurately, three frontiers: the Atlantic (including the Gulf of St. Lawrence), the Pacific and the Arctic — and the excitement and sense of arrival is no different than it was for the Prairies in the late 1800s and the Yukon at the turn of this century.

In the 1970s, world energy hunger and the depletion of oil reserves under the land pushed exploration seaward, and some of the most promising oil and gas finds were in Canadian areas of the Arctic and the Atlantic. Oil reserves in the Beaufort Sea, for instance, have been estimated at between 9 and 32 billion barrels, and discoveries off Newfoundland, including the giant Hibernia field, are believed to be large enough to supply 250 000 barrels a day over 25 years, starting in 1990. Canadian natural gas resources have been discovered recently in bonanza proportions near the north shore of Melville Island in the western Arctic.

But fossil fuels are only one resource in the seas off Canada's coasts. The nation also has jurisdiction over massive stocks of fish, brought under Canadian control with the extension of fishing limits in 1977 from 12 to 200 nautical miles.

Port Maitland, Nova Sc



FISHERIES

Canada, in company with roughly 100 other coastal states, declared its 200-mile zone as a matter of fisheries survival. On the Atlantic coast particularly, groundfish (bottom-dwelling) stocks, which had been the mainstay of the Atlantic fishing industry, were being decimated by modern long-range fleets operating from as far away as the USSR and Japan, employing high-powered catching technology and extremely efficient fish-detecting devices.

Until about the middle of the twentieth century, bad years for fishing on Canada's Atlantic coast were at least compensated by good ones, and the industry remained the backbone of the coastal economy. In Newfoundland, particularly, it was and is one of the largest employers. The commercial fishing fleet on the Atlantic coast numbers 35 000 vessels, supplying some 600 separate fish processing operations. Ashore and afloat, the industry employs nearly 100 000 people in an area with a total labour force of one million. Atlantic fisheries landings totalled $585 million in 1982. On the Pacific coast the figure was $300 million for the same period.

With the declaration of the 200-mile exclusive fishing zone, Canada was able to bring an end to over-fishing of most — but not all — stocks on which its coastal communities depend. While the zone more than covers Canada's narrow Pacific shelf, it falls short on the Atlantic side in places by over 200 miles (nor does it include the Flemish Cap, more than 600 nautical miles off the Atlantic coast).

Canning mackerel: Iles-de-la-Madeleine, Quebec.

Fishery officer aboard boat inspects operations.

Still, the area contained is huge, as are the resources. With the extension of the zone, Canada added 632 000 nautical square miles of ocean to the area over which it exercises fisheries responsibility. With this acquisition has come a new lease on life for the fishing industry, and the first real opportunity to put fishing — as an occupation and as an industry — on an even keel. But the 200-mile demarcation has also brought new responsibilities. Scientific management of the fisheries in this area, the essential condition for a stable industry, now is a strictly Canadian responsibility.

Since 1977, Canada has been striving to effectively manage the 200-mile zone. The first priority has been rebuilding overfished stocks and, in the most badly damaged cases, this has meant giving them a breathing space through the setting of strictly enforced limits on the catch. These efforts have begun to show results, particularly on the Atlantic coast, where landings of fish rose from 895 000 tonnes in 1976 to 1.2 million tonnes in 1981. The cod fishery in particular has made a remarkable recovery, with catches doubling in the same period. As a result of extended jurisdiction, and the recovery it has made possible, Canada's fish exports expanded substantially currently amounting to about $1.5 billion annually. But recently the industry has suffered setbacks owing in part to the depressed state of the world economy and also to a hardening of the Canadian dollar against European currencies.

Technician works in high-hazard lab at the Canadian Centre for Inland Waters, Burlington, Ontario.

Canada's fisheries resources have come under scientific management, meaning that the fishing effort is concentrated not only on the biological condition of the stocks but also on economic realities: fishermen must earn a decent living and fish must bring a good price.

The foundation of this kind of management is scientific research: solid information about the stocks themselves; their present numbers; age composition; and the factors that affect their abundance over the long term.

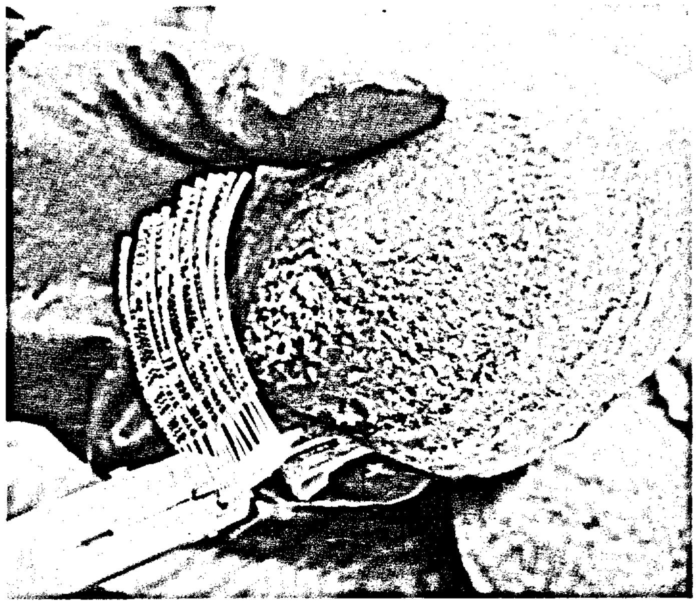
In Canada, the responsibility for overseeing the fisheries rests with the federal government, primarily with the Department of Fisheries and Oceans. The department, which traces its beginnings back to 1867, the year Canada became a nation, has achieved an international reputation in fisheries research.

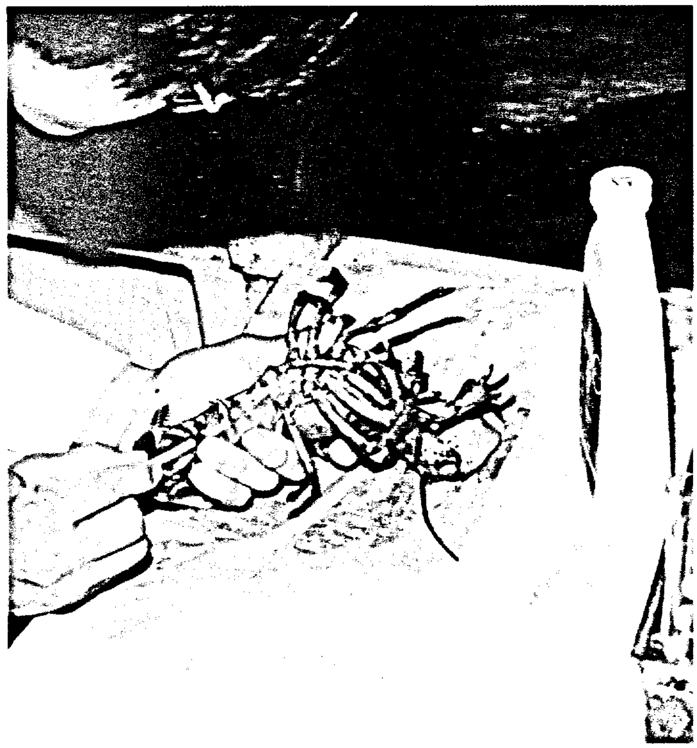
Since the declaration of the 200-mile zone, Canada's marine fisheries research programs have expanded. Canada employs some 440 scientists in fisheries programs. An important and now almost routine aspect of their work is the measuring of the size and composition of fish populations — "stock assessments" as fisheries biologists call them. Canadian scientists are engaged in these ongoing studies of 50 key stocks on the Atlantic coast and 30 more on the Pacific. Since catch quotas and estimates of yield are based on these studies, and since good management starts with exploitation set at a rate that is neither too high nor too low for optimum economic yield, a great deal depends on the soundness of stock assessments.

But stock assessments represent only the day-to-day housekeeping aspects of fisheries management. Other more complex and difficult riddles need to be solved — questions which, if answered, could make fisheries management a more precise art, and the industry a more secure environment for earning a living.

The impacts of overfishing, however lethal, are only part of the pressures put on fish stocks. Fish vie with fish, competing for food supplies, in some cases providing food for each other. Canadian scientists are investigating the interactions and interdependence of fish stocks. They are also heavily engaged in studies of fish habitat — the areas in which fish breed, rear and live, and whose destruction by pollution and general industrial heedlessness represents as dangerous a threat as overfishing ever did.

Establishment of fishing zones has done nothing to prevent fish from behaving like fish — i.e. as citizens of the world! Some stocks, by fortunate coincidence, live and die within one fishing zone. Many straddle national boundaries (such as Canada-US borders) and still others, such as tuna, make the whole world their home. Not surprisingly, fisheries science is marked by a close degree of international cooperation in which Canada is prominently involved. The nation is represented on a dozen international fisheries commissions (including the Northwest Atlantic Fisheries Organization — NAFO — which oversees the stocks that spill over the 200-mile limit into northwestern Atlantic international waters). Most of these organizations exchange data and ideas on fisheries management, and their representatives serve on industry groups set up by bodies like the Food and Agriculture Organization (FAO) of the United Nations.





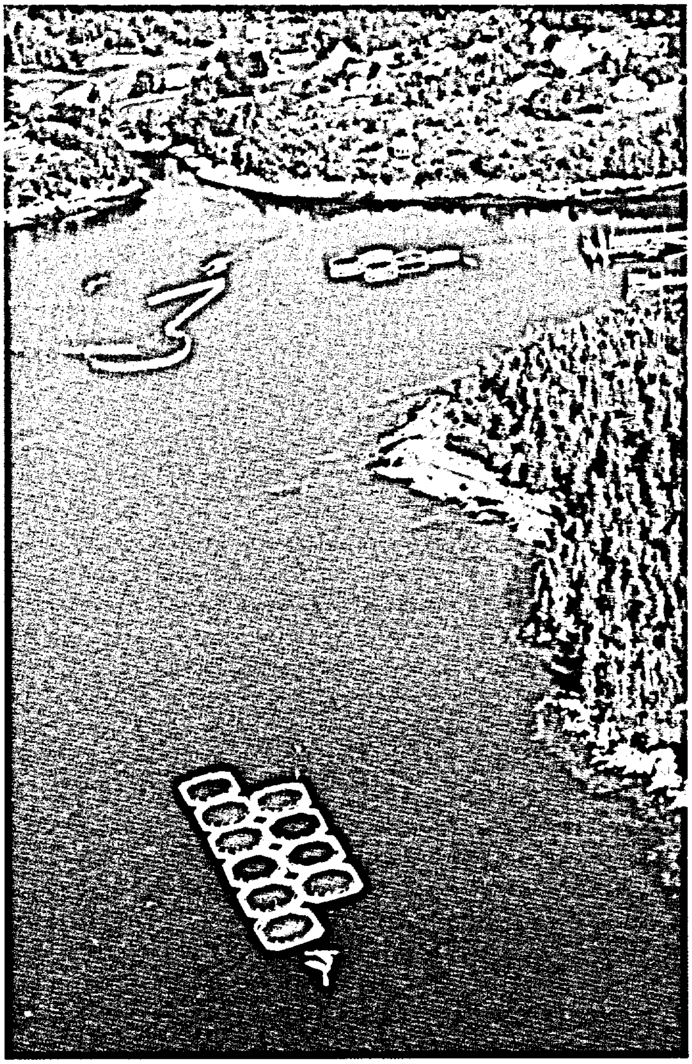
Scallops are tagged by research technicians.

Blood samples are taken from lobster.

On Canada's Pacific coast, a large share of the total fisheries research effort is devoted to rebuilding (fisheries people prefer the word "enhancing") stocks of Pacific salmon. Once so abundant that in spring Indian tribes caught their fill by stretching their nets across the river mouths, Pacific salmon have dwindled fast in this century, partly because of overfishing but also because of the blocking, drying-out, paving-over, pollution and general destruction of the streams and rivers that are their bases of survival. Seven years ago the government of Canada joined forces with the province of British Columbia in a program to rebuild salmon stocks with sea-run trout to raise the levels to where they were at the turn of the century. The Salmonid Enhancement Program, as it is called, is a costly undertaking. The federal share alone will cost close to $150 million over seven years. It calls for production of large quantities of hatchery-bred salmon and for the restoration of damaged salmon streams. Intensive research is being focused on the effects on salmon habitats of logging, mining, hydroelectric development and other industries.

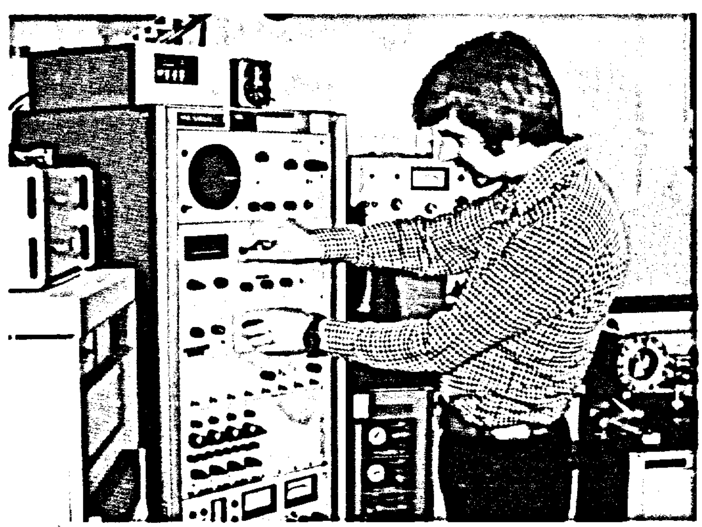
The scope of fisheries and aquatic research is extremely varied, covering studies in biology; ecology; population dynamics; distribution and migrations of fish marine mammals and shellfish; and the forecasting of fish stock abundance. Studies are also directed toward the quality control of fish catches and fishery products; the development and application of aquaculture techniques in salt and fresh water; the study of relationships among species; and the calculation of sustainable yields of fish and marine mammal stocks harvested in the commercial and recreational fisheries. Specialists also carry out social and economic analyses to assist in policy formulation for all significant aspects of fisheries use, potential and management.

Aquaculture experiments by researchers from St. Andrews Biological Station, New Brunswick.



A plankton haul is used as part of sockeye salmon research: Babine Lake, British Columbia.

Read out from water samples is recorded at Institute of Ocean Sciences, Sidney, British Columbia.



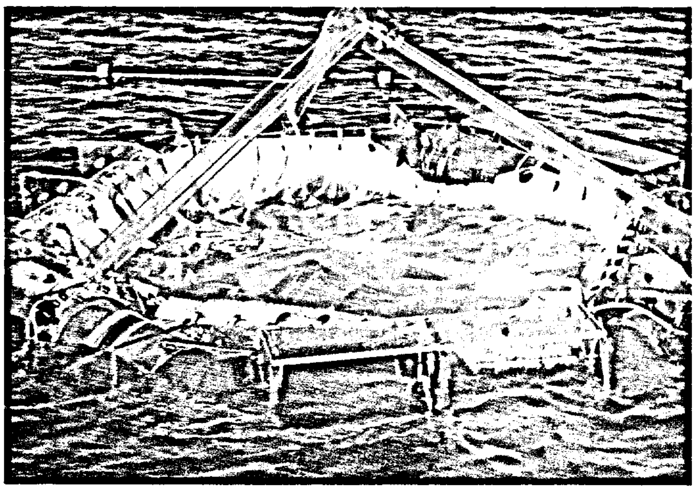
FISHERIES RESEARCH CENTRES

Recently completed is Canada's Northwest Atlantic Fisheries Centre (NAFC), one of the world's foremost fisheries research facilities. Built on a 12-hectare site in the rugged White Hills area overlooking St. John's, Newfoundland, NAFC's futuristic exterior is a perfect mirror for the leading-edge technologies found inside.

About 400 people work in the 30 buildings stretching across the site. The NAFC complex houses some of the most advanced equipment and testing facilities available anywhere.

The major research areas of interest to the centre include: marine, freshwater and anadromous fish management; habitat protection; and experimental ecology. NAFC is also responsible for looking after the 500 small craft harbours which indent the Atlantic coastline throughout this rich fishing region.

The Pacific Biological Station in Nanaimo, British Columbia is a fisheries research station that specializes in studies and enhancement of the Pacific salmon species, as well as other west coast species; the Freshwater Institute, in Winnipeg, Manitoba, is engaged in research of freshwater species; the Sea Lamprey Control Centre in Sault-Sainte-Marie, Ontario is headquarters for work controlling sea lamprey in the Great Lakes; the Arctic Biological Station in Sainte-Anne-de-Bellevue, Quebec specializes in the study of marine mammals; and the St. Andrews Biological Station in St. Andrews, New Brunswick specializes in the study of Atlantic salmon and other east coast species.



Ocean enclosure used for pollutant pathway studies by international groups.

OCEANOGRAPHY

Oceans cover 70 per cent of the globe. Oceanography is an international science. No one nation possesses the resources—financial or otherwise — to investigate the oceans in isolation.

Still less than 150 years old as a science, oceanography has been shaped by the sheer impossibility of trying to deal with or even understand global phenomena from the limited perspective of a single discipline. It has developed in Canada, and elsewhere, not so much as a science of its own, but as a multidiscipline — including physics, chemistry, biology and mathematics — on ocean questions. Studies of the oceans would be hopelessly inadequate if not co-ordinated with investigations of the atmosphere or of the land mass. Oceanography is closely linked with meteorology, geology and geophysics.

Ocean research is the responsibility of the Ocean Science and Surveys (OSS) section of the Department of Fisheries and Oceans. OSS defines its mandate as "research and development of the marine environment around and within Canada — and the optimum use of renewable and non-renewable resources". This covers a very long waterfront. Canada's coastline, measured at 131 650 nautical miles, is the longest in the world. The nation's ocean research effort, or at least that part of it conducted by the federal government, is carried out by roughly 112 scientists backed by support staff operating in research establishments on the Atlantic and Pacific coasts, and at other locations inland.

The Bedford Institute of Oceanography and the Institute of Ocean Sciences are the Atlantic and Pacific bases for Canadian oceans studies. Both enjoy an international reputation for excellence and innovation in the field. The Bayfield Laboratory for Marine Science and Surveys in Burlington, Ontario and the Champlain Centre in Quebec City, Quebec also conduct oceanographic research.

OCEAN CLIMATE

In modern times, the cliché question, "can't anyone do something about the weather"? has taken a remarkable twist. The answer is that man does seem to be changing the climate, with undetermined implications for the future.

That the climate of earth is relatively moderate, and not a Venus-like inferno is due to the fact that radiation reaching it from the sun is reflected back into space as infra-red radiation. The growth of a layer of carbon dioxide (CO_2), produced by decades of burning of fossil fuels, overlaid on natural CO_2 production in photosynthesis, may be blocking the escape of the sun's radiation. The phenomenon expected as a result is called the greenhouse effect: heat energy enters the earth's atmosphere but cannot be reflected back into space. This "extra" heat is dissipated within the atmosphere, and a general warming of world temperatures may result. Some scientists are predicting that temperatures may rise by about 3 degrees C for most of the globe, ranging as high as 10 degrees C in northern latitudes. Other scientists believe that the world is now in a cooling cycle and any such additional heat inputs would simply help to reduce its effects.

Many nations have been conducting independent climate studies for some time. But now, this subject seems to be at least one area which most agree transcends national boundaries. For the past 13 years, Canada has actively participated in a program conducted by the World Meteorological Organization (WMO) to sudy climate, and the way it is shaped by the sea, the atmosphere and, particularly, by the interactions of both.

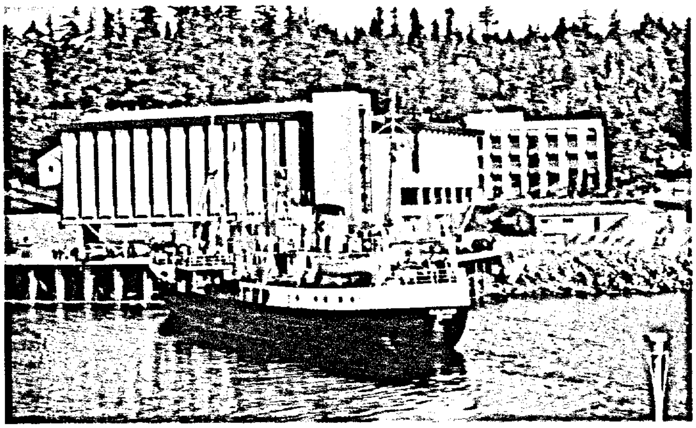
THE WORLD ACCORDING TO GARP

International co-operation is helping to increase man's collective knowledge of the oceans without placing too great a financial burden on any one nation. The Global Atmospheric Research Program (GARP) is a good example.

Jointly sponsored by WMO and the International Council of Scientific Unions, GARP was designed to develop models of the circulation of the earth's atmosphere.

In 1979, in the first GARP global experiment, about 300 drifting buoys were deployed in oceans in the southern hemisphere. Primarily set up to relay position and sea-surface temperature, the buoys transmitted data to a satellite which in turn beamed it to a receiving station in France. Data were then forwarded to the Marine Environmental Data Service in Canada, among other centres, for analysis. An enormous amount of information was gathered in the experiment. Much of it is still being studied, and the results of this international effort are bound to be far-reaching in the advancement of knowledge, and in encouraging further co-operative projects.

One reason for heavy Canadian involvement in world climate studies is that the north Atlantic is a perfect subject for investigation — an ocean which offers scientific researchers the full range of atmospheric conditions, including the vast movement of warm waters from the equator into northern latitudes, and partly into the Gulf Stream. This phenomenon does much to moderate Europe's climate, which otherwise might be harsh.



Research vessel arrives at Nanaimo, British Columbia.

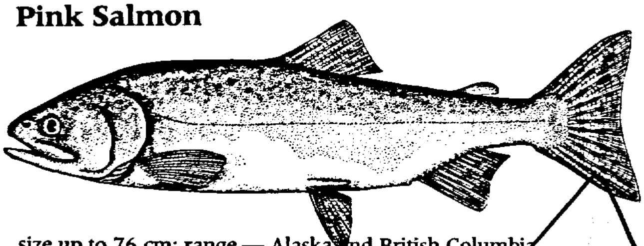
Many of the studies in which Canadian scientists are engaged focus on the horizontal frontier where sea and atmosphere meet. Others are concerned with areas where masses of warm and cold water merge. From the investigations, scientists hope to learn more about how heat, salinity, wave momentum and gases are transferred across the ocean surface, how sea waves are formed and grow, and what factors control the formation, journeying and final decay of icebergs.

Much of this work is done at the Bedford Institute by the staff of the Atlantic Oceanographic Laboratory (AOL). One study, completed in 1980, has produced a new understanding of wind stress and heat exchange occurring when masses of air move over ocean areas. This particular study required 24-hour-a-day measurements of ocean temperature, turbulence and wave height over a period of months. To carry them out, AOL designed an instrument platform equipped with receiving sensors and moored it off Halifax where, for 20 months, it withstood the full blast of north Atlantic winds and waves.

The Labrador Sea is another frontier that has become the subject of accelerated research. Apart from its location on the new northern energy transportation route, the Labrador Sea is a mixing bowl for cold northern and warm southern waters. The extent of this mingling is directly related to weather and climate. If, for instance, the supply of warm waters of the south tapers off for any length of time, temperatures drop even further. If the supply is increased, northerners can loosen their parka hoods.

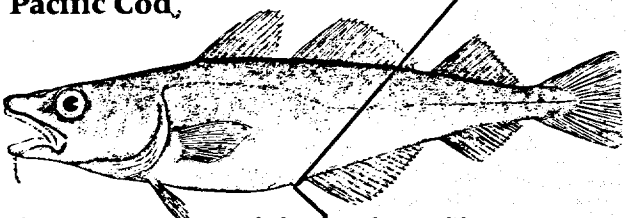
Common commercial fish of the Pacific Coast

Pink Salmon



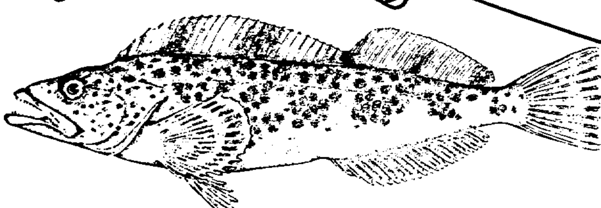
size up to 76 cm; range — Alaska and British Columbia.

Pacific Cod



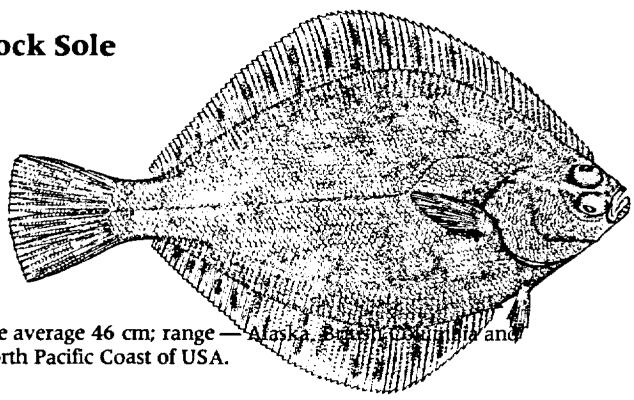
size up to 1 m; range — Alaska to southern California

Lingcod



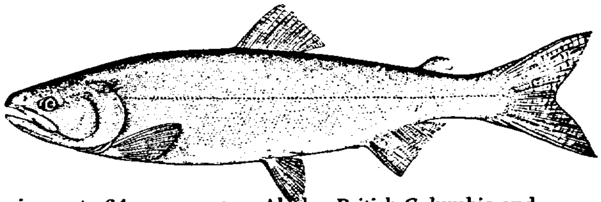
size up to 1.53 m; range — southern Alaska to Baja, California.

Rock Sole



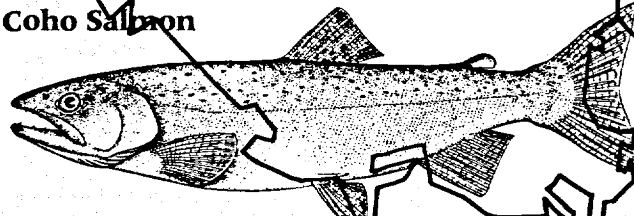
size average 46 cm; range — Alaska, British Columbia and North Pacific Coast of USA.

Sockeye Salmon



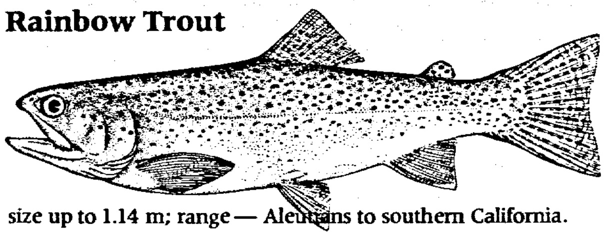
size up to 84 cm; range — Alaska, British Columbia and Oregon

Coho Salmon



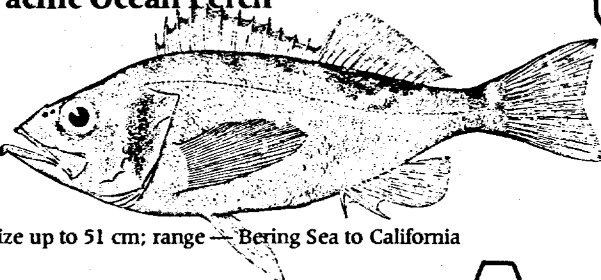
size up to 91 cm; range — southern Alaska, British Columbia and Oregon down to California.

Rainbow Trout



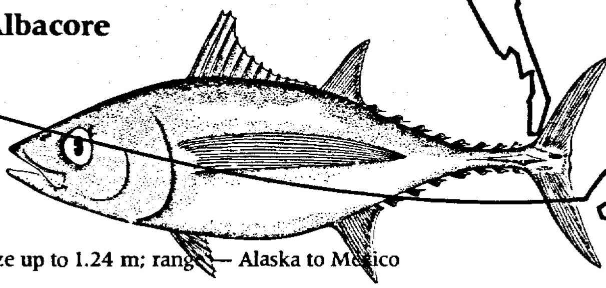
size up to 1.14 m; range — Aleutians to southern California.

Pacific Ocean Perch



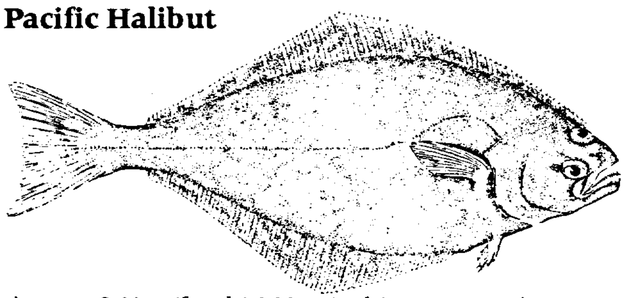
size up to 51 cm; range — Bering Sea to California

Albacore



size up to 1.24 m; range — Alaska to Mexico

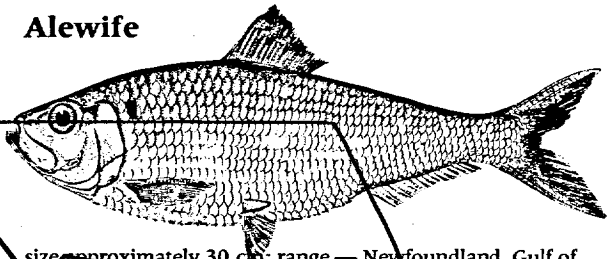
Pacific Halibut



size up to 2.44 m (female) 1.20 m (male); range — Bering Sea to southern California.

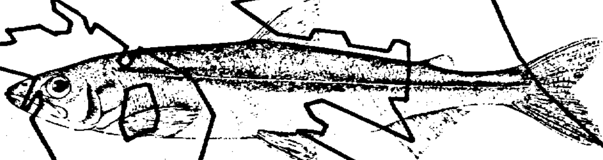
Common commercial fish of the Atlantic Coast

Alewife



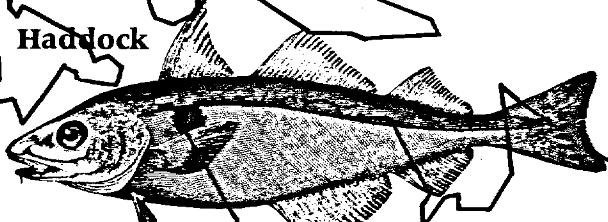
size approximately 30 cm; range — Newfoundland, Gulf of St. Lawrence and down to North Carolina

American Smelt



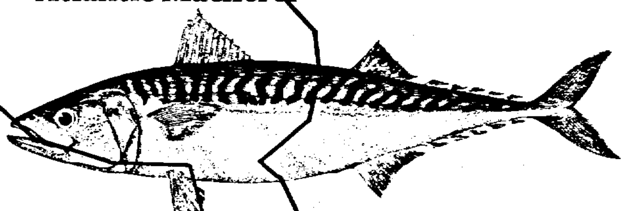
size up to 30 cm; range — coast of Labrador, Gulf of St. Lawrence and southward to Virginia

Haddock



sizes between 38 cm–63 cm; range — Bay of Fundy, Grand Banks, to North Carolina

Atlantic Mackerel

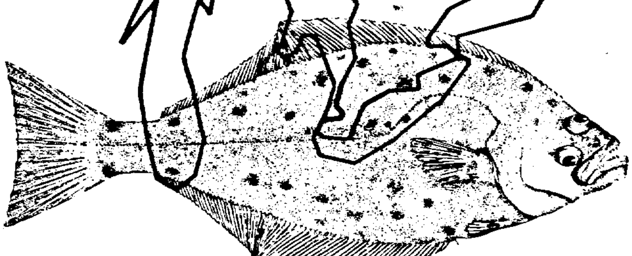


size up to 56 cm; range — southern Labrador to Cape Hatteras, North Carolina

Bluefin Tuna

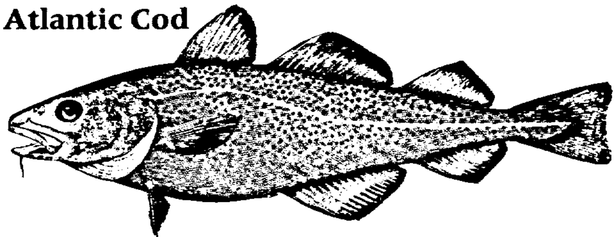
size up to 4.25 m long; range — Newfoundland coast to West Indies

Atlantic Halibut



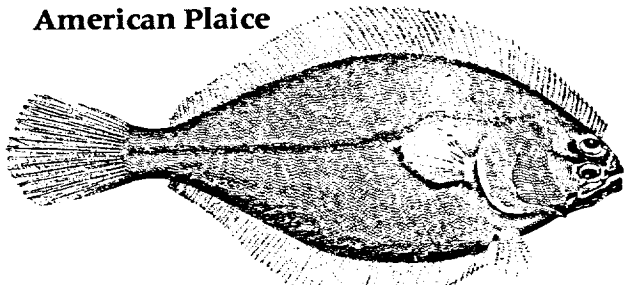
size between 1.5 m–2.5 m; range — banks off Labrador, Gulf of St. Lawrence and the Grand Banks

Atlantic Cod



sizes between 46 cm–76 cm (adult); range — from Baffin Island, Labrador Coast, the Grand Banks and Gulf of St. Lawrence to North Carolina

American Plaice



size average 60 cm; range — southern Labrador, the Grand Banks to off Rhode Island

THE ARCTIC CHALLENGE

Canada is fully committed to the opening up of Canada's Arctic energy reserves. Although work ranges throughout the Arctic, present activity is found primarily in two areas: the Beaufort Sea and on and near Melville Island.

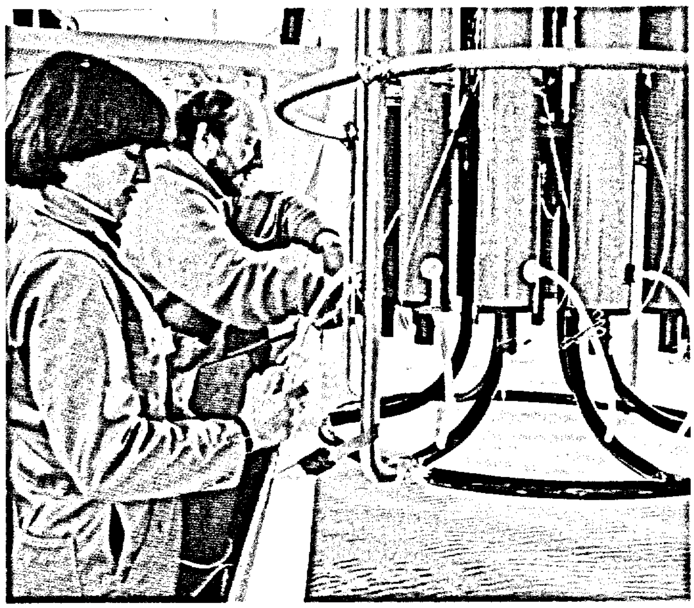
Oil from the Beaufort and gas from Melville and other Arctic islands could be shipped eastward by tanker through the Northwest Passage to markets in Europe or elsewhere. Arctic traffic is already increasing and ice-breaking tankers could begin demonstration voyages as early as 1986.

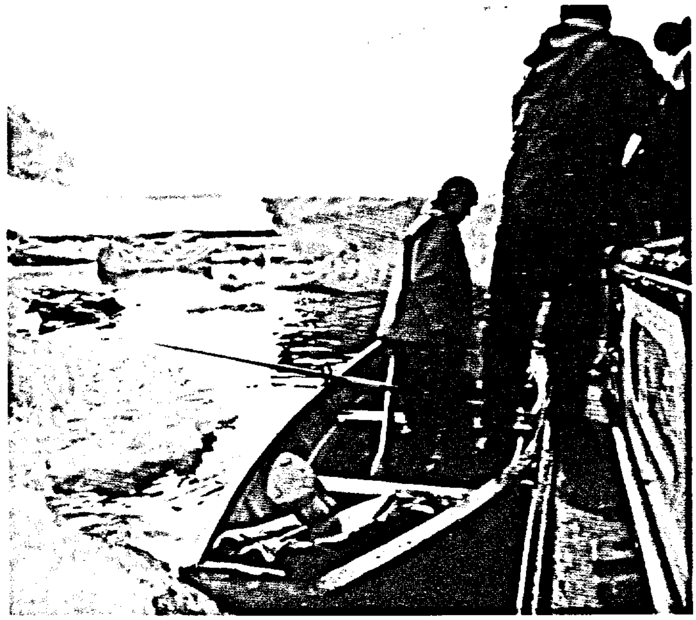
The possibility of increased numbers of larger ships regularly traversing the Northwest Passage has raised many important environmental questions. No one can yet predict with certainty the effects of a major oil spill or well blow-out in the Arctic. Neither are the effects of tanker traffic on marine mammals or indigenous birds and wildlife fully understood. Scientists still do not know all the variables. They do know that a cold sea has characteristics very different from a warm one. For instance, oil in warm water dissipates quickly, while below a certain temperature it will tend to stay in one mass, more solid than liquid.

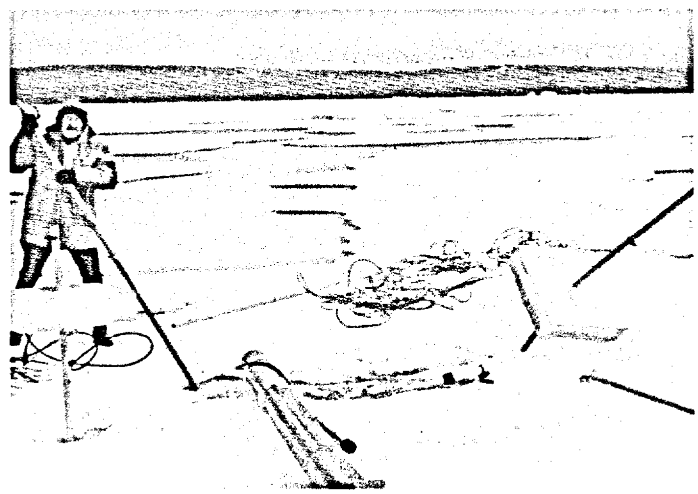
The Arctic environment also has a different growth schedule than that of the south, where animal and plant life metabolize far more rapidly and the environment has an extraordinary capacity to replenish itself. If a spill or blowout were to occur in the far north, the consequences could persist for years. Spilled oil might remain trapped under permanent ice packs and scientists can only guess the possible implications. Other difficult questions have been raised about how to deal with a blow-out on the ocean floor in frigid Arctic waters. Both the Canadian government and the companies concerned are researching these potential problems.

In the early 1960s, one of the world's largest reserves of natural gas was discovered off the north shore of Melville Island. Some experts believe that the field holds over 150 billion cubic metres of the valuable fuel. A consortium, headed by Petro-Canada, is working on plans for an Arctic Pilot Project in which 50 million cubic metres of natural gas from Melville would be transported to European markets over a 20-year period. Once it is proved that natural gas from the Arctic is a practical proposition economic full-scale exploitation could begin.

Plans call for natural gas to be piped under the permafrost from the northern to the southern shores of Melville, a distance of 160 kilometres. There, at Bridport Inlet, a majestic 93-kilometre natural habour, the gas will be converted to liquid and pumped aboard huge carrier vessels built specifically for this work. Then comes the task of "threading the Arctic needle". These icebreaking super-tankers, 40 metres wide, 375 metres long, each displacing 130 000 tonnes, would journey from Bridport to overseas markets, moving south past Resolute Passage, through Baffin Bay before entering the high seas. Each journey would cover over 5 000 kilometres. The super-carriers would make the voyage 15 times a year — taking 16 days for the return trip in summer and 33 days in winter. Nothing on this scale has ever been attempted in the Arctic or anywhere else.







Rosetta water sampler aboard M.V. Bayfield: *Lake Ontario.*
Hydrographic launch: Beaufort Sea.
Retrieval of surface current meters from sea ice: Austin Channel, Arctic archipelago.

The Canadian Hydrographic Service (CHS) is involved in tackling various aspects of this problem. One is the improvement of navigational methods by which ships fix their positions. This work involves a blending of satellite data, the Loran navigational system and old fashioned "dead reckoning". CHS is also improving Arctic navigational charts. Apart from the routine challenge of charting unfamiliar waters, this task is complicated by the need to plot shipping routes through or around natural minefields made up of "pingoes" (hillocks and spear-like ice-coned formations pushing up from the Arctic floor, in some cases to less than 20 metres from the surface).

ARCTIC INFORMATION

Because of increased activity in the Arctic, the Canadian government has established a central facility to co-ordinate and store the mass of information now being generated from a multitude of Arctic studies.

This centre, part of the newly established Oceanographic Information Division (OID), is located at the Institute of Ocean Sciences. Since its inception in 1980, it has been the focal point for all data gathered in the western Arctic and along the Canadian west coast.

Information from studies carried out separately and jointly by government and industry is relayed *via* the centre to government regulatory bodies such as the Federal Environmental Assessment Review Office (FEARO), for use in environmental assessments of Arctic projects.

BEDFORD INSTITUTE OF OCEANOGRAPHY

Located at Dartmouth, Nova Scotia, the Bedford Institute serves as a base for the scientific exploration of two of Canada's ocean frontiers — the Atlantic and the Arctic. Scientists attached to three government departments work there, each pursuing a specific ocean interest: fisheries and oceans; energy, mines and resources; and environment. But Bedford is no ivory tower of the oceans. Its scientists work on problems directly related to the urgent needs of the moment, one of which is the necessity to pry open, safely but effectively, the treasure of energy off Canada's Arctic and Atlantic shores.

This, however, is only a small part of the work carried out at Bedford, which is one of the best equipped ocean institutes in the world. It is home base for five major vessels, including the *CSS Hudson*, which made history in 1970 when it became the first ship to circumnavigate the Americas. The scope of Bedford's scientific activities has grown to include physical, chemical, geological and geophysical studies of the oceans, as well as biological and fisheries studies. The institute also plays a major role in the charting of navigation channels (hydrography) and natural resource mapping.

Installation of a marigraph for tidal studies: Fury and Hecla Strait, Northwest Territories.

INSTITUTE OF OCEAN SCIENCES

Canada's newest oceanographic institute, the Institute of Ocean Sciences (IOS), is situated on the Pacific coast near Victoria, British Columbia. Its broad mandate includes the study of lakes and rivers, coastlines and oceans. Like the Bedford Institute of Oceanography, it is a regional centre and co-ordination point for the ocean research activities of several government departments. Serving as home base for hydrographers and specialists in marine sciences, IOS is involved in several long-term international experiments including the investigation of marine pollution, ocean circulation and the ways in which the oceans affect the earth's weather and climate.

CHAMPLAIN CENTRE FOR MARINE SCIENCE AND SURVEYS

One important set of studies carried out at the Champlain Centre for Marine Science and Surveys in Quebec is in the area of pollution control. Now under study is the distribution of mercury and cancer-causing hydrocarbons in the ecosystems of the Saguenay Fjord and the Gulf of St. Lawrence. Among native species, the blue mussel has been singled out for careful study. It is a particularly useful "tip-off" species for the state of pollution in marine waters.

Other studies are concerned with the substantial increase in hydroelectric development projects on major Quebec waterways. In response to the mega-projects either completed or planned for James, Hudson and Ungava Bays, as well as for the northern Gulf of St. Lawrence, oceanographers are intensifying research on the impact of man-made changes to the freshwater run-off on the marine environment.

The centre is also determining the impacts, if any, of heavy liquified natural gas tanker traffic on the waters off Quebec's coastline. Assessments are now being made of possible sites for terminals.

Hydrography in Quebec is also conducted from this institute.

TSUNAMIS

Tsunamis are particularly terrifying waves. Triggered by quakes on the ocean floor, they race silently across the ocean, several hundred kilometres long, but only a metre or so high, travelling as fast as jet airliners, but invisible from ships and aircraft. Only when close to shore, where the shallow bottom forces them upward, do the tsunamis rear to full height, sometimes as high as ten metres. Arriving with stupendous force and without warning, they have taken heavy tolls on life throughout history. They are more prevalent in the Pacific than anywhere else.

Canadian research on the tsunami phenomenon is aimed at improving early warning capabilities. Canada is one of 25 member countries engaged in co-ordinated tsunami research. Information is gathered from outposts throughout the world and relayed to threatened areas when tsunamis are detected. Since 1948, when an early warning system was established in Honolulu, the cost in lives has been greatly reduced.

Canada has pioneered an automatic telephone "early warning system" for tsunamis.

BAY OF FUNDY STUDIES

In response to the proposed damming of a river mouth for a tidal power project on the Bay of Fundy, scientists at the Marine Ecology Laboratory of the Bedford Institute of Oceanography have developed a mathematical computer model of the dam's effects. With this, they can predict the ecological and tidal impacts of building a real dam. The effects of such a dam would be as far-reaching as the influence of Fundy tides themselves — which range from the Bay of Fundy and the Gulf of Maine as far south as the city of Boston, USA.

In such a mammoth and potentially dangerous project, mathematical modelling gives planners a good idea of what to expect at relatively small expense. For instance, the computer can predict disastrous tidal backlashes that may occur when the volume of an entire river is thrown back on itself.

In supporting studies, scientists are investigating the potential impacts on neighbouring wildlife habitats in low-lying areas.

Information generated by these studies, and from other sources in government and industry, is continuously channelled into a central bank of information, called MEDS (for Marine Environmental Data System). MEDS is a fully computerized bank from which scientists, engineers and others can get answers to their questions about the oceans.

Bedford Institute, Dartmouth, Nova Scotia.

BATFISH

The *Batfish* is a sophisticated underwater probe that carries a variety of advanced scientific instruments. Its full complement of sensors and technical equipment includes a variosens fluorometer (to detect chlorophyl concentrations), a continuous plankton recorder and a digital conductivity-temperature-depth unit.

Towed behind a ship, the research craft continuously dives and rises, cycling in a sawtooth pattern between two pre-set depths, gathering and relaying data to scientists aboard the mother vessel.

Designed and built in Canada, the *Batfish* system has proved to be an important scientific tool in several biological research programs in the coastal waters of Nova Scotia, in the frontal regions along the Scotian break and in studies of the coastal upwelling system of Peru.

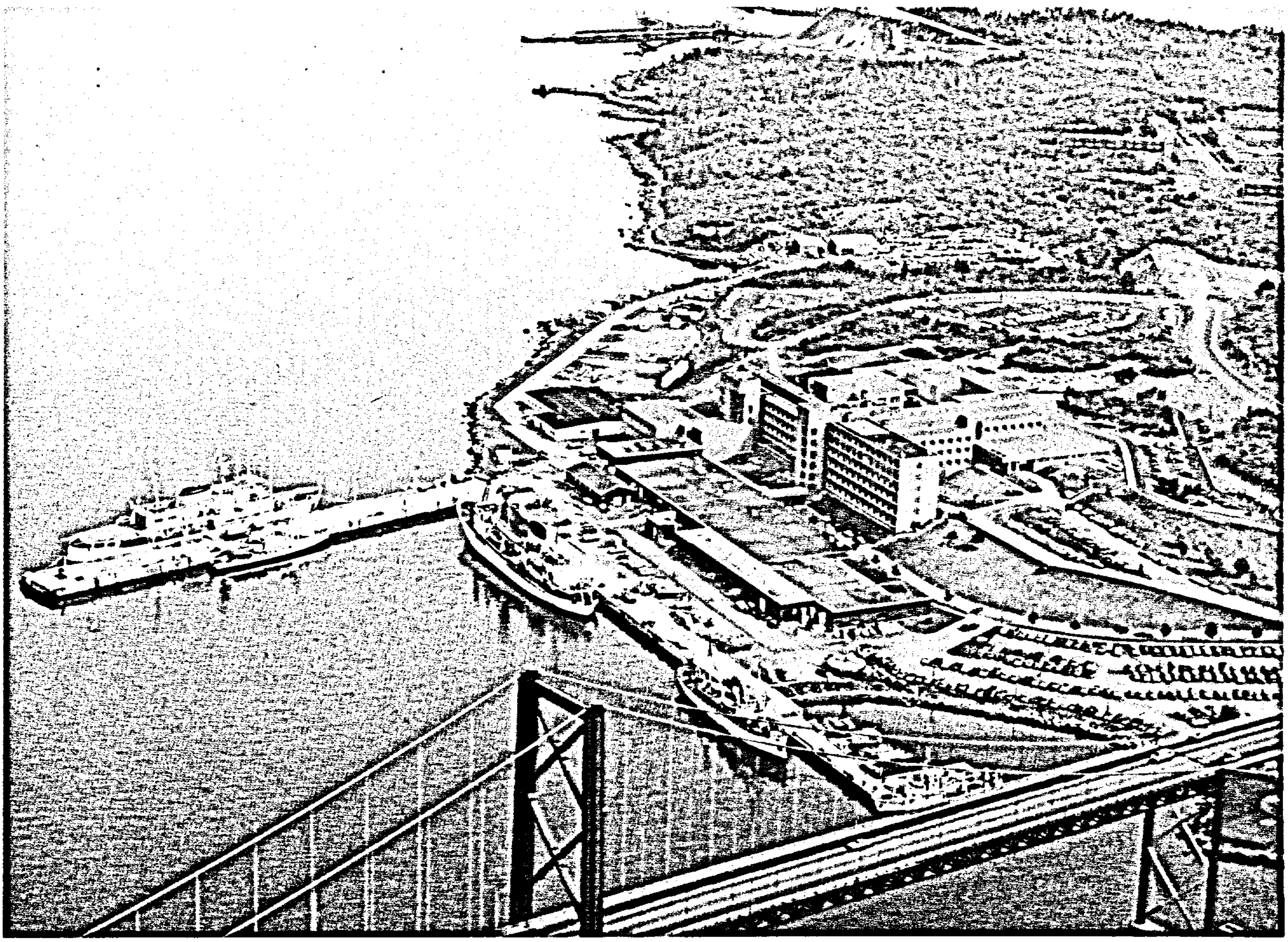
PISCES IV

Based at the Institute of Ocean Sciences on Canada's west coast, the *Pisces IV* is a deep-sea research submarine that carries three people. With over 1 000 dives on the log, some to depths of more than 1 500 metres, it is one of Canada's most valuable and most used research tools.

Six metres in length and weighing 12 tonnes, the submersible is berthed in a private hangar aboard its mother ship, *Pandora 2*. *Pisces* is piggy-backed to a dive site, and then set gently down into the water by *Pandora's* powerful crane. After the dive the submarine is hoisted back on deck and returned to the hangar.

This underwater craft has been used for many different tasks and in many locations. It was brought in to check the telephone lines that run across the floor of the Strait of Georgia linking Vancouver Island with the mainland of British Columbia. Canadian oceans scientists have studied the ocean floor with *Pisces* for private firms planning to run natural gas pipelines across the bottom. The submersible has been used to search for crashed aircraft and sunken ships. In one emergency, it dived to investigate the extent of damage to a capsized barge that had been transporting tanks of chlorine.

Pisces' most important feature is its versatility. Equipped with television cameras, remote-controlled steel arms with detachable claws or grabbers, and a full spectrum of modern sensors, it has done extensive work in the Arctic for the Canadian military, on the east coast for Hydro Quebec and local universities, and on the west coast for the federal government. The craft is designed to accept new, more specialized sensors as they become available, and meanwhile may be fitted with anything that can be bolted on or somehow attached to the frame. Modifications for each dive depend on who is using *Pisces* and the immediate objectives.



CODS

The Canadian Ocean Data System (CODS) uses a series of drifting buoys to measure winds, temperatures, wave heights and other aspects of the oceans.

The system started in 1979 with the first Global Atmospheric Research Program, in which 300 remote sensing buoys were released into oceans of the southern hemisphere. Originally intended to give preliminary mappings of ocean circulation patterns, the experiment was instrumental in encouraging the development of a general technology behind this type of data collection. Its success has led to the design of buoys with more advanced technical capabilities.

Canada has begun phasing-out the collection of oceanic and atmospheric data by weather ships stationed in the Pacific. The ships will probably be replaced by a combination of sophisticated, fully-automated floating platforms — developed in Dartmouth, Nova Scotia — and satellite weather information.

This is only one possible application of this sort of advanced sensing technology. The platforms are used extensively by Canadian institutes for oceanographic research, and by several oil companies seeking on-the-spot information about ice conditions and other ocean phenomena off the east coast and in the Arctic.

FLUORESCENT LINE IMAGER

The Fluorescent Line Imager (FLI) is a remote imaging sensor usually mounted on aircraft or satellite. It is designed to relay data to a ground receiving station which, when interpreted by computer, makes images of chlorophyl concentrations in the oceans. Chlorophyl subtly alters the colour make-up of water — with the level of change varying according to concentration. Although the colour variations are not visible to the naked eye, they can be detected by special sensing equipment. The FLI has been designed to register and enhance these variations, making it easier to pinpoint areas of high chlorophyl concentrations.

Concentrations of chlorophyl are directly related to the abundance of microscopic forms of plant life (phytoplankton). A more complete knowledge of where, and how much, chlorophyl exists will lead to a better understanding of phytoplankton ecology, its relationship to higher aquatic life forms, and to the ecological effects of water pollution in coastal areas. Also, since phytoplankton has no power of independent motion, realistic models can be developed about circulation patterns of the oceans simply by observing phytoplankton movements.

FLI has been tested extensively at the Institute of Ocean Sciences. There, in a joint effort by Canadian and German scientists, the sophisticated instrument was mounted on aircraft for use in low-altitude surveys of the British Columbia coast, the eastern Arctic and the Mediterranean.

FLI is only one product of Canada's pioneering efforts in the relatively recent field of remote sensing technology. The first satellite to possess a chlorophyl sensor was the US's *Nimbus 7*, launched in 1978. It did not carry a Canadian-made FLI, and in experiments corroborated by the West Germans, the Canadian imager was proved more accurate and more versatile in differing weather conditions.

THE CANADIAN HYDROGRAPHIC SERVICE

Hydrography is the practice of surveying and charting waters for navigation. In early seafaring days this meant lowering a lead weight on a line over the side of a ship to obtain critical depth measurements. In modern times, soundings are taken using sonar. Sound waves projected downward from the surface echo back from the ocean floor, providing accurate estimates of water depth and bottom-terrain characteristics.

Organized hydrographic surveys of Canadian waters began in the late eighteenth century. Among the earliest contributors were the great explorers Cartier, Cabot and Champlain. Prior to the British North America Act in 1867, all surveying off Canadian shores was done by British ships. Then, in 1904, with the creation of the Canadian Hydrographic Service, Canada undertook full responsibility for all hydrographic research in national waters. This meant charting 131 650 nautical miles of coastline and 739 366 square nautical miles of continental shelf and territorial waters.

During 1982, CHS compiled and produced the fifth edition of the General Bathymetric Chart of the Oceans (GEBCO). The series of charts is the culmination of eight years' work by CHS and hydrographers and oceanographers throughout the world. CHS produced it for the International Hydrographic Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization.

These charts of the floor of the oceans, which are the major source of reference for oceanographers, provide invaluable information for maritime countries seeking to establish offshore limits to regular petroleum development and other submarine resources.

With bases at three advanced Canadian institutes (Bedford in Nova Scotia, the Bayfield Centre in Ontario and the Institute of Ocean Sciences in British Columbia) and controlling a $175-million fleet comprising 180 vessels of varying size and function, CHS is one of the best equipped hydrographic agencies in the world.

Canadian research vessels Baffin *and* Hudson *are used primarily for soundings, gravity readings and magnetic readings.* Hudson *was the first ship to circumnavigate North and South America.*

THE CSS HUDSON

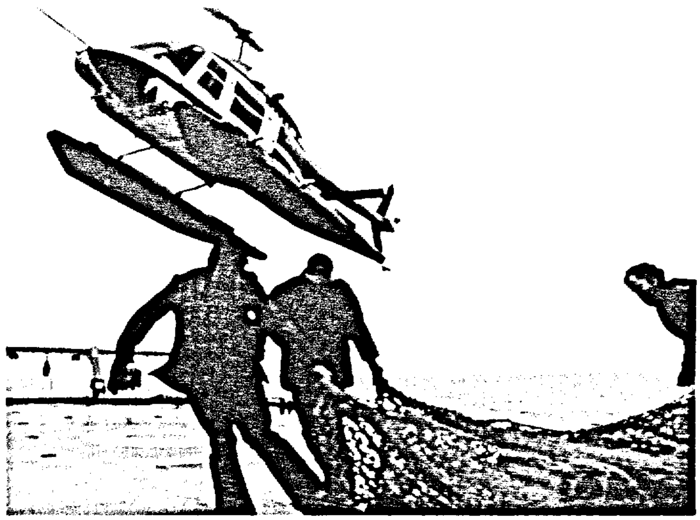
Work horses of Arctic exploration are ships like the *Baffin* and the *Hudson*. In 1980 for instance, *Baffin* cruised the straits of Labrador from the Newfoundland coast to Ungava Bay collecting bathymetric sounding data over a distance of 12 000 kilometres.

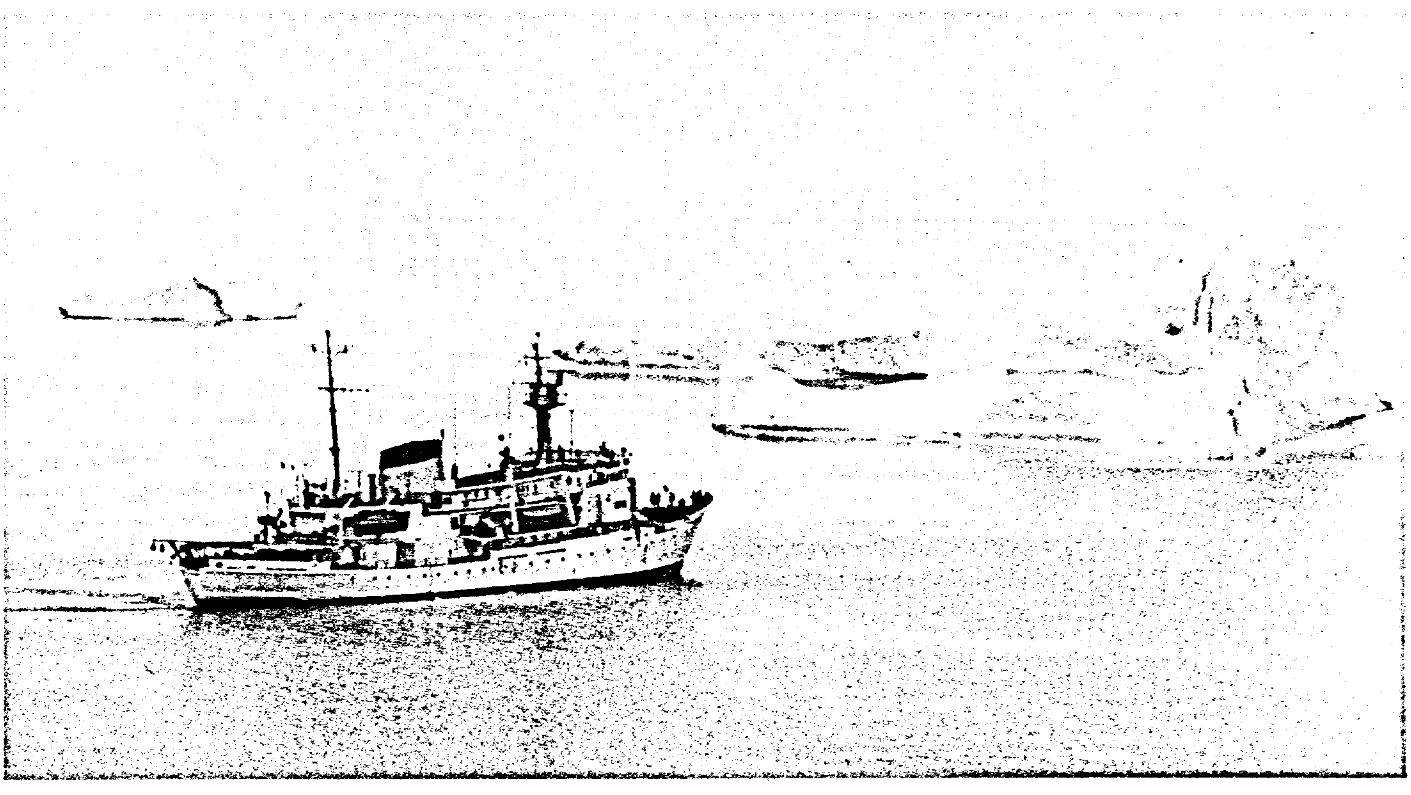
The *Hudson*, loaded with scientists and experts from a variety of fields, set a record for shipborne oceanographic exploration, reaching as far north as 74 degrees N., far up the bleak passage that separates Ellesmere Island from neighbouring Greenland. As it sailed, biologists studied phytoplankton and their feeding processes. Oceanographers traced the flow of Arctic waters east into the Atlantic, and professionals from both fields co-operated in investigations of the flow of "rock flour" mineral particles which make up part of the diet of phytoplankton.

During this voyage, the *Hudson* found time to visit and pinpoint the scene of an Arctic mystery: an unmistakable oil slick rising to the surface at Scott Inlet, thousands of kilometres from the nearest oil rig, and in waters where no tanker has yet travelled. Scientists determined that the oil is seeping from faults in the ocean floor.

Pisces *during a dive.*

Helicopter prepares to land on the Hudson*: Arctic waters.*





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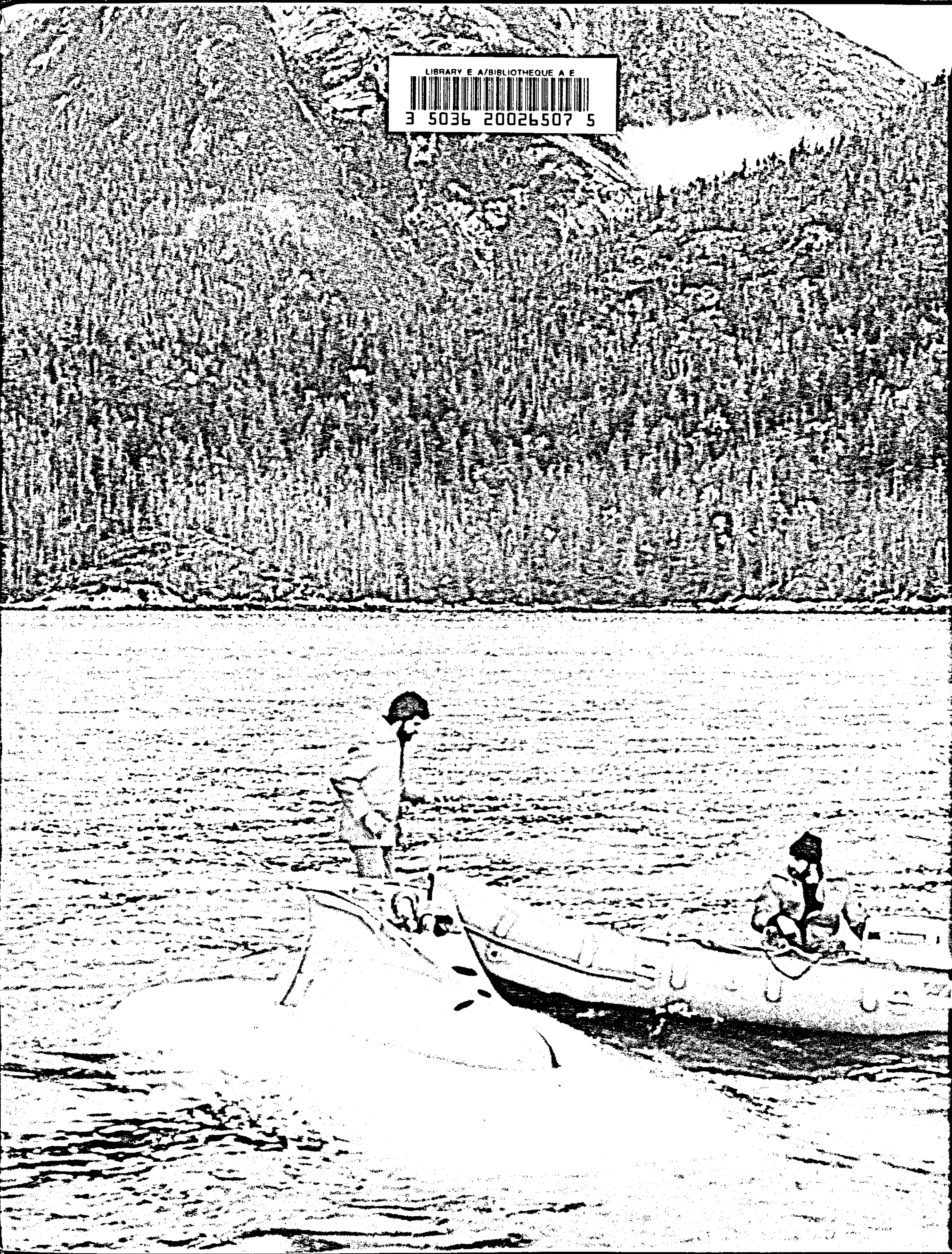


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