Bedford Institute of Oceanography

BIO REVIEW '83

Canada

The Bedford Institute of Oceanography (BIO) is the principal oceanographic institution in Canada; it is operated within the framework of several federal government departments; its staff, therefore, are public servants.

BIO facilities (buildings, ships, computers, library, workshops, etc.) are operated by the Department of Fisheries and Oceans, through its Director-General, Ocean Science and Surveys (Atlantic). The principal laboratories and departments are:

Department of Fisheries and Oceans (DFO)
- Canadian Hydrographic Service (Atlantic Region)
- Atlantic Oceanographic Laboratory
- Marine Ecology Laboratory
- Marine Fish Division

Department of Energy, Mines and Resources (DEMR)
- Atlantic Geoscience Centre

Department of the Environment (DOE)
- Seabird Research Unit

BIO operates a fleet of three research vessels, together with several smaller craft. The two larger scientific ships, *Hudson* and *Baffin*, have global capability, extremely long endurance, and are Lloyds Ice Class I vessels able to work throughout the Canadian Arctic

BIO has four objectives:

(1) To perform fundamental long-term research in all fields of the marine sciences (and to act as the principal Canadian repository of expertise).

(2) To perform shorter-term applied research in response to present national needs. and to advise on the management of our marine environment including its fisheries and offshore hydrocarbon resources.

(3) To perform necessary surveys and cartographic work to ensure a supply of suitable navigational charts for the region from George's Bank to the Northwest Passage in the Canadian Arctic.

(4) To respond with all relevant expertise and assistance to any major marine emergency within the same region

T.D. Iles - *Chief, Marine Fish Division, DFO*

M.J. Keen - *Director, Atlantic Geoscience Centre, DEMR*

A.J. Kerr - *Director, Atlantic Region. Canadian Hydrographic Service, DFO*

K.H. Mann - *Director, Marine Ecology Laboratory. DFO*

G.T. Needler - *Director. Atlantic Oceanographic Laboratory. DFO*

D.N. Nettleship - *Seabird Research Unit. Canadian Wildlife Service, DOE*

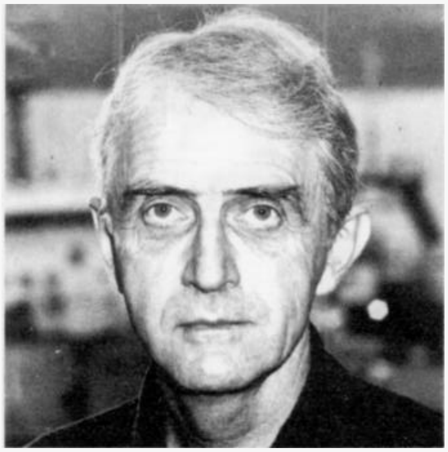
On the cover:

A painting by Pat Lindley of the DOLPHIN vehicle at sea with its parent vessel, *C.S.S. Baffin*, in the background. A fleet of such vehicles, each equipped with an echo sounder, will be built to accompany *Baffin*. The vehicles will be stationed three on each side of the ship to collect parallel profiles of bathymetry. This will increase the productivity of offshore surveys and lower the cost per unit area surveyed.

DOLPHIN was designed and built by International Submarine Engineering Ltd. of Port Moody, B.C.: it was funded through the federal Unsolicited Proposal Program, the Arctic Transportation R & D fund, and OSS Atlantic at BIO. The name of the vehicle is an acronym for Deep Ocean Logging Profiler Hydrographic Instrumentation and Navigation.

Operationally, DOLPHIN cruises 3-4 m deep at impressive speeds of up to 14 knots so as to maintain station on the parent vessel. Radio-telemetry controls the vehicle and a microcomputer services the command and data links from ship to DOLPHIN for maintaining continuous information on the status of the submerged vehicle. Control range is of the order of several miles. Future plans include developing a handling system for lowering and hoisting the vehicles aboard the parent vessel, a navigation system, and a data collection and handling system. For more information on DOLPHIN, see chapter 3.

Surveys and Services



Alan Longhurst.

This is the third *BIO Review*, and once again the choice of what topic to concentrate on has been automatic: 1983 is the centennial of the Canadian Hydrographic Service, an important component of the federal Department of Fisheries and Oceans, and also of BIO. To honour this youthful centenarian, and to complement our previous issues, this year we have chosen to concentrate on surveys and monitoring, on charts, atlases, and data reports, and on the development of instrumentation. In short, on surveys and services.

Our first issue in 1981 discussed how BIO programs responded to the oceanographic issues facing our nation, and how the priorities of our work were influenced by evolving national needs for information about the ocean. Our second issue was published in 1982, the same year the Joint Oceanographic Assembly met here in Halifax: it dealt with our basic research in oceanography, which we characterized as a very young science.

In contrast, our starting point this year, hydrographic surveying and cartography, was already a very old science when the Canadian Hydrographic Service was established 100 years ago. Three hundred years earlier, the traditions were already well established: sailing from England in 1580, sailing-master Arthur Pet was enjoined by the owners of his ship “. *when you come upon any coast, or find any shoal bank in the sea, you are then to use your lead oftener as you shall think it requisite, noting diligently the depths, and the deepening and shoaling*” and “ *diligently observe the latitude as often and in as many places as possible, and also the variation of the compasse, noting the observations truely when you come upon any coast where you find floods and ebbs, doe you diligently note the time of the highest and lowest water in each place which way the flood doth run,* how *the tides doe set.* “. Diligence in studies of cartography, navigation. and tides remains the hallmark of our hydrographers, and the starting point for this *Review.*

Our knowledge about the ocean exists not only in the scientific papers on ocean processes that are the primary output of oceanographers, but also in the ordered data obtained from surveys of all kinds; this is what is most often sought by those who use ocean information to go about their business at sea. Perhaps because of its unusual diversity, combining within one institute the functions of what in other countries are commonly separated. BIO is unusually rich in this kind of material. In recent years, we have taken especially active steps to make our charts, atlases, and data banks more readily accessible to users. In this way, the Institute has been able to assist in the remarkable developments that have taken place off Canadian shores since the developing new international regime in the oceans began to take effect.

Recent years have seen a very significant upswing in the demand for ocean data services of all kinds: masters of fast, deep-draft ships need new revisions of old navigation charts; managers of Canada’s 200 n. mile fisheries zone need information on variability in water temperatures; oil companies need wave and current data to establish engineering criteria for offshore rigs and platforms; government and industry need baseline data on ecology and contamination levels prior to undertaking coastal engineering works. The list is very long.

This *Review*, then, is intended to record BIO’s performance in meeting the new and evolving demands placed on it while also maintaining its momentum in the research that we have highlighted in earlier issues of *BIO Review.* We also report here on a number of activities related to the main theme, especially those where our interaction with Canadian industry of all kinds is strongest; we discuss therefore our mechanisms for reacting to formal environmental impact statements within the FEARO mechanism, and how we develop new instrumentation in partnership with Canadian companies.

Finally, the latter part of this edition contains an updating of the general information about BIO that we have provided previously and shall continue to provide annually. We hope that here the enquirer will be able to get the information he needs about our current organizational structure, our research projects and who is involved in them, and listings of our various kinds of output. Our next issue, *BIO Review* ‘84, will likely be a regional study of one part of the ocean or continental shelf where we have worked particularly intensively.

Perhaps it would be appropriate to wish the Canadian Hydrographic Service a successful second century by quoting owner William Burroughs final instructions to his sailing-master Arthur Pet 400 years ago “. . *and prosper our voyge with good and happy success, and send you safely to return home againe, to the great joye and rejoycing of the adventurers with you, and all your ,friends, and our whole countrey*” .

- *A .R. Longhurst*
Director-General
Ocean Science and Surveys, Atlantic Region
Department of Fisheries and Oceans

C.S.S. Acadia, shown above ca. 1952 along with some of her crew and one of her hydrographers at work ashore, served the Canadian Hydrographic Service (CHS) well. From launch in 1913 to retirement in 1969, *Acadia* surveyed the eastern seaboard of Canada from Nova Scotia to the Arctic, concentrating in her last years on the charting of Newfoundland waters. Today, the Grand Old Ship of Canadian hydrography is on permanent display at the Maritime Museum of the Atlantic in Halifax.

C.S.S. *Baffin,* shown at right steaming past the BIO jetty at the start of a 1980 hydrographic voyage, has now served the CHS's Atlantic Region for a quarter century. Commissioned for service in 1957, *Baffin* has since surveyed the Atlantic Coast from Barrow Strait to the Bay of Fundy as well as coastal parts of the West Indies and West Africa. As reported in *BIO Review* '82, the ship was recently refit, markedly enhancing her capability for both hydrographic and oceanographic work. *Baffin* should continue to serve the CHS well for years to come.

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CHAPTER 1

Data Gathering - Surveys, Monitoring, and Baselines

By means of some examples, this chapter is intended to illustrate how data are gathered by BIO ships to produce the charts, atlases, and data banks discussed here and in subsequent chapters. Surveys have come a very long way from the lead-line and magnetic compass era of the 19th century, and this chapter describes some of the techniques that can now be deployed for the collection of organized information at sea. It also illustrates the great range of subjects surveyed by BIO, from the classical collection of bathymetric data by hydrographers to the surveys and counts of seabirds along the coast and in the great stretches of open ocean.

SOUNDINGS AND POSITIONING

- A.J. Ken

Nearly everyone doing business on the sea needs to know the depth of water beneath them and their position in relation to the often distant land. To provide this information, hydrographic surveyors have developed, over many years, techniques to measure the ocean's depth and to precisely fix their position. Unlike their associates, the land surveyors, hydrographers do not have aerial photographs from which to and measure every topographic detail. Instead, they must use remote sensing to establish the depth and record the shape of the seafloor. Their commonest tool is the echo sounder, a device that measures the time it takes a sound signal to travel from the ship to the ocean floor and back: the sounder then automatically converts this time into a depth reading. The shape of the ocean floor, on the other hand, is obtained by using special acoustic sonars. These transmit sound signals obliquely through the water and provide an image of an area of the ocean floor.

Until the last world war, vessels were positioned by optical means. In coastal waters, compass bearings and horizontal sextant angles could be observed; in offshore waters, ships were positioned by astronomical means using sextants and chronometers. During the war, the first electronic positioning systems were developed - notably Radar, Loran, and Decca. Since then, electronic positioning systems have been increasingly refined both for commercial and naval navigation as well as for surveying. In the sixties, the need to precisely position nuclear submarines led to the development of a satellite positioning system. Modern positioning systems permit hydrographers and oceanographers to position themselves very accurately.

Below we discuss some of the routine surveys undertaken by the Atlantic Region of the Canadian Hydrographic Service, see and mention some of the obstacles hydrographers face in completing their task. In the last section we discuss in more depth the positioning systems in use today

Fjords such as this one at François Bay on the southern coast of Newfoundland have had to he resurveyed to modern standards by the Canadian Hydrographic Service.

Roger Bélanger

Coastal surveys

We are often asked when the hydrographic surveying of Canada will be completed. The answer is never, because as interest in more and more offshore areas heightens so does the need for more detailed mapping. Our present knowledge of the bathymetry of Canada's east coast is sufficient to tell us where the water is deep and where it is shallow. In some places, particularly major ports, our knowledge is detailed, but in others, such as the coast of Baffin Island, our information is scanty. Even where we consider an area well surveyed to modern standards, which in the offshore is a sounding profile every 8 km, our information is limited compared with that on land. For instance, were we to take an east-west profile every 8 km over Halifax, the result would be one line crossing the harbour entrance near Devil's Island, another line through Point Pleasant Park, and another line through Rockingham. This would mean that the entire Halifax peninsula would remain unmeasured.

Hydrographic surveys are time consuming and expensive, and the detail included is normally associated with need and the scale at which the chart itself will be published. Typically, harbour charts are drawn at a scale of 1:25,000, and their base surveys are made at a scale of 1: 10,000 with associated profiles 100 m apart. Coastal charts are commonly drawn at scales of 1: 100,000 and their associated surveys are made at scales of 1:50,000. For the offshore, a series of natural resource maps at a scale of 1:250,000 are being produced, and the surveys to provide the data are at a scale of 1: 150,000 with profiles 8 km apart.

It is not practical to chart progressively along all of the coast, and so a system of priorities is developed. At present, offshore Newfoundland is being extensively surveyed. Not only are our existing data for that area limited and old, but the oil discoveries offshore have brought a surge of economic development. Fishing has also had an effect on priorities for surveys, and new surveys are now being carried out off Nova Scotia in the area of Meteghan and on the Scotian Shelf. Systematic coastal surveying is usually related directly to the scheduled production of navigational charts, although in some cases (such as our recent surveys of Fortune and Trinity bays in Newfoundland) they are tied to interest in deep fjords as potential sites for constructing oil production platforms.

In recent years, the Arctic has been given particular attention. The discovery of oil and gas in the Arctic Islands and the Beaufort Sea, and the plans being made to ship the resources out through the Northwest Passage by supertanker have led hydrographers to give urgent attention to this area. The Arctic is particularly difficult to survey: the working season is short and many areas are permanently covered with heavy pack ice. Although BIO has two major ice-strengthened ships (C.S.S. *Hudson* and C.S.S. *Baffin)* available for oceanographic research and hydrographic surveying, many parts of the Arctic are made inaccessible to them by heavy ice. For example, the Queen Elizabeth Islands, where natural gas has been found at King Christian Island and the Sabine Peninsula, and Viscount Melville Sound, at the centre of the Northwest Passage, are both inaccessible to our ships. Fortunately, this difficulty has in part been overcome by the use of Coast Guard icebreakers. Nonetheless, some areas simply cannot be surveyed by conventional means, and the Canadian Hydrographic Service has been a pioneer in developing methods to sound through the ice. These through-the-ice soundings are done from helicopters or all-terrain vehicles equipped with echo sounders (see DOLPHIN and ARCS, chapter 3).

The Labrador coast is dotted with islands that must he carefully surveyed by the Canadian Hydrographic Service to assist mariners.

Route surveys

Surveying vast Arctic waterways from shore to shore would take a very long time. Thus it was decided several years ago to concentrate on surveying shipping routes, which would be widened as traffic increased and survey resources became available. This approach is analogous to building a cart track, then a dirt road, then a single-lane paved highway, and finally a multi-lane highway. A route has now been surveyed in this way through the Northwest Passage from Baffin Bay in the east to the Beaufort Sea in the west. Parts of it are wide, others narrow. Such route surveying has been particularly applicable in Viscount Melville Sound where through-the-ice sounding methods were employed; the entire area was surveyed on an open grid whereas, along the proposed navigational route, a very closely spaced grid was used.

This approach was also successfully used in the Beaufort Sea where very thorough coverage along the proposed route is essential because of obstructions on the seafloor known as PLFs (Pingo Like Features) that could endanger supertankers. These PLFs occurred where oil has been located, and consequently a very detailed route into the oil fields has had to be surveyed.

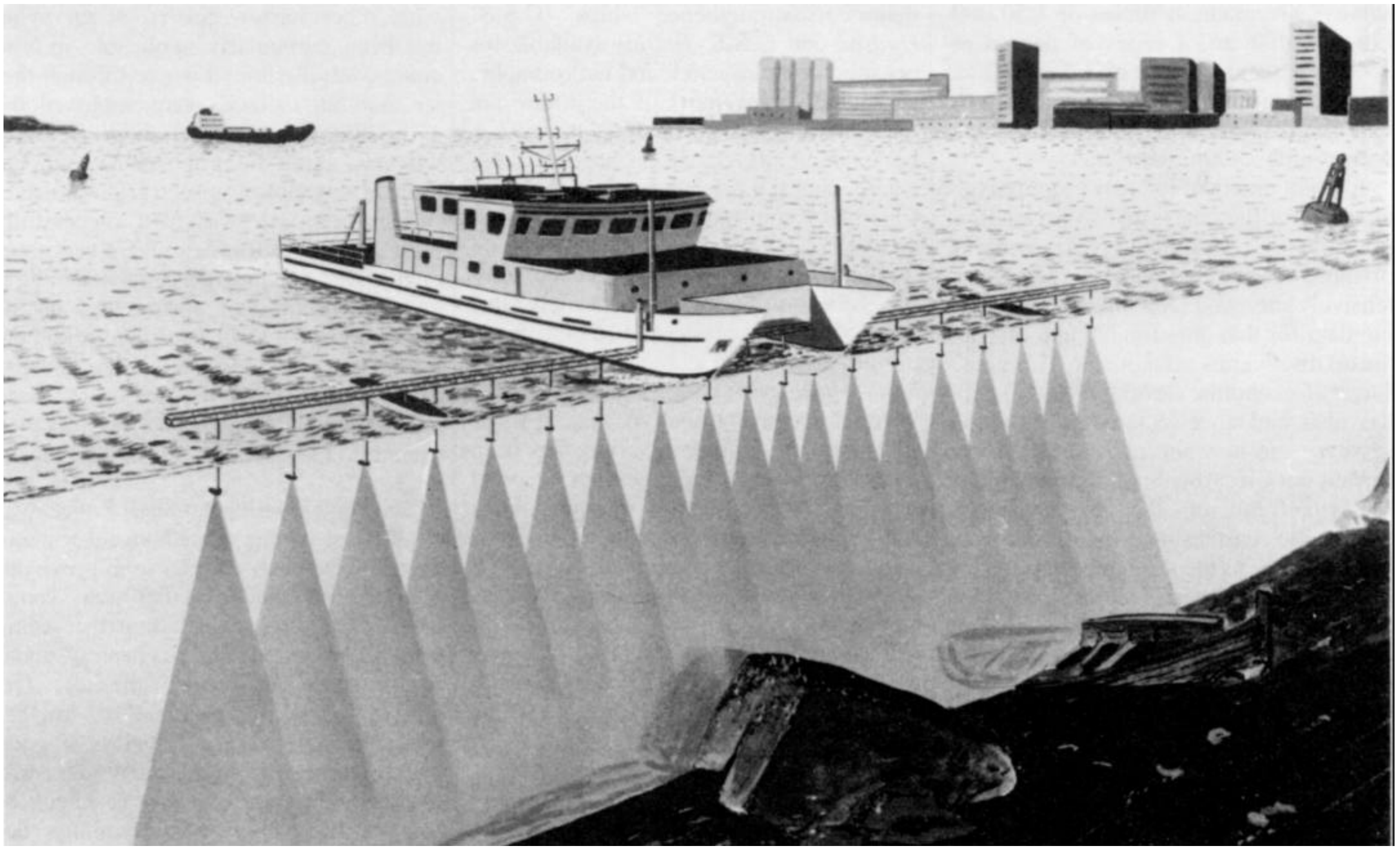
The Polar Continental Shelf Project was established by the Canadian government over 20 years ago in order to improve our scientific knowledge of the area. Today most of the Arctic including the Arctic Ocean continental shelf has been systematically surveyed through the ice. The measurement grid used had 10 km between points, but nevertheless a good overall knowledge of the bathymetry was obtained. This information has been of considerable help in planning developments in the Arctic.

Route surveys are now being superimposed over the general bathymetric coverage and as resources become available they are being extended through the critical passages of the Arctic islands. In recent years, Fury and Hecla Strait, Belcher Channel, and Prince of Wales Strait have been surveyed. Future work will include surveying the route through Jones Sound and further development of the route through the Beaufort Sea. These important Arctic surveys will involve the co-operative participation of all the regional offices of the Canadian Hydrographic Service.

Repetitive surveys

In places, the seafloor around the Canadian coastline is constantly changing. Such changes hamper tasks like the laying of oil pipelines and submarine cables. In shallower inshore waters, seafloor instability leads to greater erosion in some areas, higher sediment deposition in others. While geologists study the processes, it is the engineer who must be concerned about maintaining ship channels and harbour entrances. This is a concern where at least three government agencies come together: the Department of Public Works dredges the channels, the Coast Guard maintains the buoys and beacons, and the Canadian Hydrographic Service provides up-to-date charts.

In Atlantic Canada, the channels in



several ports particularly those of New Brunswick regularly clog. The major port of Saint John is especially susceptible to siltation, as are those of Bathurst, Dalhousie, Pugwash, and Stephenville. Particular difficulties are experienced in the long ship channel leading in through the Miramichi estuary, and a current multimillion dollar dredging program will significantly alter this channel.

One means of improving the systematic surveying of these channels is now being developed. The acoustic sweep system is essentially a rake of echo sounders 30 m long that is carried by boat along the length of the channels in several sweeps to ensure that no obstructions exist in the channel. This procedure will be carried out following dredging of a channel to ensure that the dredge has left no areas shallower than the clearing depth. Annually thereafter the channel will be resweeped to detect changes that may have occurred during the course of each year particularly from the effects of winter ice and spring run-off.

Positioning systems in use

We have already noted that positioning at sea is now carried out almost exclusively by electronic means. With the exception of modern satellite systems, there is a trade-off in positioning systems between range and accuracy: those used for short ranges are usually more accurate than those used for long ranges. Most surveys conducted within sight of land are positioned by some form of microwave system such as the Miniranger or Tellurometer MRD systems. These, with accuracies normally better than 10 m, are restricted to line of sight or what the instrument can see. Medium-frequency systems are used when you are 100-200 km from shore: these have lesser accuracies of around 20-50 m. Typical systems in this range are the Hi-Fix 6 and Argo.

A newcomer to the medium-frequency systems available has recently been evaluated and shows great promise. The unusual French Syledis system operates on ultra-high frequency but has a range of over 100 km. It incorporates a unique pulse coding system and unlike many of the other systems its signals do not appear to be significantly affected by passing over a mixed land and water path. For longer ranges out at sea, increasing use is being made of the Loran-C system, which operates between 500 and 1,500 km with an accuracy normally between 50 and 200 m. The Loran-C system is used by both the hydrographers who produce hydrographic charts and by the navigators. Therefore, the Canadian Hydrographic Service carefully calibrates the system before a survey is undertaken and also lattices the charts with a precise grid of Loran-C reference lines.

Overlapping the medium and long-range systems and providing worldwide coverage are the satellite systems. To date the Navy Navigation Satellite System (NNSS) has been used, but in the future the Navstar-GPS system will be available (see also Chapter 3). The NNSS was originally developed by the U.S. Navy to precisely position Polaris submarines. A number of polar-orbiting satellites send out signals from which the doppler change in frequency can be used to acquire a precise position relative to the orbital parameters provided as part of the satellite message. A limitation of the NNSS is that a position can only be obtained at intervals of approximately 90 minutes, and furthermore the velocity of the receiver must be accurately known. The Navstar-GPS system will provide continuous positions and is not affected by the ship's velocity. One of the major navigational developments at BIO has been the integration of different systems to provide a precise position by optimizing the various signals. This system, known as BIONAV (Bedford Institute of Oceanography Integrated Navigation System), is now used on the majority of our major ocean voyages.

The acoustic sweep system is being designed and built at BIO to improve systematic surveying of busy port channels. The system incorporates many echo sounders that in several sweeps of a vessel can verify the presence or absence of obstructions to shipping in the channel. Drawing by Imagecom

THE WATER COLUMN

Canada's network of tide- and water-level gauges

- S.T. Grant

The Canadian Hydrographic Service assumed full responsibility on 1 April 1982 for the operation and maintenance of the majority of the Permanent Tides and Water Levels Gauging Network known as the PGN. Previously, the PGN had been handled by the Department of the Environment, which has retained responsibility for the four gauges in the province of Quebec (2330, 2550, 2780, and 2935).

Water level gauges at strategic sites on Canada's coasts and major inland waterways have been operated for almost 90 years by the federal government. For example, the gauges at Saint John (0065), Halifax (0490), and Pictou (1630) were established in 1894, 1895, and 1896 respectively. The numbers, types, locations, and responsibility for the management of the gauges have undergone numerous changes over the years. The present network includes 140 gauges across Canada: 25 gauges on each of the coasts, 15 in the Arctic, and 75 on the Great Lakes and St. Lawrence Seaway system.

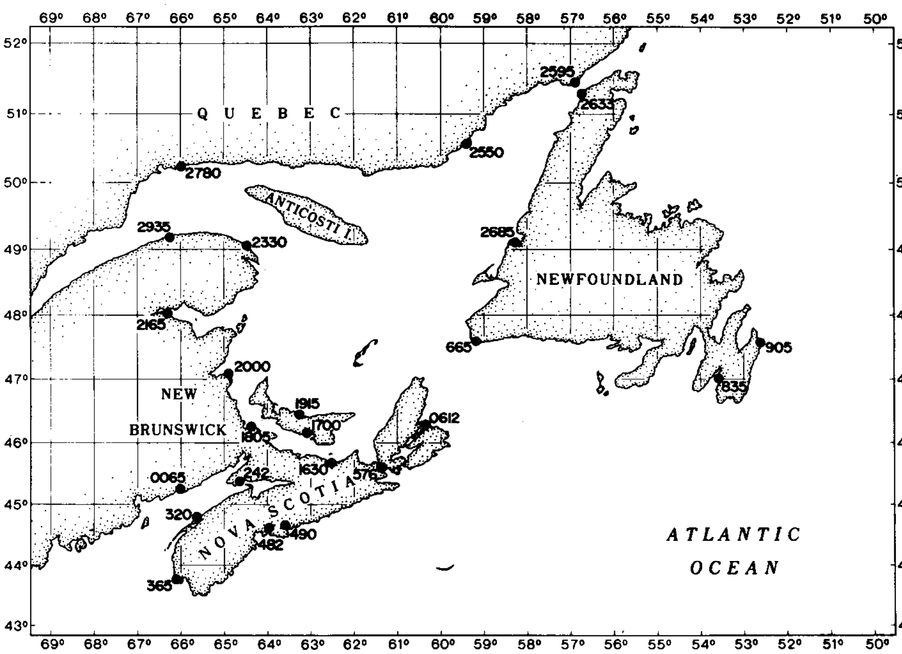
Three tide gauges are used in the PGN: a float type, a pressure (blubber) type, and the submersible Aanderaa pressure recorder. Float gauges measure the water level by sensing the vertical motion of a float in a stilling well, a vertical enclosure with only limited access to the outside water that damps or stills the effect of high frequency wave action. Pressure (bubbler) gauges pump a steady stream of bubbles down a hollow tube to the sea bottom and sense the change in pressure required to pump the bubbles due to the changing head of water over the end of the tube. Aanderaa submersible gauges are self-contained units that lie unattended on the seabed for a year or more recording pressure on magnetic tape at preselected intervals (usually once Per hour). The data they record are not accessible until the gauges are recovered. Submersible gauges record the sum of water and atmospheric pressures, so a separate atmospheric recorder must be present at each site in order to eliminate the atmospheric pressure's contribution. This extra feature makes these gauges more expensive; consequently the PGN only uses them in the Arctic where float and bubbler installations would be very expensive. The submersible gauges are replaced each summer by divers.

All gauges, even submersible ones, are affected by harsh Arctic conditions. For example, when divers tried to recover the Lake Harbour (Baffin Island) submersible gauge in the summer of 1982, they found a 10 m wide, 5 m deep iceberg scour where the gauge should have been.

The Permanent Gauging Network is continually being improved and modernized. Eight of the Atlantic Region gauges have Tidal Acquisition and Telemetry System (TATS) units installed and four more units will be installed for 1983. These incorporate microprocessors that record tidal height every 15 minutes for up to 7.5 days. The data they collect can be retrieved over a telephone line that will load the information into a shore-based computer. The Marine Environmental Data Service (MEDS) of the Department of Fisheries and Oceans has a PDP-11 computer programmed to automatically phone and acquire the tidal data from each of the 30 or so TATS units across the country every day. A number of the PGN stations in the Great Lakes have Tele-Announcer units that will report the water height as a taped message over the telephone. The Pacific Region has a number of specially equipped gauges to give automatic warning of the arrival of tsunamis - ocean waves produced by an earthquake or volcanic eruption.

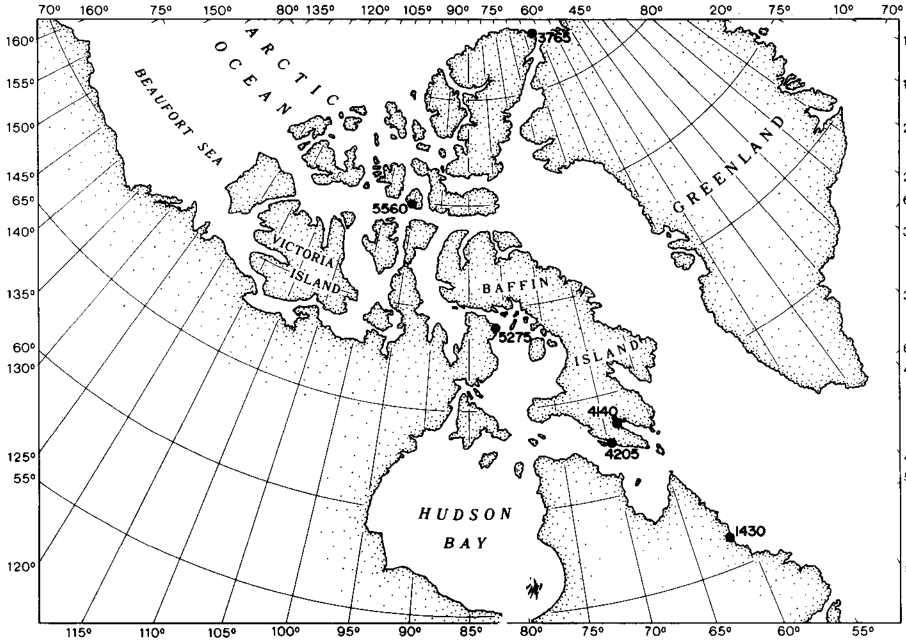
Attendants are contracted to visit each of the gauges two or three times a week and to record the tide heights from the gauge, as well as from an external tide staff and/or a separate hand-operated gauge within the gauge house, and from the TATS unit, if present. At the end of each month, the attendant removes the analog record from the tide gauge and forwards it and other records to a Regional Tidal Office for careful checking and annotation before the data are forwarded to MEDS in Ottawa. The tide data from the PGN are digitized, analyzed, archived, and distributed by MEDS, who receive hundreds of requests for PGN data every year. The following list illustrates the variety of uses that are made of the PGN data:

- *Navigation:* in predicting short and long term tide and water levels (i.e., Tide Tables); in providing real-time data and waiting-time tables for safe shipping in some rivers and harbours
- *Hydrography:* for use in sounding reductions and cotidal charts; to provide chart datums, low and high water lines, and vertical clearances for producing charts and sailing directions
- *Geodesy:* to establish vertical datums for national and international net works
- *Geophysics:* for studies of crustal movement, earth tides, and shape of the earth



Atlantic Region and Quebec stations of the Permanent Tides and Water Levels Gauging Network of Canada. CHS Atlantic is now responsible for all but the Quebec gauges.

- *Oceanography:* for ocean tidal studies; to establish mean sea level; to detect tsunamis; to set boundary conditions for numerical models
- *Limnology:* for studies of seiches, wind set-up, and storm surges
- *Coastal Engineering:* for design of marine terminals; for dredging and harbour development
- *Hydraulic Engineering:* to establish lake level control for optimum storage; to calculate discharge; to design sewage outlets and aquaduct inlets
- *Legal Authorities:* to establish high and low water boundaries; to establish water levels for investigations of ship groundings and property damage from flooding
- *Photogrammetry:* to provide tidal data required to determine best times for aerial photography of beaches and marshes and to establish elevations on photographs
- *Ocean Resources:* to establish maximum tidal ranges and currents for tidal power studies; to provide tidal data needed by offshore drilling platforms



Eastern Arctic stations of the Permanent Tides and Water Levels Gauging Network of Canada. CHS Atlantic is responsible for all these gauges.

There is much to be done. Many gauges are old and will have to be replaced within the next few years. A gauge costs between $20,000 and $50,000 to build, depending on its intended location, and it should last about 30 years. The gauge network has grown, to some extent, to meet local needs; consequently there are some areas with very good coverage and some with no coverage at all. For example, only one gauge (Nain, 1430) exists on the Atlantic coast between St. John's (905) and Frobisher Bay (4140) and it is one of those that urgently needs to be replaced. Coverage in the Arctic is also very sparse. The long-term measurement of tides in the Arctic is a very difficult problem because of the harsh environment. However, work is under way by the Tidal Development Group at the Bayfield Laboratory of the Canada Centre for Inland Waters in Burlington, Ontario, to develop a permanent bubbler type Arctic tide gauge.

Long-term temperature monitoring

\- B. D. Petrie

Brian Petrie.

Water temperature has a profound effect on the growth, spawning, and feeding of marine animals. Fisheries biologists must have enough information to separate the effects of water temperature from those of other oceanic variables. To do this, measurements made over several years are required, and they must be obtained from the fishing grounds themselves.

In 1978, four scientists from the St. Andrew's, N.B., Biological Station approached BIO for help in establishing a long-term program for monitoring bottom temperatures. They were studying the influence of temperature on the growth and feeding of nearshore commercial invertebrate stocks such as lobsters, crabs, and scallops: this information would help them estimate the stocks' growth rate and catchability. Time and financial limitations restricted the sampling that year to a total of 14 sites in the Yarmouth, Digby, Guysborough, and eastern Northumberland Strait areas.

Measuring water temperature on a large fishing ground is not straightforward. Many temperature recorders must initially be moored in a given area so that the changes in space and time can be adequately sampled. Once this is done, redundant instruments can probably be removed. However, it must be remembered that instruments placed in heavily fished areas can be damaged or lost if run over by fishing gear. Last year's redundant gauge can be this year's only gauge. Therefore, an inexpensive instrument-mooring package is required. The nearshore long-term temperature monitoring program has used the Ryan Model J analog thermograph (a $400 instrument) since it began. This gauge can measure temperature for 6 months to ± 0.5°C. The mooring consists of a net bag, which holds the instrument, attached to an anchor on the bottom, and a small surface float. About 80% of the sites are handled by local fishermen hired to moor, inspect, and recover the gauges. The remainder of the installations are tended by individual scientists.

The accompanying table and figure illustrate the growth of the program since 1978. By 1982, the number of sites and amount of data had grown by factors of 7

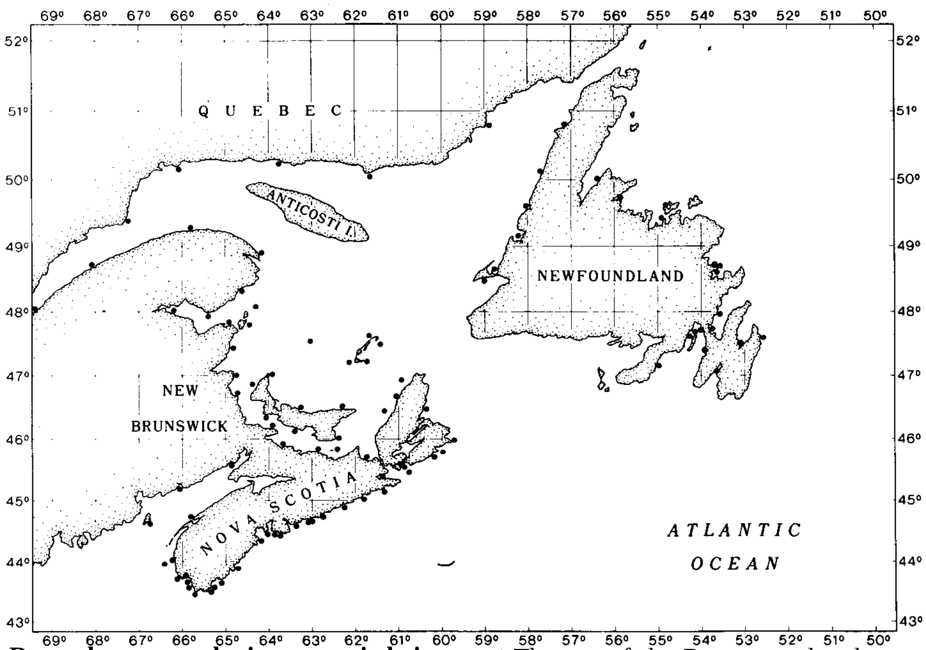
Growth of the long-term temperature monitoring program, 1978-1982

Year	1978	1979	1980	1981	1982
Number of Sites	14	41	43	60	94
Data Days	255	1,968	3,991	6.055	14.280
Percentage Data Return	58	56	76	55	77

and 56 respectively. The number of agencies participating in the field measurements was 12 in 1982 compared to just one (St. Andrews) in 1978. Some sites are maintained year-round while the majority run from early spring until late fall.

There are now 207 Ryan thermographs to be divided among the Gulf, Newfoundland, and Scotia-Fundy regions. Des Dobson of the Atlantic Oceanographic Laboratory handles the distribution of instruments to fishermen whom he has hired to operate the field program. He also handles the calibration of every recorder before and after deployment, the maintenance and repair of the gauges, and the record keeping. His full-time involvement with the program and intimate acquaintance with the thermograph have led the company to make at least eight modifications to the instrument at his suggestion. The two most significant were a simple change that increased the recorder's depth capability from 150 m to 370 m, and the introduction of clear tops that allow the person in the field to check the gauge's operation without opening it. Des also thought that the gauge might be modified into a time release so that after a prolonged period in the water it could release a float and rope to the surface. The gauge could then be recovered. This reduced the risk of the instrument mooring being hit by nets if the rope and float were deployed through the entire mooring period. Orion Electronics of Nova Scotia has successfully produced six low-cost release mechanisms that we are presently using.

Each year Evans Computer Applications Ltd. of Nova Scotia digitizes the analog traces to four hourly readings and produces plots, listings, and a magnetic tape of the data. A yearly report, available from



Ryan thermograph sites occupied since 1978 and planned for 1983.

Des Dobson, includes some assessment of the data and sampling array.

Lobster fishermen from the eastern Northumberland Strait area and St. Georges Bay, N.S., have reported good fishing when the wind is from the northwest and poorer fishing when the wind blows from the southeast. Data from temperature recorders placed on the bottom in the Strait and from the Marine Ecology Laboratory's programs in St. Georges Bay indicate that northwest winds favour warmer bottom temperatures and southeast winds lead to colder bottom temperatures. It would appear then that lobsters are feeding more actively, and consequently entering traps, during periods of warm bottom-water intrusions.

The use of the Ryan recorders has not been restricted to invertebrate fisheries. This year biologists will further examine the onset of herring spawning in the Mira. michi region of New Brunswick while last year the Newfoundland group employee the thermographs in a similar program in-. volving capelin in the Trinity Bay area.

A problem with the program has been the turnover of biologists involved, either through changing fisheries jurisdictions or simply changing jobs, which has led to a reduction in continuity. Long-term programs are particularly vulnerable to this. Some fishermen have done an outstanding job of maintaining sites over the years. whereas for a small number interest flag: after the first year. The program will undergo a comprehensive review in 1983 that will decide its future course.

Point Lepreau environmental monitoring

- J.N. Smith

John Smith.

In October 1982, the Point Lepreau nuclear generating station, located 20 km southwest of Saint John, N.B., on the Bay of Fundy, began to generate power from its 660 MW CANDU reactor, thereby becoming the first nuclear reactor operating on the Canadian coastline. Discharges of heat and radioactivity from the Point Lepreau station will be principally into the marine environment and could present pollution problems not previously encountered at other installations in Canada. In recognition of the special environmental constraints posed by the proximity of the reactor to the ocean, a monitoring program has been established within the Department of Fisheries and Oceans to assess the long-term environmental impact of the Point Lepreau station.

In contrast to most previous environmental surveillance programs, which tended to focus almost exclusively on human health considerations, the Point Lepreau Environmental Monitoring Program (PLEMP) has been designed to provide a broader understanding of the distribution of radioactivity in the environment. Radioactivity measurements are performed on representative samples from the major environmental reservoirs such as seawater, sediments, marine flora and fauna, atmospheric gases and particulates, terrestrial biological phases, soils, and lake sediments. These measurements, in conjunction with other ecological and oceanographic Parameters, are used to identify transport pathways for radionuclides through the environment and to determine fluxes of radionuclides alone specific pathways. The monitoring program is divided into pre-operational and operational phases. During the pre-operational phase of PLEMP, background radioactivity and chemicals were mea sured within the vicinity of Point Lepreau

Measurements made during the operational phase of the reactor's life are presently being compared to background conditions to document any detrimental environmental effects associated with the operation of the reactor.

A large quantity of baseline environmental data has been collected during the pre-operational phase of PLEMP. The sediment distributions of the naturally-occurring radionuclides, Pb-210 and Ra-226, have been extensively studied in order to estimate sedimentation and bioturbation rates throughout different Bay of Fundy lake and marine depositional regimes. Radionuclides derived from nuclear weapons' tests in the atmosphere, such as Cs-137, Sr-90, Pu-239, and Pu-240, have been employed as environmental tracers to examine their uptake in physical and biological phases. Cosmogenic radionuclides produced in the upper atmosphere, such as H-3 and Be-7, have been measured in water vapour and on atmospheric particulate material in order to predict dispersion pathways for radioactivity released in stack gases from the Point Lepreau station. Additional baseline chemical data include nutrient and trace metal measurements in seawater, sediments, and suspended particulate material from the Bay of Fundy.

Other types of environmental baseline data collected, during PLEMP include surveys of nearshore benthic communities near Point Lepreau to assess the impact of thermal releases on benthic community diversity and structure, and a survey of seabird feeding habits in the Point Lepreau region. A surface and bottom drifter survey was conducted for 2 years to predict transport pathways for radionuclides released from the reactor in dissolved and particulate phases. A network of air monitoring stations established in the Point Lepreau region (with one operating at Digby, N.S.) provide continuous information on meteorological parameters and atmospheric radioactivity levels. The baseline environmental data collected from PLEMP are published in annual reports (see Smith, J.N. *et al.*, Publications, Chapter 5).

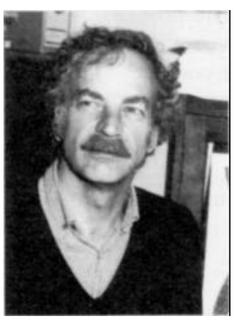
Results from the pre-operational phase of PLEMP do not indicate any apparent increases in radionuclide concentrations with increasing trophic levels of the organism, although significant discrimination has been observed in radioactivity levels between different tissues of individual organisms. Radionuclide levels are several orders of magnitude lower in marine biological phases (algae, plankton, mussels, etc.) compared to terrestrial (lichen, alder, voles, hares, etc.) and aquatic (water lily, frog, muskrat, etc.) biological phases. Evidently this is due to the presence of a large diluting seawater reservoir and the high ionic strength of seawater, which acts to limit the sorption of radionuclides onto particle surfaces. Similarly, the highest fallout radionuclide levels were measured in the organs of birds with a terrestrial diet, such as starlings, while reduced levels were observed in the liver and muscles of birds with a marine diet, such as herring gulls and cormorants.

Lichen are extremely efficient collectors of air particulate material and are presently used as a cost-effective indicator species for monitoring atmospheric radioactivity levels at Point Lepreau. Good agreement was obtained in measurements of isotopic ratios of radionuclides produced during a nuclear weapons' test by the Chinese in October 1980 between lichen samples and particulate material collected by air monitoring stations throughout the summer of 1981. The pre-operational results from PLEMP indicate that baseline radionuclide levels in the Bay of Fundy are low and are generally in agreement with levels detected in other coastal marine environments.

During the present operational phase of PLEMP, measurements are being made to characterize the steady-state distribution of heat and radioactivity released from the Point Lepreau station. The uptake of radioactivity in different environmental reservoirs will be observed during the next 3-5 years, and ecological effects associated with the concentration of radioactivity in specific phases will be documented. The ultimate goal of this program is to provide government with a sound, scientific basis to assess the environmental implications of the operation of nuclear reactors in coastal environments.

Labrador Sea studies

- J.R.N. Lazier & R.A. Clarke


John Lazier.

Roger Bélanger

The Labrador Current flows southeast along the coast of Labrador and brings cold, low salinity water from the Arctic and the northwest Atlantic to the southern Canadian continental shelf and slope. In winter and spring, the current is full of pack ice and icebergs from Baffin Bay: in summer, the area is dotted with drilling rigs exploring for gas and oil, and fishing boats exploiting one of Canada's richest fisheries. Away from the continental slope, the waters of the Labrador Sea are warmer and saltier than in the coastal currents. Winter winds from Labrador cool these waters, increasing their density, and thus an intermediate water mass known as Labrador Sea Water is formed. This water can be found spreading throughout the northern North Atlantic Ocean at depths of 1,500-2,000 m. This process is important to the atmosphere-ocean balance of carbon dioxide and to the renewal of deeper ocean waters.

The hydrography of the Labrador Current and the Labrador Sea was first studied systematically by the U. S. Coast Guard in the late twenties and early thirties. Their information was used to predict iceberg drift and decay off the Newfoundland Grand Banks and also to plan an oceanographic monitoring program that has continued up to recent times. The monitoring program was usually conducted from April through June, the period during which the iceberg hazard is the greatest.

In the fifties and sixties, other multi-institutional expeditions were run in the northwest Atlantic and Labrador Sea in support of the growing exploitation of the region's fish stocks. Standard hydro-. graphic sections across the Greenland. Labrador, Newfoundland, and Scotian shelves were laid out by the Northwest Atlantic Fisheries Organization, and its member countries undertook to occupy these sections seasonally on an opportunity basis. On these banks, large variations in the year-class strengths of the various fish stocks were seen from year to year These were believed to be caused by similar variations in the physical environment. Scientists hoped to monitor the physical environment through the standard sections and then relate its variations to those in fish populations.

In the sixties, physical oceanographers realized the ocean had a lot of variability on space scales of 100 km and time scales of days to weeks. Standard sections occupied seasonally could neither resolve this variability nor correct for its effect on estimates of, for example, a seasonal aver age temperature for a given year. Monitor ing, to be effective, had to be more frequent. Initial deployments of moored internally recording instruments on the Scotian Shelf confirmed the inadequacy of the seasonally occupied sections for this region.

In the autumn of 1978, AOL began to monitor velocity, temperature, and salinity at four positions across the continental shelf at Hamilton Bank. This program is now the Laboratory's main effort in the area. Its aim is to obtain records over long enough periods to indicate the seasonal and longer term changes in the transport or water characteristics of the Labrador Current. This knowledge can then be related to changes in the atmospheric circulation, or similarly to changes in fish stocks and spawning success. Such information is vital to sensible development of the Labrador Sea's resources.

Because such a monitoring program could involve at least two voyages a year for 5 to 10 years, we wanted a site close to towns serviced by aircraft and in an area commonly traversed by BIO ships. Also, we wanted a site where the Labrador Curient was well confined by bathymetric features, so that a few measurements at fixed locations might provide reliable transport estimates. Hamilton Bank appeared to be the best compromise position.

Initially, three mooring sites were chosen in a line running from inshore to offshore (shown in the accompanying figure). Position 1 was set at the southern end of the Labrador Marginal Trough, in a 200 m depression between the coast and Hamilton Bank. This site is nominally within the inshore branch of the Labrador Current. Positions 2 and 3 at the 300 and 1,000 m isobaths were meant to be in the core of the main or offshore branch. Each mooring had a single Aanderaa current meter just above the bottom; position 3 had an additional meter at 400 m. We would have preferred current meters in the upper 100 m at each site; however previous attempts indicated that losses due to icebergs and/or fishing trawlers would be very high.

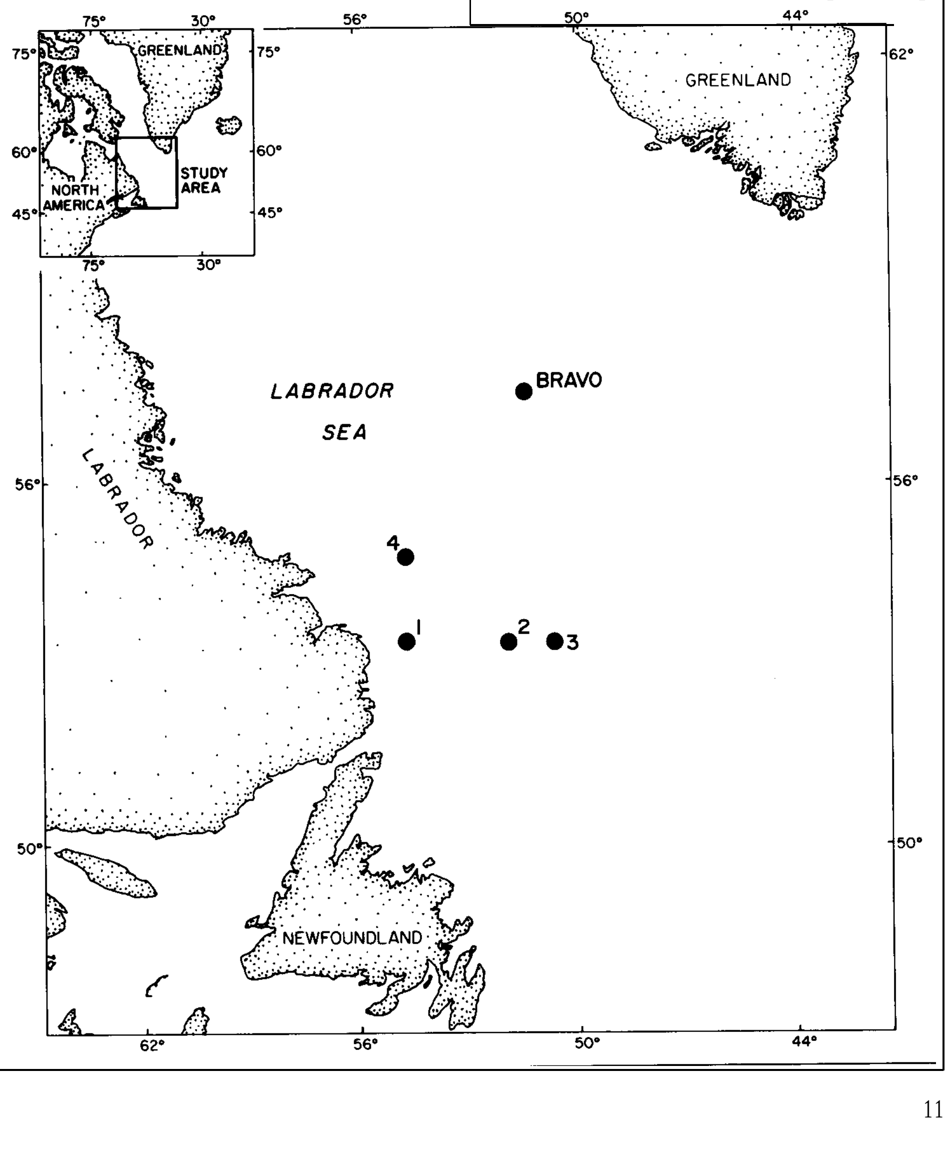
During the fifties, hydrographic measurements began to be made on a regu-ar basis from the ocean weather ships (OWS). An analysis of the data collected at OWS Bravo in the Labrador Sea up to 1974 showed that a large change in the near-surface salinity had existed for several years. The change could be related to changes in the atmospheric circulation in the region and was similar to other oceanographic changes noted in the waters around Iceland. The presence of this low-salinity upper-water inhibited convection in the Labrador Sea for several winters, and this in turn caused changes in the deep hydrographic conditions over a larger area of the North Atlantic Ocean.

AOL carried out systematic surveys of the Labrador Sea in 1965-1967 and then again in 1976-1978. These data, together with earlier work in the area by ourselves and many others, show how the Labrador Sea Water has changed over the past decade in response to changes in surface waters. By studying these changes, we can begin to estimate a circulation time for an intermediate water mass such as the Labrador Sea Water. This estimate is needed to design mathematical models to predict the distribution of substances released at deep ocean dump sites and to construct models of atmospheric climate.

From 1976 to 1978, AOL placed current meter moorings beneath and within the Labrador Current. They showed a great variation existing at periods of a week or two, which indicates that the sparsely sampled historic Labrador Current hydrographic data set cannot be used to determine intra-annual variations. On the other hand, data from hydrographic stations such as Bravo and Station 27 off St. John's, Newfoundland, indicate that variations over several years are likely and significant.

As of November 1982, we have set the array 8 times, mooring a total of 27 current meters. Out of a possible 164 current-meter-months of data, only 89 months have been obtained. At position 3, moorings and current meters were lost due to corrosion; at position 2, lost to either trawlers or icebergs; and at position 1, lost to faulty release equipment or icebergs. To reduce the corrosion losses, we have replaced stainless steel wire with a synthetic non-corrosive Kevlar rope. Site 2 seemed exceptionally exposed to icebergs and trawlers and was abandoned. A new mooring site was established in November 1982 at Site 4.

Not all our recoveries have been made by BIO people. One mooring drifted south to be picked up by a fisherman from Baie Verte, Newfoundland, 2 weeks later. Another broke loose 3 weeks before its scheduled recovery and drifted for 15 months across the North Atlantic to be picked up



Initial mooring sites chosen to monitor velocity, temperature, and salinity across the continental shelf at Hamilton Bank. Also shown is OWS *Bravo*.

on the west coast of Ireland with a perfect data record intact.

After 4 years, we have obtained 24 months of data from position 1 and 36 months (with a 3 month gap in the summer of 1981) from a depth of 1,000 m at position 3. Important features of seasonal and longer term changes are just becoming evident. There is a tantalizing suggestion that the current speed below the offshore branch has been decreasing over the past 2 years. Further measurements will, we hope, confirm that this is not due to small changes in the position of the mooring each time it is reset.

The offshore record clearly shows an annual temperature change from about 3.2°C in May to 3.7°C in January, a surprisingly large change at a depth of 1,000 m. The inshore record also shows a large annual cycle in temperature with approximately the same phase as the deep water record. An unexpected observation at the inshore site was a sudden drop in temperature and salinity accompanied by an increase in velocity in the middle of February 1979 and 1980. The cause of these changes is unknown. Unfortunately, the moorings over the following two winters were lost.

The project is now nearly half finished. Although our losses have been higher than usual, we have learned much about the problems of working in the area and are developing better techniques. The recovered data are of excellent quality, and contain important clues pointing to a better understanding of the dynamics of this complex and ecologically productive shelf region. Over the last half of the program we anticipate a decrease in mooring losses, more efficient use of ship time, and an application of the lessons we have learned in order to take a more concentrated look at the unique features of the flow around Hamilton Bank.

THE LIVING RESOURCES

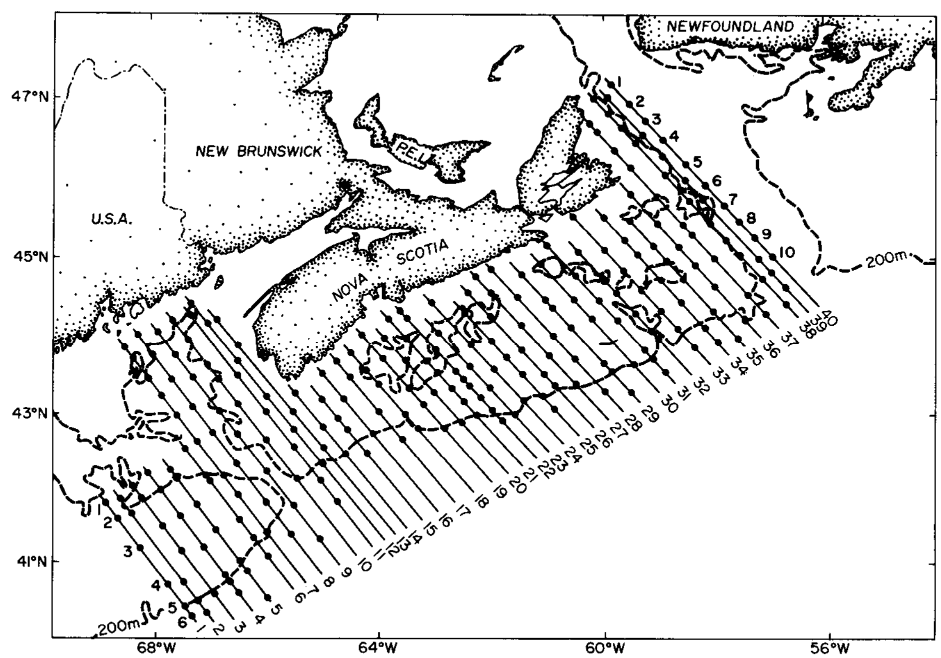
The Scotian Shelf Ichthyoplankton Program: 1977-1982

- R.N. O'Boyle

Resident on BIO's mainframe computer is a data base of grand proportions. It holds information on the egg and larval distributions of over 200 zooplankton and ichthyoplankton species collected on 38 research surveys from 1977 to 1982. In the same computer are data on weather conditions (wind speed, swell height, etc.) as well as on biological oceanography (nutrients, chlorophyll, particles) and physical oceanography (temperature, salinity, light) taken at the same time as the plankton data. This data set, collected under the auspices of the Scotian Shelf Ichthyoplankton Program (SSIP), represents the most comprehensive overview of the plankton communities and their environment off the coast of Nova Scotia now available.

The program has its roots in a 10-year time series of ichthyoplankton surveys conducted in the Gulf of St. Lawrence by A.C. Kohler of the Marine Fish Division (MFD) at St. Andrews, N.B. Upon completion of these surveys in 1975, it was felt that a similar survey conducted on the Scotian Shelf would be useful. However, whereas the Gulf surveys were intended to gather distributional information, it was decided at the onset that surveys on the Scotian Shelf should also provide larval abundance estimates for use in designing fisheries recruitment models. Thus, in addition to a different sampling design, the planned survey needed to have a high level of quality control and standardization.

An international workshop was organized by MFD and held at BIO in late August of 1977 to develop what could be considered the ideal survey design. Plankton biologists from Canada, USA, and Europe were invited to present their experiences and comment on how best to achieve



The Scotian Shelf Ichthyoplankton Program's station grid. Solid dots indicate primary stations; hydrographic stations are circled. The boxed area shows those stations considered in a special study of Emerald Bank

the stated objectives. Their conclusions:

(1) The seasonal and geographical distribution of ichthyoplankton species on the Scotian Shelf should be delineated over 3 years;

(2) A time series of estimates of abundance, mortality, and growth for various ichthyoplankton species should be developed; and

(3) Data on chlorophyll, particle size, and hydrography should be collected for the development of theoretical models of the fisheries that would assist in fisheries science and management.

The workshop made a number of recommendations that were implemented in the first standardized SSIP survey in August 1978. Prior to this date, six voyages had been conducted using the Gulf survey design and methodology, and thus were not truly comparable to the standardized SSIP surveys. The SSIP sampling grid initially contained 245 stations, roughly spaced at 15 n. mile intervals (see accompanying map) covering an area from Georges Bank to the Laurentian Channel. Tow protocol was similar to that used on plankton surveys conducted out of Woods Hole, Massachusetts, in that the entire water column was sampled. The main sampling gear used was the 61 cm paired Bongo frame fitted with two 0.333 mm nitex plankton nets. In addition, two surface tows, one with a neuston net and another with the bongo gear, as well as a midwater trawl with an Isaacs-Kidd net were conducted (see accompanying figures). Water samples were collected and temperature, salinity, nutrients, chlorophyll, and particle size and number were recorded.

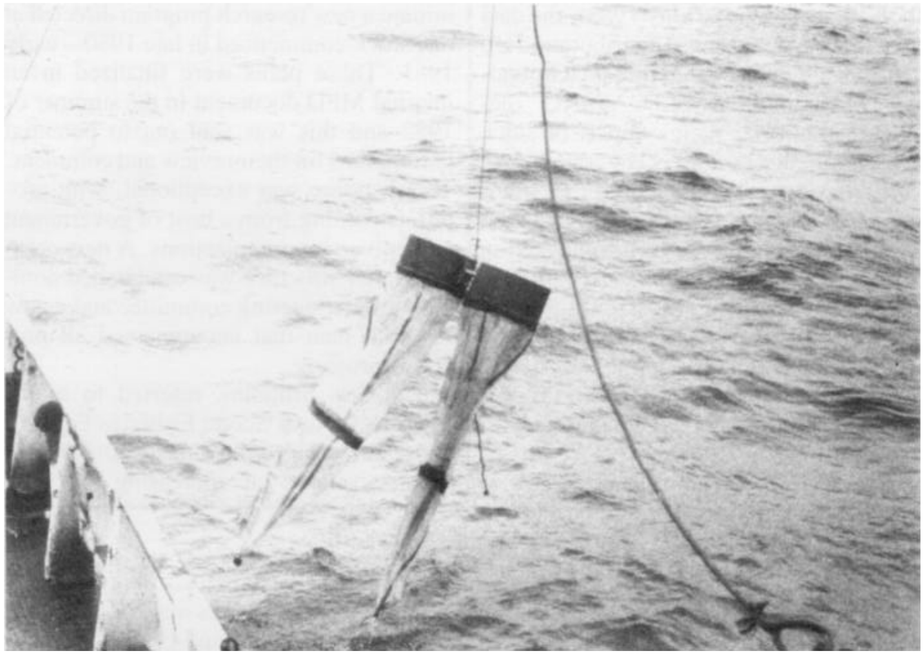
The initial sampling plan called for, at the very least, bimonthly coverage of the grid. Because the first standardized survey took almost 1.5 months to complete, some cutbacks in sampling intensity were in order. A subset of 150 stations was first chosen from the initial 245. Next, hydrographic work was restricted to five transects perpendicular to the coast but, to collect a large size range of organisms, the array of plankton gear was maintained. This new survey protocol resulted in voyages of one month's duration that provided good sample coverage, and it was adopted for the remainder of the program.

SSIP has enjoyed the participation of many groups both within and outside of BIO. In the summer of 1978, the Marine Ecology Laboratory formally entered the program to support the hydrographic work and zooplankton analysis. In 1979, the program' voyages were used to survey oil pollution in support of studies by the Atlantic Oceanographic Laboratory of the *Kurdistan* oil spill. In the same year, R.G.B. Brown of the Canadian Wildlife Service participated in a number of cruises to examine seabird distribution on the continental shelf. Outside BIO, J. Roff, L. Coates, and J. Trembley of University of Guelph became involved in 1978 in a 3 year study of community structure and fish larval food habits. At different times, Dalhousie University staff have collected samples aboard SSIP voyages. By far the largest external participation has been by the Soviet Union. That country entered the program in 1977 and by September 1982 had conducted 15 SSIP-style surveys in support of joint Canada/USSR silver hake research. Three of these, conducted in 1980, were in-depth process studies directed specifically at silver hake.

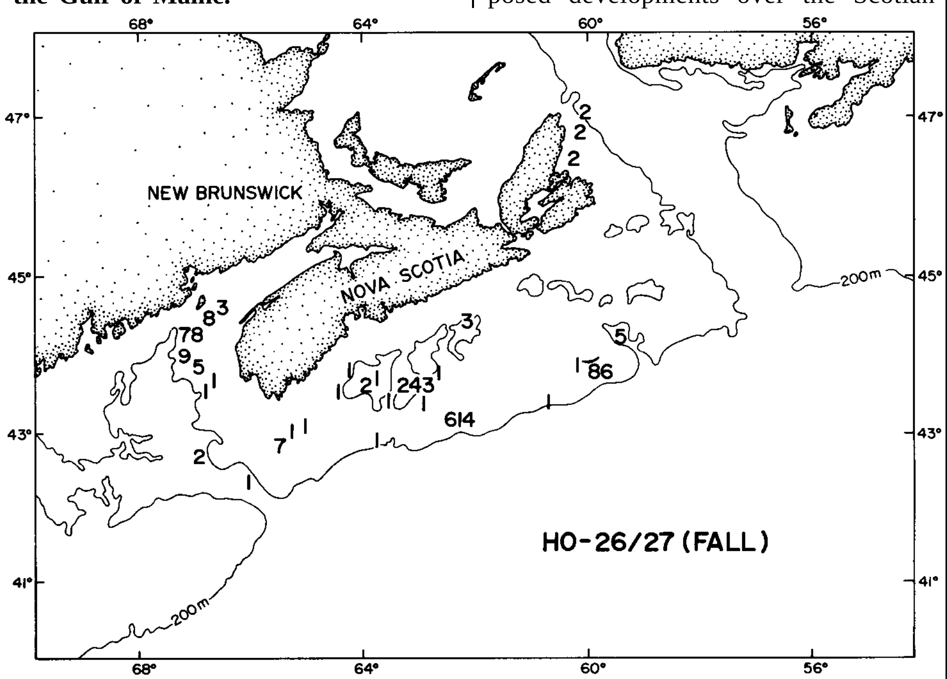
The program underwent reviews in 1979, 1980, and 1981 during which the probability of meeting the originally stated objectives was extensively discussed, both in view of the resources needed and in light of the experiences of others throughout the world. It was felt that the first objective, the definition of distributions, could be realized with the program survey design but that the second objective, establishing a time series of data, would require more intense sampling, which would have to be restricted to one species and even one stock to reduce costs. As well, scientific thought then was coming round to the idea that recruitment was determined by processes acting during the first year of life, not just for the first 3-4 months. Thus, any subsequent survey design would have to involve surveys of ichthyoplankton, juvenile fish, and even adult fish. This realization led to the first thoughts on a successor program to SSIP.

SSIP officially ended in March 1983 when Canada and the USSR decided to stop further ichthyoplankton studies and to initiate a new survey design specifically directed for silver hake. During the SSIP program, the 35 broad scale surveys conducted generated an estimated 40,000 plankton samples. Indeed, these have been labelled a national resource and are presently undergoing curation and archiving. Over the entire time period, the Scotian Shelf was sampled at least once and most often twice per month. By May 1983, virtually all collected data, excluding the neuston samples, had been processed and placed on the BIO mainframe's System 2000 data base.

To date, the most frequent use of the information has been by oil companies and their environmental consultants to prepare Environmental Impact Statements for proposed developments over the Scotian



The SSIP used a paired bongo frame fitted with two plankton nets.



Sample data from the SSIP: Distribution of pollock catch (numbers per tow) in the fall from Canadian research vessel surveys on the Scotian Shelf and in the Gulf of Maine.

Shelf. Most recently (May 1983), the data In pollock egg and larval distributions (see figure) were presented before the Ground-Fish Subcommittee of CAFSAC (described in chapter 4) in support of stock Delineation discussions. The same may well happen for most of the other commercially important fish stocks. In 1984, the silver hake data are to be analyzed in tandem with data on juvenile and adult fish to define recruitment processes during the rirst year of that fish's life. There are also plans to conduct community structure analysis on the data set. Thus, profitable analyses of SSIP data will continue for some time.

But what about future work? Plans to initiate a new research program directed at one stock commenced in late 1980 - early 1981. These plans were finalized in an internal MFD document in the summer of 1982 and this was sent out to potential participants for their review and comment. The response was exceptional, with proposals coming from a host of government and university organizations. A new organizational structure was established complete with a steering committee and a new research plan that encompassed all proposed projects.

The new program, referred to as the Southwest Nova Scotia Fisheries Ecology Program, consists of almost 30 different projects aimed at increasing our understanding of the production processes of the Southern Nova Scotian Shelf area and of how the resident haddock population is affected by these. Studies range from an examination of current flow on and around Brown's Bank to the activity of the fishing fleets and how fish prices affect these. A major part of the program will examine the processes affecting haddock egg and larval distribution and mortality. This part of the program is in a very real sense a continuation of SSIP. Only the name and participants have changed. Perhaps in a year or so you will be reading a review of the Fisheries Ecology Program and how far it extended the knowledge gained from SSIP.

The Observer Program

-B. Wood

The Marine Fish Division relies heavily upon samples of commercially caught fish in assessing fish stocks. This sampling takes place both on land and at sea, and may involve Canadian or foreign vessels. The Observer Program is responsible for the at-sea portion of this sampling. It works through a group of observers who spend sea time aboard Canadian and foreign trawlers. For many offshore fisheries, these observers, who are trained in both scientific data gathering and basic fisheries management, are the only sources of current information.

The Observer Program grew out of a 1977 study in which Canadian observers were placed on Soviet and Cuban trawlers. The study's objective was to assess whether placing a limit on foreign fishing seaward of Sable Island would reduce fishing pressures on Scotian Shelf haddock and cod stocks.From this initial scientific-management program, the basic observer role evolved.

Since 1977, the observers' prime role has not only been to estimate and sample catches, but also to assist in the overall management of many of the fisheries. Below we describe mainly the sampling aspects of this program.

There are now about 35 contract observrs involved in a wide range of fisheries. In addition to the silver hake fishery on the Scotian Shelf where they were initially deployed, observers are active in the Scotian Shelf squid fishery, the cod fishery in the Gulf of St. Lawrence, the Japanese tuna and squid fishery, the northern shrimp fishery, and all fisheries involving large Nova-Scotia based offshore draggers. Observers are also used in occasional special projects, such as the haddock mesh study in southwestern Nova Scotia, or in the monitoring of foreign vessels that receive herring catches from local fishermen. All these activities make the Observer Program a year round-project.

Although an observer encounters a wide variety of vessels, fishing methods, and catches throughout the year, the sampling structure and objectives remain similar. In all sampling activities, observers must be careful that their data are representative of the fishery. Obviously, because an observer is alone on a fishing vessel, he or she can never hope to analyze an entire catch. Therefore, the observer attempts to randomly sample the total catch. To do this, all fish in a given species catch must have an equal chance of being selected for the experiment; the tendency to select only the large fish must be resisted. Randomness in stock assessment is vital; without it, the efforts of observers and of the whole Marine Fish Division would be worthless.

The actual sampling of catches may involve simply measuring lengths and weights, or may include observing feeding patterns, community structure, and maturity stages, and noting the presence or absence of parasites. Observers also gather samples at sea for later analysis on shore. These latter samples provide the Marine Fish Division with important data for fisheries management related research.

Perhaps the most important of all these samples are otoliths, or "ear bones", that are used for ascertaining the age of fish. Fish are generally aged using either body scales or otoliths. An otolith is a bony

An observer at work - Dave Spallin.

mechanism at the base of a fish's brain that contains growth rings not unlike those of a tree. Although gathered by observers at sea, otoliths are examined on land by Marine Fish Division staff. Once known, a fish's age is combined with other information such as its length and weight.

These data are then used to determine the age structure of a stock and establish either that it is healthy or that it is in possible danger. For example, a large proportion of smaller, younger fish can indicate good recruitment or replenishment. The combination of otolith and other data helps Marine Fish Division scientists establish growth rates and catch at age statistics (a breakdown into age groups), important parameters in the stock assessment process.

Observers also collect certain fish samples that are subsequently brought into BIO laboratories for stock discrimination work. For example, because the stock structure of silver hake on the Scotian Shelf was unclear, fish from different areas were analyzed in the laboratory in an effort to reveal variations in fish anatomy that might indicate the existence of distinct stocks. Observers routinely gather fish stomachs for processing on shore as part of an ongoing study of fish feeding patterns. They document and return to shore any unusual or rare specimens occurring in catches. Some of these specimens find a place in the National Museum or at the Huntsman Marine Laboratory in St. Andrews, New Brunswick.

There have been occasional special projects over the past 2 years in which observers played important roles. In 1981, an observer accompanied an experimental squid jigger fishing under the Canadian flag and submitted a detailed report on its successes and problems. In 1982, observers were sent on small draggers fishing with experimental nets in order to assess any increases or decreases in catches.

Net mesh size and configuration have played a significant role in the Observer Program's joint research efforts with other nations. In 1978, a mesh selectivity study for squid was carried out on the Japanese vessel *Shirune Maru.* Small mesh netting was placed around a large mesh to determine the size of squid retained by each. In 1981, the effects of increasing the minimum allowed mesh size in the silver hake fishery on the Scotian Shelf were assessed. Two Soviet vessels fished side by side, one with a normal 60 mm mesh net and the other with an experimental 90 mm net. Observers from both Canada and the USSR extensively sampled the catches to discern size differences between fish on each vessel.

Through its extensive sampling of catches, the Observer Program provides answers to numerous problems in fisheries management. Its role in the traditional fisheries will continue and expand as the need arises.

(Editor's note: The role of the Marine Fish Division in assessing fish stocks is further described in chapter 2).

Seabird distribution studies

- R.G.B. Brown & D.N. Nettleship

In February 1970 the tanker *Arrow*, with a cargo of 10,000 tonnes of Bunker C fuel oil, ran aground and sank in Chedabucto Bay, Nova Scotia. It was the first, but by no means the last, major Canadian oil spill. Dead and dying auks, sea-ducks, and other seabirds began to come ashore around the Bay almost before the oil itself arrived. Two weeks later, after a storm had blown a large oil slick out to sea, oiled birds also began to come ashore on Sable Island, some 200 km to the southeast. This offshore kill was in fact larger than the well-publicized toll in the Bay itself, and included large numbers of such species as Northern Fulmars *Fulmarus glacialis* and Dovekies *Alle alle* that, up till then, were thought fairly rare in Nova Scotian waters.

One of the many lessons of the *Arrow* disaster was to show how little we knew, and how much we needed to know, about the distribution and ecology of the seabirds of eastern Canada. This point has been made again and again in many ways since 1970. The environmental implications of the recent boom in offshore hydrocarbon development off eastern Canada and of the proposal to ship liquid natural gas south via the Northwest Passage are examples. So are the impacts of new fisheries, which harvest important seabird prey such as capelin *Mallotus villosus*, and of new techniques such as monofilament gill-nets, which have drowned large numbers of auks off Greenland and Newfoundland.

The Canadian Wildlife Service (CWS), now part of Environment Canada, was the federal agency responsible under the Migratory Bird Conventions Act (1918) for the necessary seabird research programs. The research had in fact already begun in the fifties, with the work of the late Leslie Tuck on the breeding biology of murres in Newfoundland, Hudson Strait, and Lancaster Sound, and was extended in the sixties by other workers to other seabirds. It was greatly expanded in the aftermath of the *Arrow* spill. CWS was first represented at BIO in 1971, and its Seabird Research Unit was formed there in 1976.

This research has followed two distinct but inter-related themes. The greatest effort in terms of personnel and funding has been the work of David Nettleship and his co-workers on the breeding biology of seabirds. These studies have put their emphasis on the murres and other auks, highly specialized species whose diving habits have made them especially vulnerable to oil and to gill-net drowning, and whose low reproductive turnover makes it difficult for their populations to recover afterwards. At the simplest level, the surveys have set up baselines for the current population sizes of auks and other seabirds at most major colonies in eastern Canada, and have provided standard census plots by which to detect and monitor future changes in bird numbers. But beyond this, through the analysis of the timing and success of laying, fledging, and many related population parameters, they have also established baselines for breeding performance. These will allow us to examine the long-term effects on the birds of pesticide residues and sublethal contact with oil, or of climatic changes. The locations of the colonies studied have ranged from the High Arctic and Hudson Strait to southeast Labrador and eastern Newfoundland; the current emphasis is on Labrador and Newfoundland, though further Arctic work is planned. When the whole project is completed, we will have a series of 'profiles' of seabird biology collected at colonies in a wide variety of marine habitats between latitudes ca. 46-78°N, along some 3,500 km of coast - a scope far wider than anything done elsewhere.

A necessary preliminary to this was the location of the colonies themselves. Many of the Arctic colonies were discovered by the first CWS arctic surveys in 1972-73, and others were known mainly from the accounts of 19th century explorers. The last important gap was the coast of Labrador; the colonies there have now been extensively surveyed by field parties from the Seabird Research Unit under Tony Lock.

The second main theme of the Unit's work has been the location of seabirds when they are away at sea. This is an important gap of another kind, because even breeding seabirds spend much of their time foraging away from their colonies, and the subadults of many species spend several years at sea before they first come back to breed. This is the habitat where the birds come into contact with oil and gill-nets, and where they catch food contaminated with pesticide residues. The difficulty has been getting out there to study them. Until recently, almost all pelagic observations were limited to a few, well-defined, steamship routes, but the boom in oceanographic research since World War II has changed all that. The cruises of the fleet of oceanographic ships based at BIO have allowed ornithologists working with Dick Brown to make standardized, quantitative assessments of the pelagic distributions of seabirds, and to interpret their findings in the light of oceanographic data. Quantitative aerial surveys, pioneered by CWS but done for the most part by consultants commissioned by the oil industry, have added an extra dimension, providing replicate pelagic censuses in areas and at seasons inaccessible to oceanographic ships. As a result of all this work, we now know in reasonable detail the pelagic distributions of most seabirds in the waters off eastern Canada north of 40°N and west of 40°W and for most of the year south of 55°N, but only for summer and fall in the Arctic.

The current emphasis on pelagic research is towards integrated ornithological and oceanographic investigations of areas where seabirds are locally abundant, such as ice-edges in the Arctic, tidally-induced upwellings in the Bay of Fundy, and the Polar Front northeast of the Grand Banks. We are also attempting to integrate our distribution surveys with quantitative schemes in New England, the United Kingdom, and Norway. The seabirds that occur off eastern Canada do not always breed there. They come from as far away as Greenland, Russia, and Antarctica, and so an oiling incident in our waters may have repercussions far away. Thus, from the ornithological point of view, we prefer to treat the whole North Atlantic Ocean as a single unit. [The data on seabird distributions collected on these surveys are described in more detail in the ATLASES section of Chapter 2.1


Roger Bélanger

Great Bird is the larger of the two islands that make up the Bird Rocks of the Magdalen Islands in the Gulf of St. Lawrence. Until man interfered, Bird Rocks was home to the largest colony of Northern Gannets on record. Today, lesser numbers of the gannets as well as Black-legged Kittiwakes, Common and Thick-billed murres, Atlantic Puffins, and other seabirds breed there.

Lobster larvae in relation to water movement

- G.C. Harding, K.F. Drinkwater, & V.P. Vass


Roger Bélanger

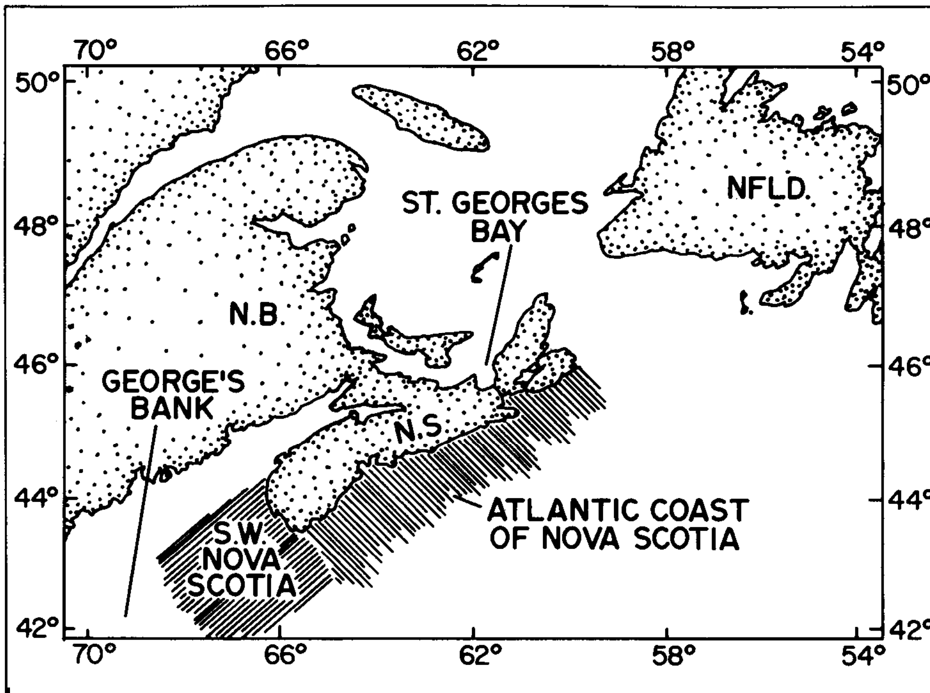
Gareth Harding.

The Marine Ecology Laboratory has 10 years of field data collected relevant to the ecology of larval fish in the southern Gulf of St. Lawrence. St. Georges Bay was chosen as a study site because its physical and biological properties were representative of a broader region in the southern Gulf, yet the presence of a gyre within the Bay increased our chances of sampling the same populations throughout the productive cycle. Equally important in this choice was that we could sample from a shore base with a small boat at a fraction of the cost of using oceanographic ships. In 1976 this working group expanded to include specialists to study phytoplankton, zooplankton, and sediment dynamics and how this production related to larval fish recruitment and survival.

In the fall of 1977, the Canso Marine Environmental Workshop was first convened to consider any effect the Canso Causeway, completed in 1954, has had on regional fisheries. The lucrative lobster fishery was of principal concern at this meeting because the Atlantic coast yields had dropped to 6% of the pre-1954 levels, and some Chedabucto Bay fishermen believed that the causeway's separation of the bays was somehow responsible for the failure of their fishery. It was generally agreed that the obstruction of adult lobster movements by the causeway would probably have had negligible effects on Gulf or Atlantic populations. The possibility that flow through the Strait could have transported planktonic larvae from St. Georges Bay in sufficient numbers to affect lobster recruitment in Chedabucto Bay prior to the causeway was considered worth examining. At this time there was little information on the abundance of lobster larvae in St. Georges Bay and none from the Atlantic coast. At the second meeting, held in February 1978 in St. Andrews, N.B., Mike Dadswell developed the idea that the closure of the Strait of Canso stopped an important source of larvae for Chedabucto Bay, which ultimately resulted in the collapse of the fishery from Cape Breton Island to Lunenburg County. Doug Robinson, however, reasoned that most females have to endure several seasons in the fishery before shedding larvae and argued the case that the Atlantic coast decline is simply a result of overfishing before females can extrude eggs.

This unsatisfactory conclusion to the workshop encouraged the Marine Ecology Laboratory to undertake a fresh survey of St. Georges Bay in 1978 with gear that would adequately sample the larval lobster population. We developed the hypothetical situation in which the causeway is removed and larval lobsters are assumed to have free passage with the residual drift

The Marine Ecology Laboratory resurveyed the larval lobster population in St. Georges Bay in 1978.



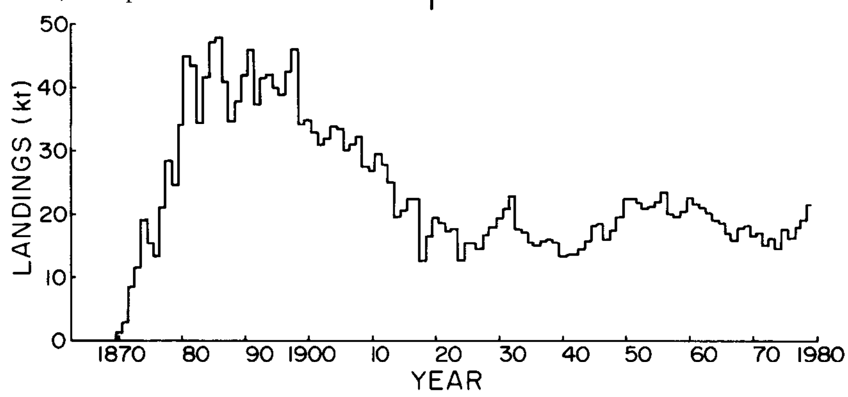
From St. Georges Bay to Chedabucto Bay via the Strait of Canso. We used our survival estimates from St. Georges Bay to calculate the worth of these larvae to Chedabucto Bay and developed a growth-survival model to estimate the value of expatriate larvae in Chedabucto Bay to the trap fishery in subsequent years. Our estimate represents 60% of the average landings in the Chedabucto Bay region during the 11 best years of this fishery from 1950 to 1960. The exact value depends on a number of assumptions, the most tenuous being the survival of lobsters in Chedabucto Bay. Nevertheless, the past importance of recruitment to Chedabucto Bay through the Strait of Canso must have been significant.

We then considered other factors that have been proposed in the past to explain changing lobster stocks. The first was that trap fishing had reached a critical intensity in certain regions thus dropping the recruitment rate below that needed for replacement, and causing a local population decline. However, we could find no evidence that the fishing effort has been greater along the Atlantic coast of Nova Scotia than for any other region.

Climate has also been associated with the success of lobster recruitment. We obtained high correlation between lobster landings bordering on the Gulf of Maine and sea surface temperatures at both Boothbay Harbor, Maine, and St. Andrews, N.B., but nowhere else. Unfortunately there is not a comparable temperature record along the Atlantic coast of Nova Scotia. We examined A.G. Huntsman's 1923 hypothesis that warm summer surface water (16-20°C) is essential for successful molt completion and bottom settlement of larvae before cooler temperatures halt development. This idea is found to be widely applicable. It helps explain the anomalously low numbers of first stage larvae found off southwest Nova Scotia compared to both the abundance of fourth stage larvae and the commercial lobster landings. The larval recruitment off southwest Nova Scotia is hypothesized to come from offshore, and we have tentatively indicated the northern face of Georges Bank as the source. We have also suggested that the Atlantic coast of Nova Scotia represents a 'fringe' zone for the lobster, since the summer surface temperatures are in general too cool and the prey species too large to allow successful recruitment of the larval stages along the open coast. However, larval refuges could exist in protected embayments where a strong thermocline can be established and where flushing rates are low. It does not appear to be economically feasible to reopen the Strait of Canso at this time; however, it is possible that the creation of protected areas for lobster spawning in warm sheltered bays along the Atlantic coast could be enough to re-establish lobster stocks.

We are presently involved in a joint project with DFO's Fisheries Research Branch to examine Huntsman's hypothesis as it applies to the Atlantic coast of Nova Scotia and to offshore southwest Nova Scotia. In 1982, larval surveys and hydrographic data were collected in St. Margaret's Bay and along one transect 11 n. miles offshore to assess local recruitment and survival of larval lobsters. This summer, a more intensive survey is planned for this same region plus we will do exploratory larval towing together with hydrographic work along Northeast Channel and Georges Bank in an attempt to locate the sources of larvae for inshore recruitment along southwest Nova Scotia from Shelburne to Digby counties. A more extensive program is being planned for southwest Nova Scotia in 1985.

Canadian annual lobster landings from 1870 to 1979



THE NONLIVING RESOURCES

Oil industry multichannel seismic data

- A.C. Grant

Alan Grant.

Geophysical surveys and drilling for petroleum off eastern Canada, from Scotian Shelf to Davis Strait, provide probably the most comprehensive set of geologic data from a continental margin anywhere in the world. Although there has been no drilling north of Davis Strait, geophysical surveys have been conducted in Baffin Bay and westward into Lancaster Sound. These data are a tremendously valuable resource to the earth science community. At BIO, they are studied intensively by petroleum geologists with the Atlantic Geoscience Centre.

Multichannel reflection seismic profiling is the major geophysical tool used in exploring for petroleum. The basic principle of this method is analogous to echo sounding to determine water depth: the chief difference is that a more powerful energy source is needed for the sound waves of a seismic profiler to penetrate rock. In single channel seismic profiling systems, one receiving channel records echoes (or reflections) from the sea floor and from the sediment layers below. The single channel system has been used for many years by the Atlantic Geoscience Centre to map the offshore geology usually to depths of not more than a few hundred metres. Oil companies use the much more powerful multichannel receiving systems to record reflections from depths as great as 10 km beneath the sea floor. The hydrophone cable towed behind a survey vessel to detect these reflections may be as long as 3 km, and carry several hundred receiving channels. The firing rate of the energy source is determined by the spacing of the receiving channels in the hydrophone cable, and the ship's speed relative to the sea floor. This survey method provides an array of reflection paths from subsurface reflectors (i.e., sediment layers) that can be analyzed to determine sound velocity and in turn the depth to the reflector. The reflected signals can be processed to remove spurious events and to enhance genuine reflections, a process that involves large volumes of data and requires extensive computer capacity. The computer processing of multichannel seismic data is usually more costly than collecting the data at sea. In Canada, computer centres capable of processing multichannel seismic data are available only in Calgary.

Oil companies have been conducting multichannel seismic surveys in marine areas off eastern Canada since the early sixties. Initial surveys established a broad grid of seismic lines that indicated the general shape and structural style of the offshore sedimentary basins. Subsequent surveys focussed on specific areas of interest and, eventually, favourable locations for drilling exploratory wells were defined. Pinpointing the drilling target often requires several years because exploring at Canada's latitudes can only be done during part of the year and because processing the seismic data is time consuming. The first exploratory wells off eastern Canada were drilled on the Grand Banks in 1966, on Sable Island in 1967, and on the Labrador Shelf in 1971.

According to Canada Oil and Gas Lands Administration (COGLA) officials in Ottawa, offshore seismic coverage to the end of 1983 in the region from Scotian Shelf to Baffin Bay will total 1,076,000 km. This represents an expenditure of $385,850,000. For the period March 1982 to March 1983, seismic coverage totaled 92,000 km, with a value of $104,070,000. In addition, detailed seismic surveys of the seabed at proposed drilling locations totaled 19,000 km, at a cost of $23,316,000. In the period March 1982 to March 1983, the 4,920 km of drill site surveying done cost $6,460,000.

Oil companies report on the above surveys and send copies of their seismic records to COGLA as proof of expenditure on their exploration permits. The seismic data are thus the property of the Canadian Government. However, to allow the companies a period of competitive advantage in which to follow-up on the geophysical work they have done, the seismic data remain confidential for a period of 5 years. Seismic data more than 5 years old may be obtained from COGLA offices, for the cost of reproducing paper copies.

The 5-year release of seismic data has been in effect only since 1982; previously, regulations were such that most geophysical data remained confidential indefinitely. A small group of scientists in government worked with these data for the purpose of assessing hydrocarbon resources, but the results of those studies also remained confidential.

In contrast, geologic data from drilling are released after 2 years, and by the early seventies it was apparent that the optimum value of this information could only be realized in conjunction with multichannel seismic control. Consequently, the Atlantic Geoscience Centre purchased a set of seismic lines from Seiscan-Delta Ltd. that provided good regional coverage of the Scotian Shelf, Grand Banks, and Labrador Shelf. The data acquired have been invaluable in regional studies of the offshore sedimentary basins and are without question among the best investments of the Atlantic Geoscience Centre. Numerous publications have been produced from them: for example, these data were the basis for map 1400A, "Basement Structure of Eastern Canada and Adjacent Areas" (scale 1:2,000,000), published by the Geological Survey of Canada in 1977, and the stimulus for companion maps on geology (1401A) and physiography (1399A).

Few scientists in government have had the opportunity to work with multichannel seismic data because government research agencies have been unable to afford the equipment or personnel to collect and process such data. With approximately 700,000 km of industrial seismic records on open file, interest in working with these data is now growing rapidly, not only within the Atlantic Geoscience Centre but also in other government research agencies, universities, and industry both in Canada and in other countries. Much of the interest is in the economics of the Venture and Hibernia areas, and in the discovery of additional oil and gas deposits. At the Atlantic Geoscience Centre, interest in these data tends to focus on geologic processes that create sedimentary basins on the continental margin, and on the synthesis of data for studies that compare the development of offshore sedimentary basins in different parts of the world. These studies bear upon one of the fundamental elements of global geology - the zone of transition from continent to ocean. Only when we clarify how this zone 'works', can we begin to understand the how, when, where, and why of hydrocarbon occurrence on the continental margin.

Hydrocarbon appraisals of sedimentary basins

- J.A. Wade

John Wade.

Roger Bélanger

The large amounts of petroleum industry data curated and processed at BIO are used in a wide variety of scientific research projects mainly by officers of the Geological Survey of Canada. Working with seismic and well data supplied by the petroleum industry, Atlantic Geoscience Centre staff study not only the geological and geochemical parameters of hydrocarbon finds, but also the geological development of the sedimentary basins themselves. An example of a specific study is the oil and natural gas resource appraisal program, conducted in liaison with the Petroleum Resources Appraisal Secretariat in Calgary, which provides the Energy Sector of Energy, Mines and Resources with estimates of the oil and natural gas resources of the sedimentary basins of eastern Canada. These studies are used in estimating long range energy supply.

Resource appraisal studies interpret and delineate oil and gas plays - a family of prospects that have similar geological characteristics. Specific studies include: interpretation and mapping of sedimentary facies; determining ages and stratigraphic relationships; investigating the nature, quantity, and level of thermal maturation of organic matter; quantifying and delineating the porosity in reservoir rocks; identifying factors controlling the development or destruction of traps; unravelling the migration history of fluids in rock formations; and establishing the degree of geological uncertainty in the occurrence of each of these critical factors.

Once play types are defined, the geological data for each play are combined into statistical models of hydrocarbon occurrences that are converted, through the use of computers, to distributions of potential. The data for all plays in the basin are then added to provide the basin potential.

A comprehensive appraisal of the sedimentary basins on the Labrador and south Baffin Island shelves in 1980 yielded an average expectation of 135 x $10^6 m^3$ oil and $810x10^9 m^3$ gas. A l981 study of the East Newfoundland Shelf area, which includes the giant Hibernia oil and gas field, indicated an average expectation for $1,340x10^6$ m^3 oil and 290 x 10^9 m^3 gas. In 1982 the oil and gas potential of eastern Georges Bank area was reviewed. It indicated an average expectation of $168x10^6$ m^3 of oil and 150 $x10^9$ m^3 of gas. A detailed reappraisal of the potential of the Scotian Shelf is now being undertaken.

Quaternary geology of Eastern and Arctic Canada offshore

- D.J.W. Piper

David Piper.

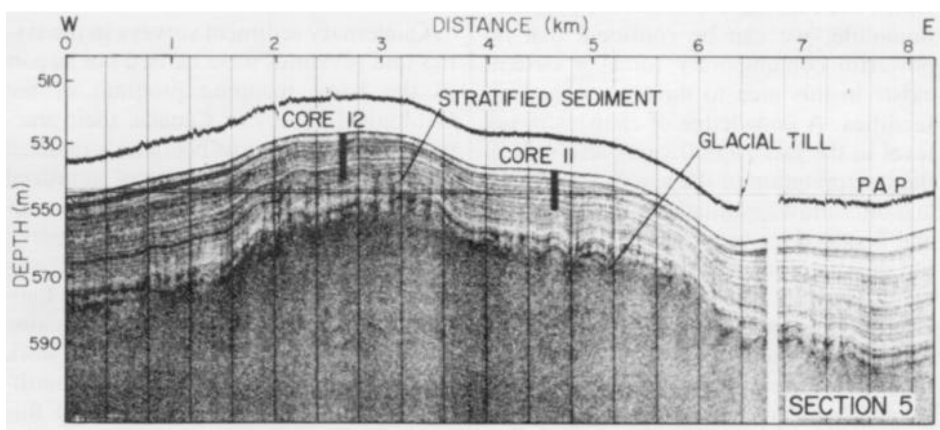
Roger Bélanger

Qutatemary sediments have accumulated offshore over the last 2 million years - a time when the Canadian landmass and its adjacent continental shelves were repeatedly covered by glacial ice. Most offshore areas are blanketed by Quaternary age sediments as thin as a veneer on some parts of the continental shelf, over 2 km thick in some deep-water areas.

Maps of Quaternary sediment distribution are essential for all engineering projects on the continental shelf and beyond, such as drilling oil wells, laying oil pipelines and electrical transmission lines, and planning the siting of oil and gas production facilities. They form the basis for assessing offshore resources of placer minerals and aggregates. Quaternary sediments preserve a historical record of proceses such as iceberg scouring and seismic shaking from which we can estimate the frequency (and hence risk) of these processes. Quaternary sediments also contain a record of past climatic and ecological changes that may help us to predict such changes in the future.

Regional mapping of Quaternary sediments has been achieved largely by acoustic methods, principally high-resolution seismic-reflection profiling. This mapping was pioneered by L.H. King and his colleagues, initially using Kelvin Hughes MS26B echograms and air-gun profiles on the Scotian Shelf in the sixties. In the mid-seventies, Huntec ('70) Ltd. developed a high resolution deep-towed boomer seismic-reflection system in collaboration with BIO; it provides a profile of the uppermost 100 m or so of sediment with a resolution to within a few tens of centimetres. These profiles have now been collected at a roughly 40 km line spacing over large areas of southern Baffin Bay, Labrador Sea, Grand Banks, and Scotian Shelf, but significant gaps in the regional coverage do remain. Acoustic reflectivity measurements provided by the Huntec system give further information on sediment properties. Where Quaternary sediments are thick, single and multichannel high-resolution airgun and sparker seismic-reflection profiles provide information on deeper strata.

Profile of Quaternary sediments made by the Huntec deep-towed system showing the acoustic reflectivity profile (PAP), the locations where piston cores were taken to provide 'ground truth', and the geologic interpretation.

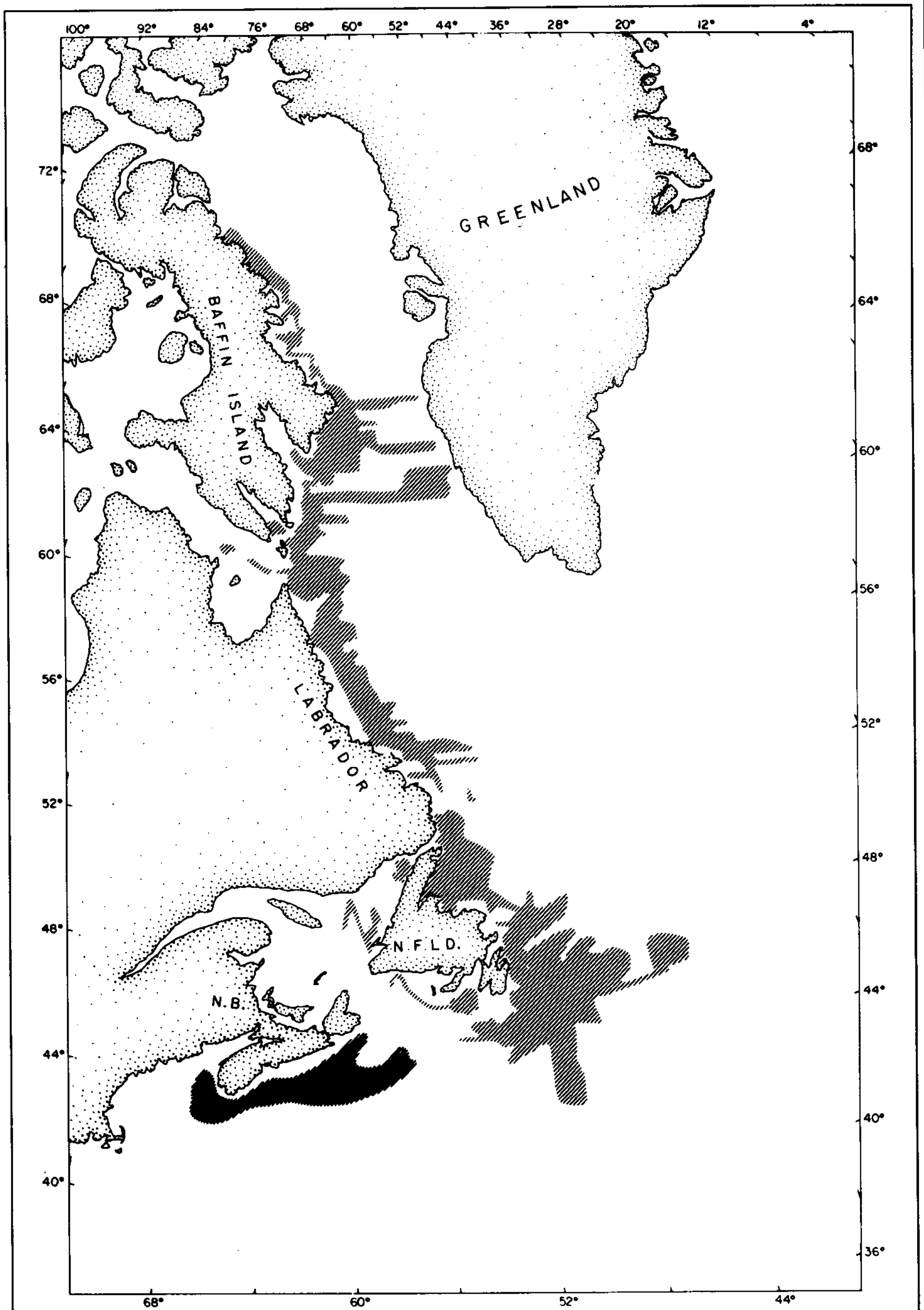


Bottom sampling provides ground-truth for the acoustic data. Piston cores sample the top 10 m in muddy sediments; a vibracorer is required to gain similar penetration into sands and gravels. Hard glacial tills are sampled using giant grab samplers. More deeply-buried parts of the Quaternary sequence can be reached only by drilling ships: such data are available only where industry has made engineering assessments for production purposes. In the Beaufort Sea, for example, a joint industry-government program is synthesizing drill-hole data with acoustic data to provide a regional assessment of the engineering properties of Quaternary sediments.

Sidescan sonar is used to obtain information on the continental shelf such as the distribution of bedrock outcrops and sediment types, the occurrence of bedforms such as sand waves, and the size and distribution of ice scours.

A scientific understanding of the way in which Quaternary sediments have accumulated is needed to provide a predictive capability to surveys of Quaternary sediments. Above all, this requires a knowledge of the ages of different parts of the sediment sequence. This may be obtained from diagnostic species of microfossils, radiocarbon dating, and the distinctive sequence of variation through Quaternary time of oxygen isotopes in seawater that is preserved in calcareous microfossils. Much of this work is carried out in collaboration with universities.

Information on the age of sediments when integrated with the acoustic data shows, for example, that ice covered most of the Scotian Shelf a few tens of thousands of years ago and that sea level was about 110 m lower some 18,000 years ago off southeastern Canada. This latter fact has important practical consequences. A sea-level rise of this magnitude tells us how sand ridges originated in the Hibernia area off Newfoundland at a depth of 80 m. Coupling this fact with the results of repeated side-scan sonar surveys of the area, which indicate that the ridges are probably immobile, we can be confident that no powerful contemporary force or current exists in this area to threaten seabed oil facilities. A knowledge of changes in sea level in the last 20,000 years also aids in the interpretation of the age of ice scours, and thus allows estimates of the frequency and depth of ice scouring over say potential pipeline routes in the Beaufort Sea or from Hibernia. Changes in sea level in the Beaufort Sea have affected the distribution of both subsea permafrost (a potential hazard to development) and near-surface sands (important as a source of aggregate).



The regional coverage of the program of acoustic mapping of Quaternary sediments undertaken by the Atlantic Geoscience Centre.

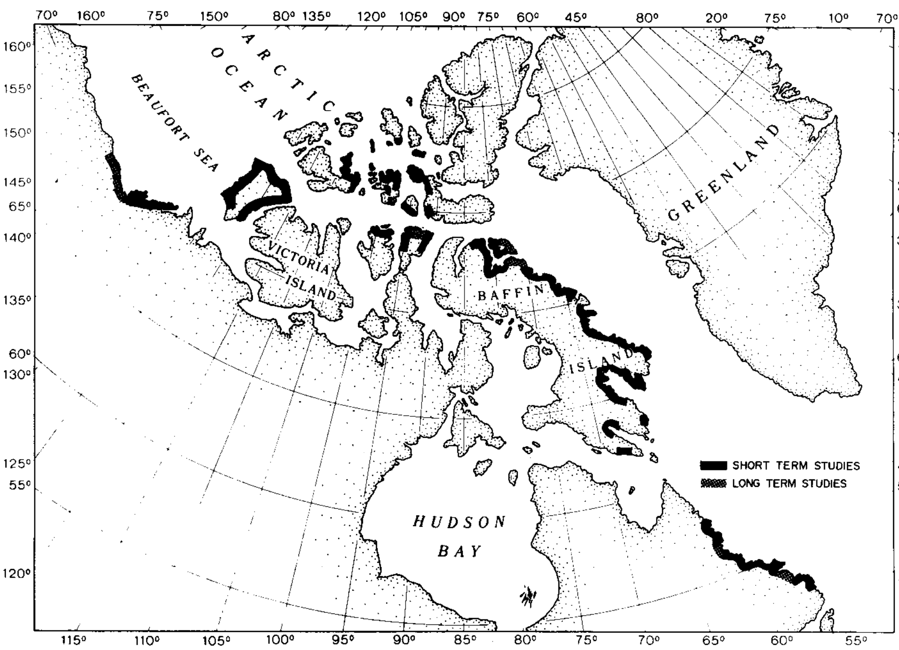
Quaternary sediment surveys in the sixties and seventies were carried out as part of the basic mapping program of the Geological Survey of Canada: their practical utility is only now being fully realized with the increasing amounts of industrial activity offshore. Basic surveys are continuing in areas with inadequate regional coverage: for example, in 1982 work was done in the Beaufort Sea, Baffin and Labrador Shelves, southwest Grand Banks, and Sable Island Banks, and in 1983 work is planned for Jones Sound and the northeast Newfoundland Shelf. Some of this work is in co-operative programs with the Canadian Hydrographic Service; however, there is also close co-operation with industry in many areas. For instance, the Arctic Petroleum Operators Association and the Geological Survey of Canada have a regional synthesis program in the Beaufort Sea directed towards evaluating seabed stability hazards, with the government component largely funded by the Office of Energy Research and Development. There is close co-operation with companies such as Petro-Canada on the Labrador Shelf and Mobil Oil at the Hibernia and Venture sites. The regional ice-scour data base developed at BIO has been transferred to industry. A second-generation system, Seabed II - see chapter 3, is now being developed by Huntec to further develop remote sensing techniques for studying the geology of the seabed. While the need for basic regional surveys remains, there is now a greater emphasis in regions already surveyed on determining the ages of the components of the sediment sequence and on understanding the processes that led to its accumulation. Seabed instability whether from permafrost, ice-scour, seismic shaking, storm action, gas venting, or down-slope movement is a major concern in areas of hydrocarbon production and to address it we need more understanding of the geotechnical properties of Quaternary sediments. To evaluate aggregate and placer mineral resources we must understand both past and present sediment accumulation processes. The move to exploit resources in the oceanic depths of the continental slope and rise, and the possibility that some nations may dispose of nuclear waste in the deep ocean make it imperative that surveys be extended off the shelf into deeper water, and that appropriate modem tools be developed for working there.

Coastal geology surveys

- R.B. Taylor

At the Atlantic Geoscience Centre, we are trying to determine the factors that control the development and evolution of coastlines. We evaluate the sedimentary dynamics of coastal regions, look for evolutionary trends in the shore zone, and attempt to predict future changes. Often we are requested to investigate human activities that may threaten the integrity of the shoreline such as removing sand from a beach. Conversely, we also investigate coastal areas where the sea threatens man by, for example, rapidly eroding the shoreline and thus endangering nearby buildings. The geographic extent of our responsibility includes the Arctic and Atlantic Coasts. This region extends some 218,000 km so we must approach our objectives at different scales of operation. The coastal program at AGC can be divided into three sections: (a) systematic coastal inventories; (b) process-oriented studies; and (c) short-term applied studies.

Reconnaissance studies are completed over large stretches of coastline in very short time periods. Field methods include aerial reconnaissance of all or parts of the coastline and collection of video tapes and/or slides of representative coastal types. We establish beach profile stations and survey cross-sectional profiles to provide quantitative measurements on morphology and a baseline for assessing rates of coastal change during subsequent surveys. We collect sediment samples from certain sites and obtain box cores of sediment to examine specific coastal features such as sand bars. Inferences are then made about the sources of the sediment and the processes that produced the coastal features. The study of sediment from actively forming features also provides modern day analogues that aid in the recognition of ancient coastal deposits in the geologic column. From reconnaissance studies we can map the spatial distribution and character of shore types and specific features. For instance, the distribution of gravel barrier beaches along Cape Breton Island and Newfoundland is being mapped and surveyed to determine what controls their crest height and stability. In the Arctic Islands, where sea ice is a major concern,



Coastal geology programs at the Atlantic Geoscience Centre are conducted at two scales - short-term reconnaissance surveys and longer term process-oriented studies.

the distribution of grounded ice ridges, the pile-up of ice on shore, and their effects on the coastal zone are being documented. Most of our reconnaissance studies have focussed on Arctic Canada; however, during the last two years, coastal surveys were conducted along Cape Breton Island and Newfoundland. Although the coastal geologist is the primary user of the descriptive coastal information, it is also used in oil spill contingency planning and planning use of coastal land. In addition, we use the information to assess the environmental impact of major engineering projects in the coastal zone.

Process-oriented studies help us develop, elucidate, or test theories of coastal evolution and change. This involves monitoring physical processes such as waves, tides, currents, and winds, and studying the morphological response of specific coastal features. These studies are conducted over extended perid of days or months.

One major project of this kind, a study of sediment dynamics in a modem barrier beach system, was undertaken in 1980-81 in Aspy Bay, in northern Cape Breton Island. This study improved our understanding of how nearshore, foreshore, and washover sediment sequences are formed. As a part of this project, we deployed RALPH (see chapter 3), a self-contained seabed monitoring instrument that provided exciting time-lapse photography of the formation and destruction of nearshore bedforms. Attention was also devoted to barrier overwash processes that are a primary mechanism for transferring sediment to the backshore and lagoon. On the Aspy Bay barrier, extensive wave overtopping has produced sheet-like washover deposits that are laterally confined in channels and terminate in thin fans or deltas. Washover channels on a barrier allow waves to overtop the beach, and thereby reduce wave backwash and beach erosion by storm waves. It is interesting to note that although washover channels on the Aspy Bay barrier have changed locations over the last 30 years, the proportion of total barrier length subject to washover remained relatively constant at 46-52%.

Results from process-oriented studies are often applied to practical problems in the coastal zone such as the fate of dredge spoils, the building of harbour facilities and the assessment of beach stability. For example:

(1) The effects of mining beach sediment for aggregate on the southeast coast of Cape Breton Island were documented in collaboration with the Nova Scotia Department of Lands and Forests; Framboise Beach appears to be recovering but Belfry Beach is rapidly deteriorating;

(2) Sequential measurements of shore bluff retreat along the Nova Scotian Coast suggest that maximum rates of 3.5 metres per year are experienced along exposed till bluffs on the Eastern Shore;

(3) At Holyrood Pond, a fjord in southern Newfoundland, a gravel barrier is perched on the fjord sill and if its stability deteriorates it may retreat landward and disappear into deep water behind the sill. This would have serious implications for the road link across the barrier and for a proposal to promote aquaculture in the fjord.

Where to now? We anticipate expanding our coastal reconnaissance studies to Jones Sound, N.W.T. (a joint program with the Canadian Hydrographic Service) and to other parts of the Newfoundland Coast in 1983. Attention will also focus on the refinement and further development of a computer coastal information system. This system will provide the group with an efficiently organized archive of coastal data and an improved method of releasing information to other users.

Other specific problems identified for attention in the next few years include: (1) documenting the characteristics of gravel and mixed sand and gravel beach deposits; (2) developing methods for measuring gravel transport, and (3) predicting equilibrium shore profiles in gravels. Models for gravel transport are virtually nonexistent in the literature, yet they are important in the Canadian context because much of the coastline is composed of coarse sediment derived primarily from glacial deposits. Transport models for sands under shoaling wave conditions are also inadequate, as well as the availability of fast-response sediment transport monitors for use in the nearshore. Consequently, we are collaborating in the Canadian Coastal Sediment Study, a program designed to promote research on problems of coastal sand transport. The study site in 1983 is at Pointe Sapin in northeastern New Brunswick.

Finally, a developing thrust is to bridge the information gap between onshore and offshore surveys. The nearshore zone is a difficult environment to work in. It includes the surf zone where ice action is intense, and where major research vessels cannot operate. For these reasons, little information on the nearshore is available despite its physical, ecological, and economic importance. We are, therefore, undertaking nearshore surveys and developing projects to look at nearshore sediment transport processes as an integral part of AGC's coastal geology program.

Studies of beaches such as this one in the Magdalen Islands tell us how storms alter the beach profile and create features such as the sand blowouts visible below.

Roger Bélanger

CHAPTER 2

Data Processing, Archiving, and Availability

This chapter describes how data, of any sort, once collected are turned into useful products. Starting from the computers that are now central to every activity of BIO ashore and afloat, we describe how nautical charts are made from the raw bathymetric data, how ocean atlases of data are produced, how fish stock assessment is done from the raw survey data. and how all kinds of data are archived in data banks in such a way as effectively to remain in the public domain, accessible to any future user.

COMPUTERS AT SEA AND ASHORE

- G. Collins

Computers at BIO are used to log. store, retrieve. and analyze data; model physical. chemical. and biological systems; and perform office tasks such as word processing. They not only reduce tedium and save time, which the researcher can use for formulating and testing hypotheses, but make it practical to perform cumbersome numerical calculations. Computers also facilitate sharing of these data with other individuals and organizations.

BIO's shore-based computing is done on a mainframe computer shared among many users and on special-purpose minicomputers: microcomputers are also coming into frequent laboratory and office use. Ship-based computing is done on minicomputers.

The mainframe computer at BIO is a Cyber 173 capable of supporting batch processing and up to 64 terminals simultaneously. Using this system. users can do most of their computing from their work areas. This computer also communicates with remote computer systems via the telephone network when extra resources, not available locally. are required. For instance, some large modelling programs are transmitted to a Cyber 176. which executes commands eight times faster than the Cyber 173.

Computer systems consist of hardware and software. The hardware is the physical objects such as the circuits that perform arithmetical operations, memory storage units, magnetic tapes drives, etc.; the software is sets of instructions, or programs, which are executed by the hardware.

Hardware costs are steadily decreasing as technology advances whereas software costs continue to rise. Creating or purchasing software once and sharing it with many users saves money. and this is the approach BIO uses with respect to both internal and commercial software.

Software activities on the Cyber can be divided between mathematical calculations ('number crunching'). data management. and high quality graphics. There are many commercially available software packages that can be used directly with minimum programming effort. Any customized software at BIO is the responsibility of the user, and circumstances dictate whether the software is developed in-house or contracted to a software company.

Debbie Casey makes an entry in the console log of the BIO mainframe computer.

Fortran is the main programming language in use at BIO for 'number crunching'. but others are also available such as APL and COBOL. A data-base management system called System 2000 is used for data storage and convenient information retrieval. The software package DISSPLA is used, with Fortran, to produce high quality graphics. Also available are various mathematical and statistical software packages. In addition to the usual complement of peripherals such as disk and tape drives, printers. etc., two plotters are available: a small, medium quality, Zeta drum plotter and a large. high quality, Xynetics 1100 flatbed plotter.

HP1000 minicomputers are used for general purpose, ship-based use. These systems log, store. screen, and analyze data on scientific survey cruises. For example. physical oceanographers are interested in the variation of salinity and temperature with depth in the ocean at various locations. An HP1000 minicomputer receives these data directly from sensors suspended from the ship and stores them on magnetic tape. One cruise can accumulate up to IO million salinity-temperature measurements. These data are usually stored on magnetic tape and loaded into the mainframe for processing when scientists return from a voyage.

A shore-based HP1000 is used for developing software for later use on the ship-based systems. While all these general purpose minicomputers are programmed and operated by researchers and their technicians. the central computer staff coordinates their usage and maintenance.

Shore-based minicomputers are also used for dedicated applications, one of which utilizes a PDP 11/34 minicomputer for digitizing data for automatic map-making. These computers are subservient to one particular application and are controlled by those responsible for the application.

Elaine Toms and Frances Bula prepare to 'upload' the WAVES/VAGUES data base of the Department of Fisheries and Oceans from an IBM personal computer to a larger mainframe computer.

Microcomputers are the latest addition to computing at BIO. These machines provide convenience at low cost for selected 'small' applications. One such application uses commercial, ready-to-use software for ecological modelling while another uses a microcomputer to log data automatically from a laboratory experiment. A ship-based application uses a microcomputer to provide ship-stability information continuously as the parameters being measured change during a cruise. Microcomputers are also being used in areas such as word processing. record keeping. and budget control. They are now an integral part of computing at BIO and supplement resources offered by the mainframe and minicomputers. This integration is physically strengthened by micro-mainframe-mini communications. There are approximately 32 microcomputers at BIO at present with most of the popular brands represented.

Declining costs in hardware and software will expand the applications of computers and make the integration of computing resources increasingly practical. A wide variety of computing resources will be made accessible through the overall co-ordination of software, hardware, and computer-to-computer communications developments. For example, computer work stations will become more popular because they allow researchers to perform functions such as text editing, program development, and creation of interactive graphics autonomously and with full access to a mainframe or minicomputer as required.

Computing requirements and technology are changing rapidly and continuously.

Shipboard computing : Francine La flamme and Roy Sparkes at work in C.S.S. *Hudson's* computer facility.

Only 15 years ago most computing at BIO was done on an isolated mainframe: today mainframe, mini-, and microcomputers communicate with one another, and all play major roles. Though it is difficult to say whether the requirements for research determined the technology or vice-versa, it is clear that the two interact closely to influence the evolution of computing at BIO.

NAUTICAL CHARTS AND PUBLICATIONS

- A.J. Kerr & R.F. Macnab

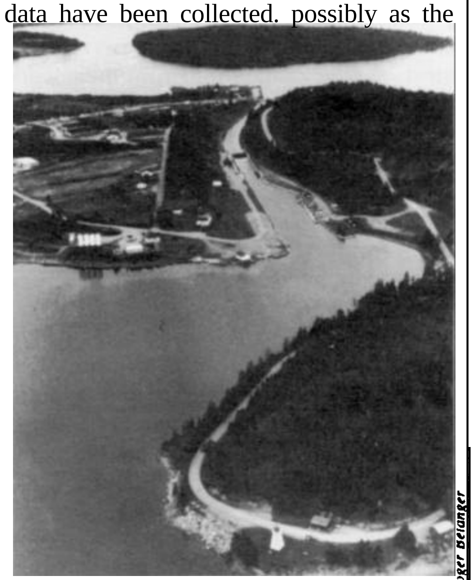
Nautical charts are essential for the marine commerce of a nation. No ship of any size sails on a voyage without them, and in fact Canada enacted legislation following the disaster of the tanker *Arrow* in 1970 requiring all ships of over 100 tons in her waters to carry them. Unlike maps, charts cannot be schemed in neat rectangles between specific geographic grids but must be custom designed to meet the requirements of the navigator. Several nations produce charts on a worldwide basis whereas Canada limits her focus to national waters. Nevertheless. with her very long coastline and large continental margin, Canada is one of the world's largest producers of charts.

The Canadian Hydrographic Service maintains over 1.000 nautical charts and also produces a large series of natural resource maps. The number of nautical charts may be compared with the United Kingdom, which has a worldwide set of about 4.000 charts. At the other end of the scale some countries, even though they may have large merchant fleets, have small coastlines and produce fewer than 100 charts.

Unlike the majority of land maps. nautical charts must be constantly maintained, and this is achieved by various methods. Every week, Notices to Mariners are issued by the Ministry of Transport of all changes needed to keep charts up to date. From time to time the chart will be brought up to date by incorporating all these notices in a reprint of the chart.

St. Peters Canal, the entrance to the Bras d'Or Lakes of Cape Breton Island, Nova Scotia. The Canadian Hydrographic Service at BIO recently produced three new charts of the lakes.

When a truly significant amount of new data have been collected. possibly as the



result of new surveys, a new edition is produced.

In Canada, the charts we possess are often direct reprints of British Admiralty charts. As these charts were compiled by the British and French navies a century or more ago, we are currently collecting new data to replace them with modern Canadian charts. Newfoundland in particular is now being resurveyed so that new charts can be produced.

The Canadian Hydrographic Service is a member of the International Hydrographic Organization (IHO), a body devoted to unifying standards for nautical charts and publications worldwide. Although major steps have been made during its 60 years of existence, it is questionable whether we shall ever see a truly international set of charts, as the matter of language will always cause difficulties in that respect. The IHO works closely with other international organizations, such as the IMO (Intergovernmental Maritime Organization) with respect to traffic routing and the IOC (Intergovernmental Oceanographic Commission) with respect to producing a worldwide series of bathymetric maps.

Cartographic facilities and production methods

The Chart Production Division at BIO is typical of a regional office of the Canadian Hydrographic Service. Data are collected every season by the field parties: however, this is but one of many sources of data used to compile a nautical chart. A technical records unit receives plans and data from several government departments and private agencies. Information arrives on newly dredged channels, engineering structures such as breakwaters and wharves, changes in aids to navigation such as buoys and lighthouses, and, most important, in reports from shipping concerning the finding of new shoals and other dangers to navigation. On arrival at the data centre, the various reports must be examined in terms of urgency. If there is an immediate danger to shipping, a draft Notice to Mariners is quickly prepared and passed to the Ministry of Transport for dissemination. If the data do not involve an immediate danger, they will be referenced for appearance on future charts.

There are several identifiable steps in the production of a chart or new edition. An overall scheme of charts is first prepared to define the geographical limits of each chart. Each chart is then drawn out in a rough form to check that the area is properly covered geographically. Insets of detailed areas at larger scales are then incorporated; border graticule and all geodetic control points are plotted very precisely on a base by automatic plotter; and data are then all brought to scale in the form of a mosaic. There is usually a considerable reduction in scale from the field plots - often to such an extent that it takes skilled eyes to interpret the result. The data compilation and selection are undertaken next: only the data most significant to the navigator will appear on the chart. Shoals are always selected. In recent years there has been a much greater use of depth contours and less on-spot values than previously. Land information is included, usually from topographic maps produced from aerial photographs. Carefully constructed navigation aids and nomenclature are added and finally information such as the title. The charts of today may appear to show less data, but in fact they are less cluttered and present more information than previously.

With the data compiled and selected. the cartographers begin final drafting of the chart. Skilled engravers once etched copper plates to accomplish this, but today most charts are scribed on plastic or produced by digitization and automatic plotting. BIO, like other CHS regional offices, has available a complex interactive cartographic system called GOMADS (Graphical Online Manipulation and Display System). This system has the potential for actually selecting information from a digital source, but at present it is used primarily for digitizing and editing it. The digitized chart is plotted with a precise automatic plotting unit by means of a beam

Heinz Wiele

Cartographers at work. Top: Catherine Schipilow uses a digitizer to punch in depth readings that are then automatically entered on a computer data base at the right latitude and longitude. Left: Sandy Weston and Nick Palmer discuss a new CHS chart. Right: Ed Lischenski operates the large colour-contact frame used in producing charts.

of light that travels along photographically sensitive material. The plots produced can then be used to develop the various colour negatives through a colour-separation process that now involves further manual work. At every stage, the product is carefully screened by quality-control specialists who ensure that the final chart is as free of error as humanly possible. Throughout the production, considerable use is made of photomechanical facilities. Base documents must be reduced and various negatives and positives must be provided to the cartographers to carry out their work. The final quality-control step involves the production of a colour proof, which allows the cartographer to see what the final product is to look like before it reaches the final printing stage.

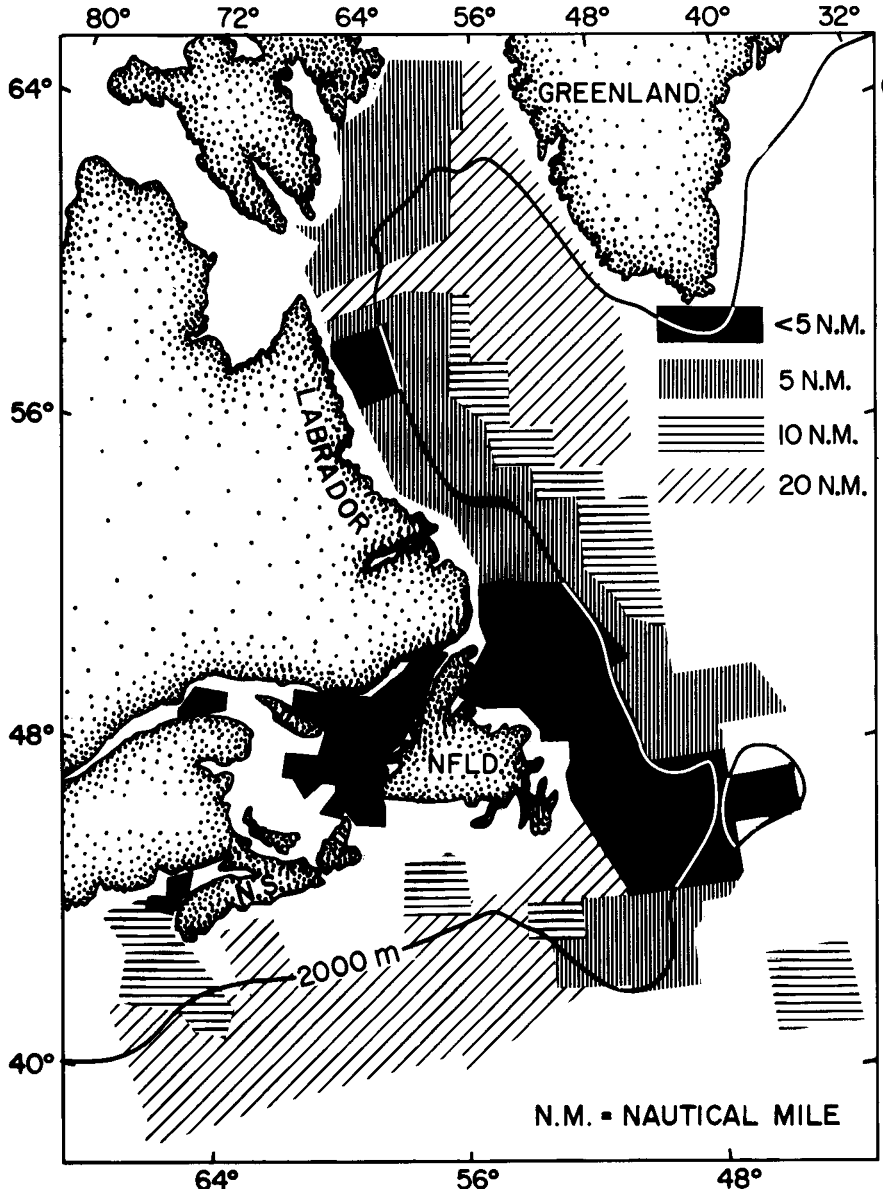
Multiparameter surveys and natural resource maps

Multiparameter surveys are co-ordinated operations designed to collect hydrographic and geophysical data off the Canadian east coast. Begun as a collaboration in the Bay of Fundy between BIO hydrographers and geophysicists nearly 2 decades ago, the survey program has resulted in the mapping of most of the region extending from the Gulf of Maine in the south to Davis Strait in the north. Spacing between parallel survey lines ranges from 20 down to 1 n. mile. In all, some 32 cruises lasting from 3 weeks to 4 months have collected nearly 500,000 line-kilometres of data.

The resulting data base serves many users - navigators, fishermen, mining and oil companies, pipeline and cable-laying engineers, hydrocarbon specialists, and scientists in a variety of disciplines. Survey information is released to the public in several forms, such as Navigation and Fisheries Charts, Natural Resource Maps, maps in the National Earth Science Series, General Bathymetric Charts of the Oceans (GEBCO), and special compilations. In addition, data in digital form are available from the Open Files of the Geological Survey of Canada.

The natural resource series of maps was initially plotted on the Universal Transverse Mercator Projection at a scale of 1:250,000. Since these were maps and not charts to be used for navigation, it was possible to butt them together on a square grid. All the maps had a base of bathymetric contours over which each of the other parameters was printed.

The bathymetry of these maps is interpreted in a rather different manner than is the case for nautical charts. On the latter, the cartographers' objective is to warn the navigator of danger in the shallow parts of



Extent and track density of multiparameter surveys from 1964 to 1982. For the most part, survey data consist of bathymetry, magnetics, and gravity but for some areas also include shallow seismic reflection profiles.

the ocean: consequently, emphasis is placed on shallow rather than deep features. The bathymetric maps on the other hand tend to make greater use of geological interpretation. The natural resource series of maps includes observations of bathymetry, gravity, and magnetic fields and anomalies. The series is available to the public and used by the oil companies and engineering organizations now working extensively over the Atlantic margin of Canada. Although the data are produced at the regional offices of the Canadian Hydrographic Service and at BIO's Atlantic Geoscience Centre, the maps themselves are produced by the CHS in Ottawa making use of the interpreted results from both DFO and DEMR.

In future, more detailed mapping will be needed to increase the coverage of the regional surveys south of Newfoundland and Nova Scotia, and also to extend this coverage further offshore. The latter activity is required to delineate the edge of the juridical shelf, as defined in Article 76 of the Draft Convention on the Law of the Sea. Further north, Baffin Bay is virtually unsurveyed to modem standards. Multiparameter mapping in this difficult region must await the development of reliable - and affordable - navigation technology.

Tide tables, sailing directions, and other CHS publications

A knowledge of tidal heights is of great importance to the navigator. Soundings on a chart are measured from the level of low water, and in most cases the depth of water is deeper than shown on the chart. This is particularly important in areas such as Hantsport in the Bay of Fundy because ships going in to load gypsum must reach the berth at high water and then actually sit on the bottom during low stages of the tide. On the other hand, clearance under bridges is shown on the chart from high water, and in some critical cases a ship may pass beneath a bridge at low stages of the tide but not at the higher stages.

Such information is made available to navigators in the form of predicted tidal height tables referenced to standard ports. Tidal observations have been made over many years at points around the coast. These observations are analyzed and tidal constituents derived. These constituents can then be used in conjunction with astronomical data to predict the height of the tide using computers. Volumes of tide tables are produced by the Canadian Hydrographic Service covering all Canadian waters.

Sailing Directions. sometimes called Pilots, are written volumes that provide the navigator with information that he cannot obtain from the chart or information. such as the existence of particular dangers that need additional stress. They are provided as a supplement to the nautical chart though in fact they predate it: Sailing Directions were in use in Egyptian times. A navigator preparing to enter a port can obtain information on the availability of pilots, on the type of supplies that he will be able to obtain, and on the currents that exist in the harbour. Fourteen volumes that cover all Canadian waters are published and made available in both English and French. Nowadays, Sailing Directions are maintained annually or biannually by a computerized text-editing system. For areas where there are many recreational or other small craft, the Canadian Hydrographic Service produces special charts, some of which are designed in strip form to facilitate their use in small boats with limited space. A special type of Sailing Directions known as the Small Craft Guide is produced for these areas and can be obtained for areas such as the Gulf Islands in British Columbia, the Trent-Severn Canal in Ontario. and the Saint John River in New Brunswick.

Yet another CHS publication is the current atlas. These atlases are produced for a specific area of the Canadian coast where the pattern of tidal currents is particularly complex. Typically, currents are shown by a simple annotation on the chart itself. However, in areas such as the Lower St. Lawrence River or the Gulf of Maine, currents move at greatly variable velocities throughout the tidal cycle and are best depicted in an atlas. One atlas page is usually devoted to a particular phase of the tidal cycle, and sometimes single pages are devoted to each hour after high water. Modern current atlases are now being produced using computers and mathematical modelling to predict the behaviour of the tides and currents for specific times.

In addition to the charts and various books published by the CHS, more detailed but less refined information is available on request in the form of the survey field sheets. These contain a great amount of bathymetric information and are in great demand by oil companies and engineering organizations working in offshore and coastal waters.

EVALUATING FISH STOCK SIZE AND YIELD

- J.M. McGlade & R.N. O'Boyle

Bob O'Boyle.

Central to the management of Canadian east coast fisheries is the evaluation of the sizes and age structures of the resident fish populations. From these can be derived annual estimates of yield or catch for a specified amount of fishing effort.

The Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC) is the body in which government scientists annually review the state of the various marine resources on the east coast and provide the industrial sector with advice on what yield levels are sustainable in the upcoming years. Marine Fish Division (MFD) is responsible for providing stock size evaluations or assessments for those fishes and mammals inhabiting the Bay of Fundy, Scotian Shelf, and George's Bank. These include cod, haddock, pollock, redfish, the flatfishes, the hakes, herring. mackerel, and prey and harbour seals. As well, the Division is responsible for assessing the viability of new fisheries, such as the one proposed for Atlantic Saury, and their impact on the rest of the ecosystem. All assessments are passed on to industry for comment. Because an error in analysis can have a dramatic effect on the economic success or failure of a fishery, much research in MFD is on the methodology of the stock assessment process.

The first step in an assessment is to define the geographical limits of the fish stock in question. This is very important as exclusion of part of the population from the analysis will result in lower yield projections than is warranted. The opposite is true if components of a different stock are included. The evaluation of stock boundaries is not a simple task. For example, Scotian Shelf pollock are currently assessed as one single interbreeding population or stock. However, SSIP plankton surveys have identified separate spawning aggregations on Brown's and Emerald Western banks. Spawning is also known to occur in the Gulf of Maine. Tagging studies of adults show differing movement patterns between Scotian Shelf and Gulf of Maine pollock. Finally, biochemical, meristic, and morphometric studies now underway suggest the presence of at least two stocks, but the verdict is not yet in. Thus it can be seen that a whole suite of research is brought to bear on the stock definition question.

The next step in an assessment is the compilation of all landing statistics for the defined stock. The collection and processing of landing data are handled on a continuing basis by the DFO Fisheries Management Service in Halifax. MFD requests from it a computer tape summarizing all data, and processes the data on the BIO mainframe computer. Normally, the catch data are compiled by month or season, by vessel type and size, and finally by area fished.

The third step in the process is one of the most important. Obviously, if we could count all the fish in the populations, we would have the most accurate view of stock size available. Because this is not possible, scientists have to depend on sampling a population in order to determine stock size and age structure. To do this we first conduct a survey using standard gear and a standard sampling design. Such surveys have been conducted every July since 1970 and in addition every March and November since 1979. On these surveys. about 150 groundfish trawl tows are made at random locations on the continental shelf and all fish caught are assessed for age, length, maturity, and sex. The advantage of the surveys is that they are rigorously controlled by the scientists and thus can be kept standard: the disadvantage is that only a small fraction of the population biomass is sampled. The best sample of the populations is the fishery itself. For instance from about 340,000 tons of pollock biomass, about 55,000 tons is harvested each year. This is a decent level of sampling intensity. If one can adequately define the age-size composition of the catch and the characteristics of the gear used, then a view of stock size can be obtained.

It is for this reason that MFD conducts an extensive commercial catch sampling program. Part of this involves observers placed on vessels (see "The Observer Program", chapter 1). Part involves samplers who process the catch when it is brought into port. The samplers are given specific guidelines on the number of samples required. These relate back to the stock in question, the gear used, time of year, location of fishing, etc. Prior to the annual fish stock assessment meeting, the catch sampling data are applied to the landing statistics to generate, for each year of the fishery, the absolute number of fish caught at each age. This is known as the catch-at-age.

The next step in an assessment is to conduct what is referred to as a Sequential Population Analysis (SPA), a means whereby the size of each age group or generation is evaluated separately, using the catch-at-age and estimates of the most recent age-size structure. If one knows how many fish are in the stock this year, and how many were caught last year, then an estimate of the previous year's population size, before commencement of the fishery, can be obtained. In the SPA, this 'additive' logic is conducted backwards in time to the first year in which a generation (yearclass) of fish enters the commercial fishery. The population size in any one year is the sum of the various generations. For instance, in Scotian Shelf pollock about ten age groups comprise in the population in any given year.

No analysis is without pitfalls. The SPA's major one is the determination of the current year's population age-size structure, which is necessary to start the analysis. This in turn is obtained through the application to the catch-at-age of the estimated mortality rate caused by fishing. Thus the problem reduces to the estimation of the current year's fishing mortality *(F)* at age.

It is now necessary to introduce the concept of partial recruitment. This refers to the fraction of each age group that is catchable, but not necessarily caught, by the fishery. This is distinct from recruitment to the population, which is due to natural processes. Partial recruitment is dependent on the fishery. It is governed by changes in the selectivity of the gear as well as the availability of the fish to the gear. Normally it increases with age to reach a maximum in the older, fully recruited age groups. For instance, age 2 pollock are estimated to be about 5% recruited to the fishery (that is 5% of all age 2 pollock are available for capture). Full recruitment or 100% catchability of an age group occurs at about age 5.

Thus, the major part of a stock assessment is to first devise the fishing mortality *(F)* of the fully recruited age groups in the current year and second to determine the pattern of partial recruitment *(PR)* over the younger age groups. Multiplication of the fully recruited *F* by *PR* provides estimates of the fishing mortality on the partially recruited age groups (in the case of pollock, those fish aged 1 to 4 years). Accurate estimates of PR are particularly important because they establish the size estimates of the year classes on which the fishery will depend over the subsequent 2 to 3 years.

F is adjusted until the correlation of fully recruited population numbers as derived from the SPA with independent estimates of stock abundance is maximized. In some stocks, such as haddock and cod, research survey data are primarily used whereas in stocks like pollock, where the survey data are less reliable, commercial catch rate indices are depended upon. The preparation of these indices of abundance is itself a complex process and the topic of much discussion.

The *PR* values for each age are sometimes determined by maximizing the correlations of survey indices for age one and two population estimates for the same ages derived from the SPA. Often, however, when survey data are lacking or suspect, estimates are based on historical fishing patterns obtained from the SPA itself. The SPA has the advantage of being 'self-correcting' the further one goes back in time. Thus, historical estimates of partial recruitment should be fairly reliable. These can be used to represent the current fishery if the gear and operational characteristics are similar. Often this is not the case and adjustments have to be made.

As one can see, the determination of the current year's population size is complex, involving a number of data sources and analytical procedures, which are necessary to weave around problems intrinsic to the data.

The last step in an assessment is to determine of the Total Allowable Catch (TAC) for the upcoming year. This is an estimate of how much fish can be caught without damaging the renewal properties of the populations. Note that MFD does not determine the fraction of catch given to each fleet section - not now at least. All that we establish is an appropriate level of catch. First an estimate of a desired level of fishing mortality is calculated. This is done through Yield per Recruit analysis. If one knows the fish's growth rate and the rate of mortality, both fishing and natural, one can estimate how much a generation will contribute to the catch during the time it remains in the fishery. If all the fish are caught at a very young age, much potential yield will be lost. On the other hand, if one lets the fish grow to an old age, most will have died due to natural causes and thus be lost to the fishery. A desirable level of fishing mortality lies somewhere in between the two extremes. The one chosen by CAFSAC is referred to as F_{01} or the level of fishing mortality at which the increase in catch by adding one more unit of fishing effort is 10% of the increase in yield by adding the same unit of effort in a lightly exploited stock. It is a conservative level of fishing effort designed to reduce the risk of stock collapse and provide economic benefit in the way of larger individual fish, as well as provide a greater number of age groups in the population, which will reduce interannual yield variability.

With the F_{01} level, yield is projected for 3 years using the current estimate of population size. These projections are then passed on to industry for review.

The evaluation of a fish stock's size is very involved. The salient features were discussed above. Points such as determination of natural mortality, stock-recruitment trends, density-dependent growth, and population interaction are considered where necessary but are too involved to be discussed here.

Nevertheless it is important to stress that the stock assessment process is a melting pot of all available data and ideas brought together with one goal in mind-the provision to industry of reliable estimates of stock size. Often, esoteric biological models, which are valid contributions to science, are considered but not used in the analysis due either to their tentative nature or to the assumptions made to construct them. The peer review process of CAFSAC guarantees that all analyses are defensible in the public's eye. Thus the annual assessment meetings are as excellent forum for evaluating whether or not a particular development in science can have direct input into the management of Canada's east coast fisheries.

ATLASES

MAPMOPP: The IGOSS pilot project on marine pollution (petroleum) monitoring

- E.M. Levy

Roger Bélanger

Eric Levy.

In the late sixties, marine pollution came to be recognized as a problem of global importance. Accordingly, the United Nations Conference on the Human Environment (Stockholm, 1972). with endorsement by the United Nations General Assembly, recommended that the Intergovemmental Oceanographic Commission (IOC) undertake jointly with the World Meterological Organization (WMO) a pilot project to explore the feasibility of monitoring marine pollution on a global scale by integrating national and regional programs. To this end. the Joint IOC/WMO Integrated Global Ocean Station System (IGOSS) embarked on a pilot project to study the occurrence of oil pollution in the world ocean. During the 5-year study, almost 100,000 visual observations of oil slicks and other floating pollutants, 5,000 samples of tar from the surface of the ocean, 3,000 samples of water for the determination of dissolved/ dispersed petroleum residues, and 3,500 samples of tar stranded on beaches were collected and analyzed. Subsequently, the data were archived, interpreted scientifically, and published by IOC as the report: *Global Oil Pollution: Results of MAPMOPP, the IGOSS Pilot Project on Marine Pollution (Petroleum) Monitoring*.

The results of this program illustrate several important features of oil pollution. Taking the data for visual observations of oil slicks as an example, it is evident that visible slicks were most frequent along the major tanker routes between the Middle East and Europe (both via the Suez Canal and via the Cape of Good Hope), and those between the Middle East and Japan. Indeed, the plot of these observations clearly delineates the major tanker routes. Less clearly defined were the trans-Atlantic shipping lanes between Europe and North America. Oil slicks were seldom observed outside the main shipping lanes.

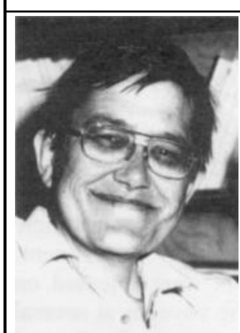
The distribution of floating tar was similar, although the data base was not as extensive. The overall concentration of tar in the North Atlantic as calculated from the MAPMOPP data was 4.4 mg m^2. It was estimated that there were 15,000 to 20,000 tons of particulate oil residues on the surface of the North Atlantic. The data for dissolved/dispersed petroleum residues at a depth of 1 m in the water column indicated that the background levels in many areas of the world ocean were around 1 microgram/litre, although there were inconsistencies among the data sets produced by different participants.

Only one participating country - Japan - carried out a detailed study of tar stranded on beaches. It was shown that the amount of tar stranding on the beaches of Japan was highly dependent on seasonal changes in the directions of the prevailing winds in the Kuroshio region.

MAPMOPP has been successful not only in providing a preliminary understanding of the global distribution of oil pollution, but also in establishing an organizational framework for future monitoring programs.

Atlas of eastern Canadian seabirds

- R.G.B. Brown & D.N. Nettleship



Roger Bélanger

Dick Brown

The *Atlas of Eastern Canadian Seabirds* was published in 1975. It was the first result of the Canadian Wildlife Service's (CWS's) quantitative surveys of the breeding and pelagic distribution of seabirds north of 40°N and west of 40°W.

Seabirds are the most conspicuous victims of oil pollution, and the potential hazard to them is one of the more important environmental concerns in any offshore oil operation. The original Atlas was timely in that it provided much of the background information required for the various environmental impact statements generated by the boom in offshore hydrocarbon exploration off eastern Canada. However, it has now been superseded by new information that comes partly from recent CWS colony surveys of the populations of breeding seabirds, partly from additional shipboard surveys on the pelagic distributions of seabirds, and in large part from the aerial surveys of seabirds at sea commissioned by the oil industry as part of the federal government's requirement for the environmental review process.

CWS is now preparing to edit and publish this new information. The original Atlas will be replaced by two publications, one covering the colony surveys and the other shipboard and aerial pelagic surveys. The new volumes will reflect not only our greatly increasing knowledge of seabirds off eastern Canada, but also the increasing sophistication of all three types of survey. CWS has been a leader in developing these techniques both in North America and Europe.

The colony survey data will show our best available estimates of the numbers of seabirds breeding in eastern Canada. As in the original Atlas, the emphasis will be on the more conspicuous colonial species such as Northern Gannets *(Morus bassanus)* and Atlantic Puffins *(Fratercula arctica)*, rather than birds that breed in many small colonies - such as most of the gulls - or those that are semi-colonial and difficult to census, like the Black Guillemot *(Cepphus grylle)*. The new Atlas will nonetheless contain more information about these last two groups of seabirds than did the original.

In the original Atlas. the colony-counts for each species of seabird were presented separately. In the new publication, all the species breeding at a given site will be listed together. This form gives us a better understanding of the importance of specific sites to the eastern Canadian seabird community, and draws attention to those species in particular need of conservation and management. The descriptions of each site will also include background environmental information on the geological formations that have created a site suitable for a seabird colony and the oceanopraphic conditions that ensure an adequate food supply for the breeding birds and their young. The past history of seabirds at each site will also be included. with particular reference to human interference, both past and present.

The pelagic distribution maps will give a broad overview of the distributions month by month of the principal species of seabirds off eastern Canada. As in the original Atlas. the survey area will be divided into an Atlantic and an Arctic section, with the boundary in the new edition lying at 60ºN. The data will be presented as the average number of birds seen per kilometre in a 'square' of 1ºN x 1ºW (Atlantic) or 1ºN x 2ºW (Arctic). This new index can represent both shipboard and aerial data. It permits better comparisons between areas, months, and to some extent species than the index for shipboard data used in the original Atlas. which gave the average number of birds observed per 10 minute ship watch.

The pelagic maps serve two functions. The first is to give a broad general picture of the species' distributions off eastern Canada month by month. The second is to show how much information is available for a specific site. Using these data, a new computer mapping program can produce a map at almost any degree of magnification. The environmental impact requirements for an offshore oil well, for example, might be met by a set of monthly maps for a 5ºN x 5ºW 'square' showing the well in the centre and the combined distributions of all species of auks, the seabirds most vulnerable to an oil spill offshore. By the same token, such small-scale maps would show at a glance the areas and the times of year for which more survey data are required.

The old Atlas had many uses. It provided information for purposes as varied as:

(1) Preparing environmental impact statements of seabird distributions in the vicinity of offshore oil industry operations at sites from Lancaster Sound south to the Grand Banks.

(2) Planning the biological oceanographic voyage of C.S.S. *Hudson* in the High Arctic in 1980. In this case. areas of high local breeding and pelagic seabird densities were used to identify areas of high marine productivity.

(3) Contributing to the BIO summary of the physical and biological oceanography of Georges Bank. which was prepared as a brief to support the Canadian boundary claim to that area.

(4) Providing background information in deciding how to dispose of the halves of the tanker *Kurdistan.* which broke in two in Cabot Strait in March 1979.

CWS hopes that the new, more flexible version of the Atlas will prove just as versatile. The timing of publication will depend at least partly on funding. but CWS hopes that the volume on shipboard surveys will come out before the end of 1983. The shipboard data base is. however, already available for site-specific mapping.

The drifter data base

- C.S. Mason & F. Jordan

Francis Jordan.

One facet of the study of the oceans is to determine the path water follows as it circulates from one area to another. Information about ocean currents has been accumulating gradually since the launching of the first hollow log: mariners realized early that good information came from watching material drifting on the ocean surface - the nature of the drifting material sometimes providing a clue to its origin.

As technology developed, our ability to chart ocean currents improved. With the advent of widespread literacy and modern postal services, it became possible to label a drifter so its finder could easily return it for a modest reward. Such ocean drifters have been widely used to track surface currents off the Canadian Eastern Seaboard and, for many years, the St. Andrews Fisheries Laboratory used ocean drifters to investigate surface water movement around the Maritimes. BIO took over this program in 1978 and has acquired data on both surface water movement and bottom sediment drift using the labelled drifter technique.

Like the castaway's messages for help. the first drifter design was just a message in a bottle. These were used up to the seventies. The more recent development is to use only the message itself as the drifter. a plastic postcard with a permanently imprinted message. Surface currents are followed by fitting the card with a buoyant float, enabling the card to float vertically with about 1 cm of freeboard.

Bottom drift is followed by a mushroom-shaped weighted plastic drifter with a postcard attached to it. In either case, the finder simply writes in on the card its the recovery point plus his name and address, and posts the card to BIO.

The BIO program has released some 50.000 drifters in the past 4 years, at locations ranging from the mid-ocean to local harbour dredging projects. In conjunction with the Canadian Environmental Protection Service and the federal Department of Public Works, seabed drifters have been dispersed at ocean dumping sites in the Maritimes to monitor the probable direction of the dumped spoil and to predict possible effects on downstream areas. Surface drifters have been used to estimate the direction of movement of oil spills and to aid fishery studies. To date, 35,000 surface and 15,000 seabed drifters have been released, with returns of 1,500 and 6,700 respectively. The apparent anomaly between the surface and seabed returns is probably due to the bed drifters being released mainly in the nearshore and harbour areas where waves drive them ashore and where the population is high enough to ensure recovery.

So far, in the variety of interesting returns, surface drifters launched in the Labrador Current have been picked up on the coast of Ireland. Others released in the Bay of Fundy were returned from France 2 years later.

An experiment to compare the relative merits of bottles used in previous programs and BIO cards was carried out on the Scotian Shelf in 1979. As an example of the extent of this experiment. 1,000 pairs of drifters were released on each of just two of the voyages at several stations and at different times. By the end of 1981, only 52 bottles and 66 cards had been returned. While this seems to be a rather poor return rate, it does illustrate the number of drifters that should be deployed in the open sea to assure a reasonable return.

Included in the returns of this experiment were four original pairs of bottles and cards. All were found in the Bay of Fundy from Yarmouth around to Grand Manan Island. The bottle of one pair was found at Yarmouth and the card near Digby, one year later. For another pair, the bottle reached the Fundy coast and the card was found in Minas Basin. The bottle of the last pair reached Minas Basin only 43 days after being released. while the card was picked up at Grand Manan 8 months later. We found little difference between the two drifter types, except that card drifters travel farther than the bottles before being driven ashore. One fact must always be remembered: the return time only reflects the time the drifter was found. Several returns from an area are needed before drift speeds can be deduced.

Returns can be expected to filter back to BIO's clearinghouse for the next few years. Clearly, these progressively later returns will be less and less useful, but the rewards will still be paid. Summer always produces an increase in returns, and some summer beachcombers have done very well in the past. earning as much as $150.00.

Drifters can be stored indefinitely and are easily available and useful for dealing with marine disasters. For example. when the oil tanker *Kurdistan* broke in two at Cabot Strait drifters were deployed around the edge of the resulting oil spill. Analyses of the drift card returns and our general knowledge of regional circulation helped confirm that oil. which had beached along the coastlines of Nova Scotia and Newfoundland, came from this source.

A recent report (see Chapter 5. "Pub. lications". Bezanson. 1989) listed over 700 release points around the Canadian coastline and 2,700 returns from 13,300 releases were plotted.

Oceanographic atlases

- R.A. Clarke

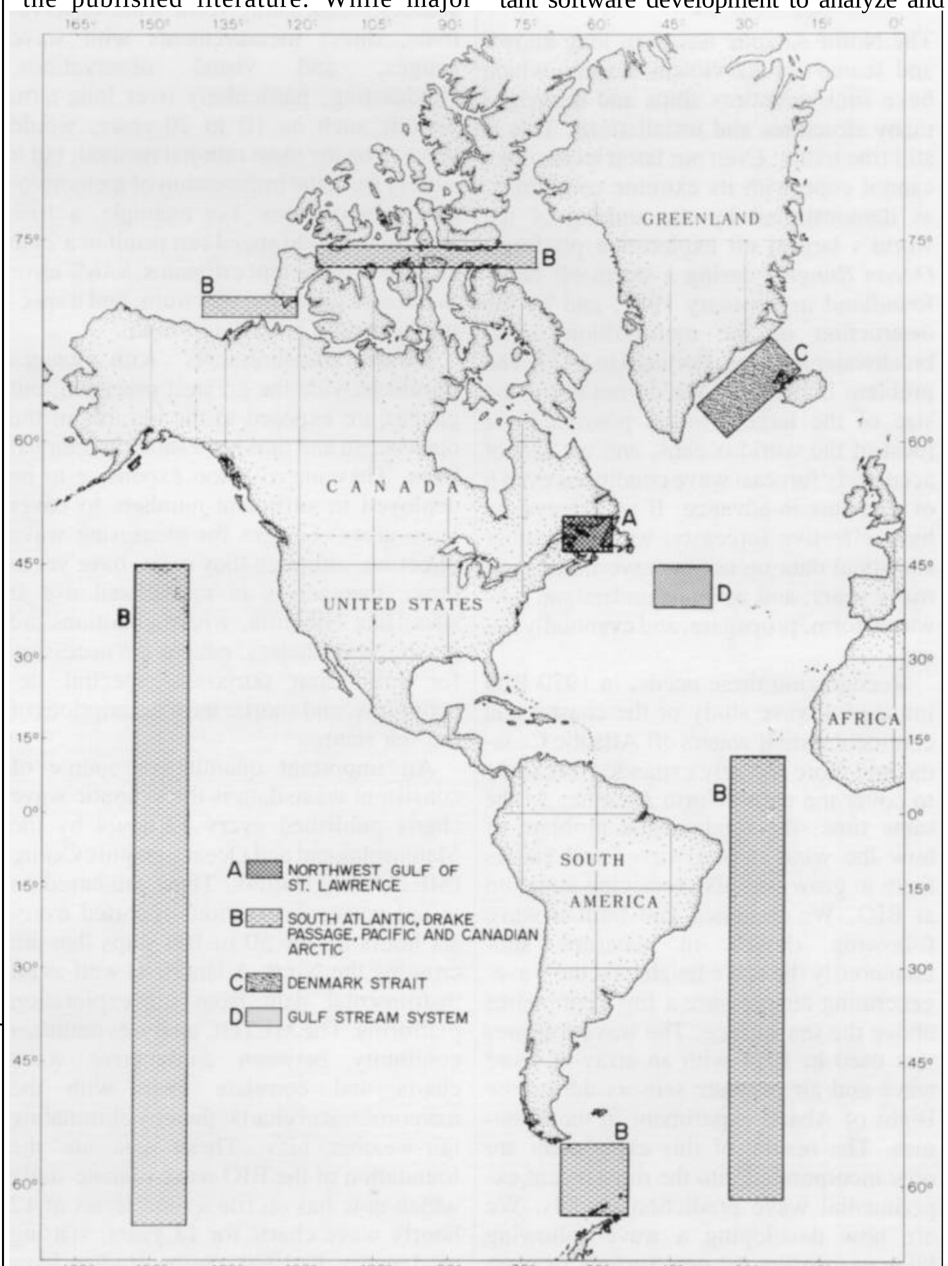
Roger Bélanger

Allyn Clarke.

Physical oceanography began in the 19th century because of a need to map surface currents, water temperatures, and wind directions as an aid to navigation. Later, the classical oceanographic expeditions of the late 19th century and early 20th century published their subsurface observations as atlases showing the oceanic distribution of temperature, salinity, oxygen, and nutrients. Most of the larger oceanographic programs of recent years have also produced oceanographic atlases.

Atlases are used by oceanographers to plan future experiments, to verify that new data sets are consistent with the older data sets, and to look for data that can be used to either test models of various physical processes or build such models. Meteorologists use atlases to build atmospheric models involving air-sea exchange. Biologists and fisheries scientists consult atlases to compare species distributions with environmental conditions. Atlases make oceanographic data available quickly to a large variety of users, many of whom do not have the time or the resources to reanalyze the raw data now available from various data banks.

BIO published several atlases in the sixties following expeditions to Davis Strait, the Labrador and Irminger Seas, and the western North Atlantic; these atlases are still cited several times each year in the published literature. While major oceanographic expeditions were mounted during the seventies, no atlases were prepared at BIO partially because our data processing staff was occupied with important software development to analyze and



During 1982, BIO published atlases incorporating physical and chemical oceanographic observations made in: (a) the northwest Gulf of St. Lawrence: (b) the South Atlantic, Drake Passage, and Pacific and Canadian Arctic: (c) Denmark Strait: and (d) the Gulf Stream System.

reduce the large volumes of data recorded by modern electronic instruments. In the past two years, however. we have initiated a program to prepare and publish atlases of much of the oceanographic data collected during the seventies. During 1982/83, we have published four atlases on physical and chemical oceanographic observations in the Northwestern Gulf of St. Lawrence; South Atlantic, Drake Passage, Pacific. and Canadian Arctic - 1970; Denmark Strait - 1973; and the Gulf Stream System - 1972.

In the coming years we will publish atlases dealing with data sets from the Saguenay River, the Scotian Shelf. the Gulf Stream System. and the Labrador Sea, and thus complete our backlog of old data sets. In the future, we plan to publish atlases within a few years of the completion of an observational program. In this way, information we collect will be available to an interested audience within a reasonable time.

Wave climate studies

- H.J.A. Neu & F.W. Dobson

Roger Bélanger

Hans Neu.

The North Atlantic has been long known and feared for its violent storms, which have sunk countless ships and destroyed many structures and installations. This is still true today. Even our latest technology cannot cope with its extreme conditions, as demonstrated by the sinking of the world's largest oil exploration platform, *Ocean Ranger*, during a storm off Newfoundland in February 1982, and by the destruction of the multimillion dollar breakwater in Sines, Portugal in 1979. The problem is twofold. We do not know the size of the largest waves possible over most of the world oceans, and we cannot accurately forecast wave conditions even 6 or 12 hours in advance. If we are ever to have effective forecasts, we must gather statistical data on ocean wave fields over many years, and we must understand how waves form, propagate, and eventually decay.

Recognizing these needs. in 1970 BIO initiated a wave study of the coastal and continental shelf waters off Atlantic Canada, and more recently expanded this study to cover the entire North Atlantic. At the same time, the fundamental problem of how the wind makes waves and causes them to grow was also receiving attention at BIO. We designed and built a wave following device to measure simultaneously the wave height and the wave-generating air pressure a few centimetres above the sea surface. The wave follower was used in 1974 with an array of fixed wave and air pressure sensors during the Bight of Abaco experiment in the Bahamas. The results of this experiment are now incorporated into the most recent experimental wave prediction models. We are now developing a wave following buoy to measure the near surface air pressure field and thereby extend the wave growth measurements to larger waves on the open ocean.

Sources of wave data

The wave climate is a description of the sea state over time scales of a month to decades and spatial scales of a few hundred kilometres to the ocean width. A wave climate can be derived from three sources: hindcasting from wind observations, direct measurements with wave gauges, and visual observations. Hindcasting, particularly over long-term periods such as 10 to 20 years, would seem to be the most rational method, but it suffers from the imprecision of meteorological observations. For example. a 10% error in the wind speed can result in a 21% error in wave height estimates, a 46% error in the area under the spectrum, and a spectral peak that is 61% too high.

Direct measurements with gauges should provide the greatest precision, but gauges are exposed to the hazards of the open ocean and thus have short operational lives. They are also too expensive to be deployed in sufficient numbers to cover large areas. Gauges for measuring wave direction, although they exist, have yet to prove themselves in operational use at sites, like Hibernia. where condtions are harsh. Nevertheless, gauges are necessary for calibration purposes, spectral descriptions, and shorter term descriptions of the sea state.

An important quantitative source of consistent wave data is the synoptic wave charts published every 12 hours by the Meteorological and oceanographic Centre (METOC) in Halifax. These are based on visual wave observations reported every six hours by the 50 to 100 ships that are crossing the North Atlantic, as well as on instrumental data from oil exploration platforms. The METOC analyses maintain continuity between consecutive wave charts and correlate them with the meteorological charts. thereby eliminating fair-weather bias. These data are the foundation of the BIO wave climate study which now has on file a time series of 12 hourly wave charts for 13 years, starting on January 1, 1970. Some studies have compared estimates of wave statistics from visual observations and direct measurements, and it appears that visual estimates of significant wave height and periods are within 4% of the direct measurements taken at the *Zapata Ugland* exploration platform. (The significant wave height H_{sig} and period T_{sig} are the mean height and period of the highest 1/3 of the waves in a wave record. The maximum wave height H_{max} is generally considered to be twice that of H_{sig}.)

Neil Oakey

Fred Dobson.

Creating the wave climate charts

For the centre point of each 5º by 5º grid-area of the North Atlantic, the observed significant wave height was determined every 12 hours and then assembled into longer term data sets. Each of these data sets was plotted as an "exceedance distribution". Practically all our data for the North Atlantic fitted the log-normal distribution better than, or as well as any of the other statistical distribution functions. For example, a statistical chi-square test showed that, near the Hibernia site, data fit this distribution with a confidence level of better than 98%. The line through the data is fitted by the technique of least squares and forms the basis for further analysis. Its relative location and slope are an indication of the severity of the sea state.

To design marine structures, engineers must know not only the normal wave state. but also the extreme wave heights, periods, and directions likely to occur at a given site. Fifty or 100 year events are common requirements, but observations over these lengths of time do not exist. By assuming that these long-term occurrences follow the same probability function as do the observed data, we can extrapolate the fitted distribution to give an estimate of extreme wave height for any period.

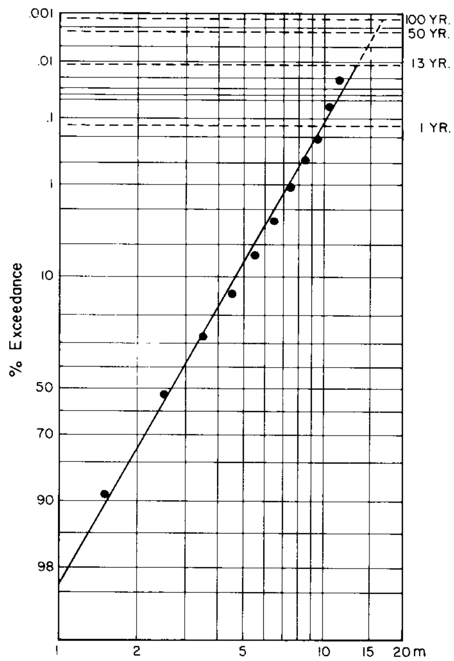
Features of the North Atlantic wave climate

The analysis of the first year's (1970) data from our wave study of Canadian waters clearly shows that the sea state on the continental shelf varies seasonally: a winter monthly energy level is about four times greater than a summer monthly level. The annual largest wave height for 1970 varied from 9 m in the Gulf of Maine to 19 m on the Grand Banks. The extrapolated 100-year wave for the outer edge of the Grand Banks was 30 m, confirming that 100 foot waves were not just a sailor's yarn - they could exist, most likely along the outer edge of Canadian waters.

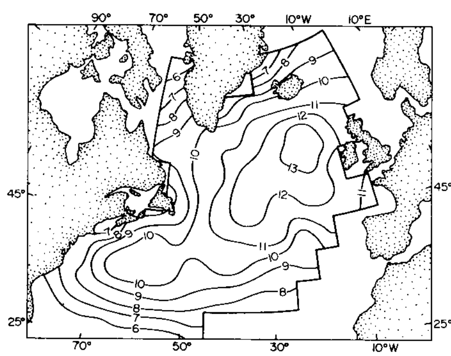
In the early seventies, oil exploration in the North Sea declined temporarily, and platforms designed for 20 m extreme wave heights were brought to Canada for drilling on the Scotian Shelf and the Grand Banks. Based on our results, we felt compelled in 1972 to state that a rig built for a 20 m design wave might withstand sea conditions on the Scotian Shelf but would probably fail on the Grand Banks or off the Labrador coast.

The lowest sea states in the North Atlantic occur along the coast of North America and across the southern part of the ocean from Florida to North Africa. From these areas and to the east and north respectively, the heights, periods, and frequencies of occurrence grow rapidly. Wave action is pronounced in the central part of the North Atlantic, but from there it increases only in the northeasterly direction with the highest wave (21 m) occurring to the west of Ireland. The frequency of occurrence of large waves is 10 to 12 times greater on the European side than on the American side.

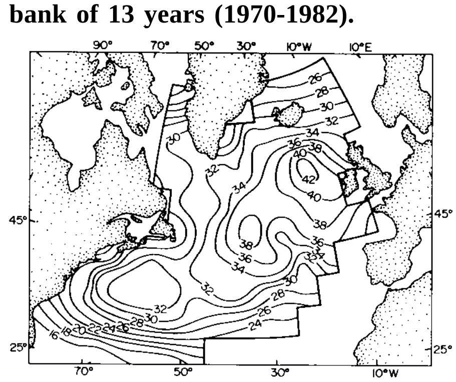
In response to intensified drilling in Canadian waters and the *Ocean Ranger* disaster, the Canadian Oil and Gas Lands Administration, the government agency responsible for monitoring drilling in the ocean, requested in 1982 a new wave climate study based on 11 years' data (1970-1980). The results (see chapter 5, Publications, Neu, H.J.A., Canadian Technical Report of Hydrography and Ocean Sciences No. 13) deal primarily with the key areas of exploration: Sable Island on the Scotian Shelf, and the Hibernia oil field on the Grand Banks and the Labrador Sea.



A diagram of wave-height exceedance for 13 years (1970-1982) and the long-term prediction for the wave climate at the site of the Hibernia oil field.



The largest significant wave height (H_{sig}) for the North Atlantic Ocean in a normal year as deduced from a data bank of 13 years (1970-1982).



Predicted 100-year (design) wave height H_{max}, based on 13 years of data (1970-1982).

The largest H_{sig} of a normal year and the 100-year (design) wave heights are presented in the accompanying figures. The large variability in the annual largest H_{sig} prompted an interim study, which showed long-term (3 and 6 years) interannual fluctuations in the sea state of the North Atlantic. These height variations were as much as 40%, or similar in magnitude to the variation in the annual cycle. Any long. term extreme value predictions that do not take such fluctuations into consideration will not provide statistically reliable results.

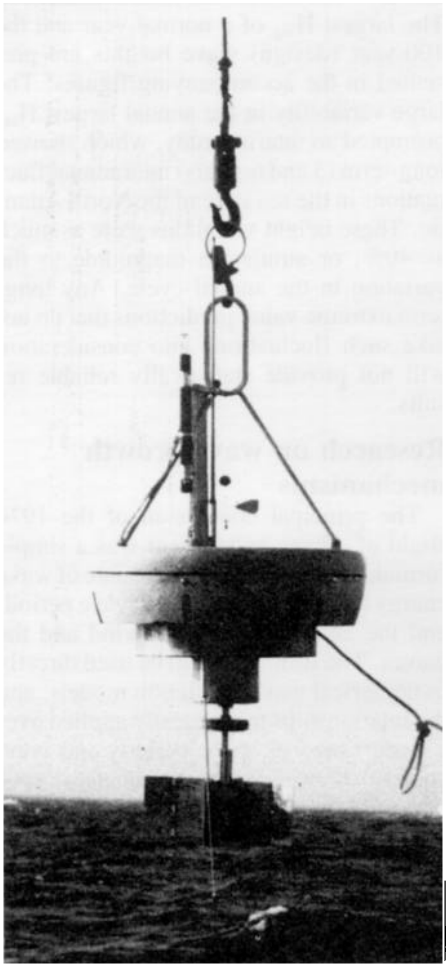
Research on wave growth mechanisms

The principal conclusion of the 1974 Bight of Abaco experiment was a simple formula relating the rate of change of wave energy to the wind speed, the wave period, and the angle between the wind and the waves. The formula could be used directly in numerical wave prediction models, and the relationships theoretically applied over a wide range of wave periods and wind speeds. However, its parameters were obtained by fitting experimental data obtained in an enclosed bay, over a small wind speed and wave period range (0-20 knots, 1-3 s). It is necessary to extend these studies to wind and wave regimes more appropriate to open ocean conditions. We have developed a freely-floating buoy equipped with sensors to measure wave height and direction, and air pressure. The buoy telemeters its signals to a nearby ship for recording and subsequent analysis. This buoy has been test-deployed twice in the ocean, in wind speeds up to 30 knots and wave periods of up to 10 s. The data it has produced are presently being studied, and we hope that within a year or two results will be obtained that will allow us to make accurate estimates of wave growth in open-ocean conditions.

Conclusions

The existence of large-scale, long-term variability in the sea states of the North Atlantic Ocean, while not unexpected, is of crucial concern to ocean engineers and scientists alike. Recent statistical predictions of the "highest wave in the next 50 years" assumed a stationary process - no variability on time scales longer than the length of record analyzed - and this is now in question. We know almost nothing of the statistics of wave direction. Yet without such information, engineers can only rely on guesses, and guesses are not good enough in such an unforgiving environment.

Waves and the winds that produce them



Neil Oakey

A pressure-sensing wave buoy being launched from the C.S.S. *Dawson* in December 1982 off the coast of Nova Scotia. The pressure sensing disc with wind vane is visible below the oblong ring. The vanes below this reduce the excess pitching of the buoy. To the left of the pressure disc are a tail fin, which aligns the buoy in the direction of the wind and a light, which helps us recover the buoy.

have a profound effect on the circulation of water in the upper layer of the ocean. One such effect is the production of vertical 'Langmuir' circulations that carry surface waters downwards and upwell nutrient-laden waters from below. Interannual variations in the wave field may also be associated with large-scale changes in the upper layer of the ocean, which in turn affect biological productivity, the strength of the oceanic circulations, and the ocean's role in transferring the heat absorbed in the tropics to higher latitudes. There is an urgent need for further work, both to determine the full extent of the long-term variability of the wave field in the North Atlantic and to investigate open-sea wave growth rates in order to verify the extrapolations from nearshore conditions used in existing wave prediction models.

ARCHIVES

Physical and chemical oceanographic records

Roger Belanger

Doug Gregory.

The Atlantic Oceanographic Laboratory has operated a regional archival centre for physical and chemical data since 1981. Our responsibilities include making these data available to users upon request and guaranteeing their proper documentation and safety against loss. We have made a special effort to identify data of industrial or commercial origin, and to obtain permission to archive it. Many of these data have a lasting usefulness well beyond the original intent of their collectors.

Data bases presently maintained by the archive include:

- 2,000 current meter series representing over 90,000 days of data, primarily from moorings on or adjacent to the continental shelf area
- Surface and bottom drifter data from a variety of drifting devices (i.e. free floating cards, ballasted and unballasted bottles, bottom drifters, etc.). The data consist of 45,000 recoveries from 240,000 releases - see "Drifter data base" in this chapter
- 500 temperature series from inshore moorings around Nova Scotia, New Brunswick, and Newfoundland - see "Long-term temperature monitoring" in chapter 1.
- Standard chemical parameters (about 3500 stations. 30,000 samples) from various western Atlantic locations taken over the past 10 years.

New data archives requiring development in the near future include satellite tracked drifter trajectories and velocity profiles from the recently acquired Ametek Straza acoustic doppler current profiler.

Before placement in the archive, all data and support documentation are screened for obvious errors or inconsistencies. As data are analyzed for specific research applications, other more subtle errors may surface. Thus the archives are continually corrected and updated. Inevitably, errors will still exist, and therefore we are presently re-examining the entire data base from both surface and bottom drifters and current meters. We will also be improving the thermograph and the chemistry data bases.

The majority of the data in the archives have come from field programs carried out by BIO over the past 20 years. Recently, a significant number of current meter moorings were deployed for studies conducted by the offshore petroleum industry. Many of these data have been acquired for the archive from the Eastern Arctic (EAMES), Labrador Shelf (Petro-Canada), Newfoundland Shelf (Mobil Oil), and Scotian Shelf (Shell Oil).

Primary use of the archive comes from within BIO, but there is a growing need from scientific and engineering consultants carrying out studies related to offshore development. Some of their requests are for complete data series, but more frequently they require graphical or statistical summaries. The Canadian Hydrographic Service also has a continuing requirement for surface current velocities for display on navigation charts.

Two new research projects within the Atlantic Oceanographic Laboratory. which initially will rely solely on historic current meter data, serve to illustrate the value of the archive. The first is a study of the surface circulation in Baffin Bay and adjacent waters, an area of potential importance in the transportation of hydrocarbons. A sizeable data set obtained from the archive provided the background information needed to plan future field programs. This eliminated many of the time consuming and expensive preliminary measurements normally required for designing a major research program.

Another major program is a study of the wind driven circulation over the Grand Banks of Newfoundland. Knowledge of this circulation is important because it tells us about iceberg drift and helps in the design of drilling platforms that may be used in the area. The study's primary objective is to develop an analytical or numerical model of the circulation. Historical current meter data, primarily from Mobil Oil but supplemented by BIO data, will be used to produce a large scale velocity distribution over the Grand Banks. When combined with meteorological data from the same period, the entire data base will be used to verify the accuracy of the different models being tested.

Curation of geological sample material

- A.G. Sherin & K. Rideout

Earth scientists at BIO began to collect marine geological sediment in 1962-63. The first material collected was from remote parts of the Arctic Archipelago, Prince Gustave Adolph Sea. Prince Patrick Island, and McClure Strait. It is still the only sediment available from some of those areas.

The sediment sample collection at BIO consists of approximately 3,200 seabed surface samples, 3,600 unconsolidated-sediment core sections. 50 drill core samples, water samples, and processed sample material. Samples are gathered in areas ranging from within 450 km of the North Pole to as far south as the Senegal continental shelf and the coast of Peru. Collection depths may vary from 5,500 m in the Sohm Abyssal Plain in the Atlantic Ocean to above the high water mark at Martinique Beach, Nova Scotia. The largest number of samples are from the Eastern Canadian and the Arctic offshore regions including a large suite of surface samples from Hudson Bay collected in 1965.

The cost of collecting sample material is high and continues to increase each year. For example, the cost of operating a major research vessel for one day is $25,000. and a helicopter costs approximately $400 per hour. To collect the material acquired since 1963 again would require several tens of millions of dollars. This does not really reflect the scientific value of the material which goes beyond replacement cost because a sample can never truly be replaced. The sample on which a researcher has developed a detailed biostratigraphy for paleoclimate studies or paleoecological studies and that has been widely used by other researchers cannot be replaced. Samples collected for one purpose can often be used for other purposes later. For example, sand collected for geochemical analyses may also be useful in compiling surficial geological maps, in evaluating the mineral potential of an offshore area, or possibly in determining if the area it came from could provide sand that would be useful in making glass.

Recently a suite of core and grab samples was collected from ten of the Baffin Island fjords. The unique sedimentological conditions in these fjords, where sedimentation rates are high, allow scientists to examine the features of the sediment in more detail than they could from samples collected in many other areas of the ocean, and by so doing to reach conclusions on paleoclimatic conditions.

In 1975, a suite of unconsolidated sediment cores from the deep part of the Labrador Sea and along the Greenland slope was collected by C.S.S. *Hudson.* The objective was to study the paleoclimate and glacial history of the Labrador Sea and to extend the work of the CLIMAP project in quantitative paleo-oceanography to northern waters. The 170 day cruise successfully acquired 62 piston cores which were later analyzed for foraminifera, radiolaria, and diatoms: these data were used to estimate paleo-ocean temperatures.

The Atlantic Geoscience Centre. through its Program Support Subdivision. curates, catalogues, and publishes indexes of marine geological samples. These are collected by its own scientists, other laboratories at BIO, Dalhousie University and other maritime universities, and consulting and exploration companies.

The purpose of curation is to ensure quality control of sample material, which is maintained in close to original condition. Certain standard information is provided before samples are entered into the Curation system: cruise number, sample number, latitude and longitude, geographic location, and chief scientist's name. Subsequently, cataloguing information may become more diversified according to the identification requirements of each sample type.

A sample box inventory exists for processed samples stored in standard sized boxes, which have a unique identification number that is recorded along with standard information in a computer file. In the future, the computer file will be expanded to include a list of all the sample numbers contained in each sample box. Grab samples are stored in plastic pails labelled with the cruise and sample numbers and large bulk dredged samples are stored in labelled crates. Because of the shortage of repository space, alternative methods for storing grab and dredge samples are being investigated. Cores are kept in cold storage.

Several steps are followed to ensure uniformity when cataloguing, storing, subsampling, and removing sample material. A standard core history log accurately records information through the collection, transport, and storage stages. Standard core description forms, as well as forms for subsampling, splitting, and nondestructive testing, provide an accurate core history. Information policies, as well as logs and related forms, are part of a reference package prepared for use by chief scientists on every sampling cruise. Lastly, a filing system organizes all the sample information for reference or updating. There is also ongoing work to round out the information framework on older samples gathered before these procedures were put in place.

Computerizing the palynological literature

- M.S. Barss

Sedley Barss.

The Kremp Palynological Computer Research Project was organized in 1968 by four industrial sponsors to compile the stratigraphic and geographic occurrences of palynomorphs in the pre-Pleistocene palynological literature. The project has since grown to nine industrial sponsors plus the Geological Survey of Canada of DEMR. It is guided by a steering committee composed of one representative from each sponsor and Dr. Gerhard O.W. Kremp. research director and originator of the project.

Stratigraphic and geographic occurrences of palynomorphs from 10,200 published papers had been compiled by the end of 1982. Each of the sponsors organizes the data into search files that meet their individual needs. Dr. Kremp and his staff in Tucson, Arizona, abstract the numerous publications. The first 8,000 were keypunched from 1968 to 1979 by the first eight sponsors (1,000 each). and subsequent publications were handled by Dr. Kremp.

The Geological Survey of Canada joined the Consortium in 1974 and installed the search file on System 2000 at the DEMR Computer Science Centre in Ottawa, which facilitated retrievals from offices in Ottawa, Calgary, and Dartmouth.

The method used to abstract and keypunch the first 8,000 publications introduced many inconsistencies and errors into the data. In 1980, therefore, palynologists at the Atlantic Geoscience Centre, with support from BIO computer personnel, redesigned the system of retrievals and prepared a computer program to clean up and verify all data keypunched till then and to scrutinize all incoming data. The computer programming for this redesign and verification was largely contracted to outside consulting companies. Once the software was completed, 9,700 publications were run through the checking programs in 15 months. With the help of the Union Oil Co. of California, one of the sponsors, a tape with 9,700 clean publications was then issued to all sponsors. During the 'clean-up', dictionaries were developed for authors and to provide information on absolute ages and hierarchical localities of palynomorphs. A species dictionary is now in preparation.

Data in the file include the author, year of publication, title of article, journal of publication including volume and issue numbers, figures, plates, pages, etc., taxa names including notes (i.e. new species, emended, etc.), and locality and age for each taxon cited. Approximately 70,000 taxa of spores, pollen, dinoflagellates, acritarchs, chitinozoans, and fungal spores are included, representing most of the world's pre-Pleistocene literature on these fossil groups.

The retrieval of information from the system can be tailored to the needs of the palynologist and can range from a single item of information to a combination of several taxa of specific stratigraphic occurrence from a limited geographic area. A recent retrieval request asked for bibliographic references for a group of 226 species belonging to 25 genera. The retrieval took 397 seconds on the computer's central processing unit. The time required to do a manual search through this literature is about six man-months.

This data base provides the palynologist with the means to search the world literature while carrying out studies on taxonomy, hydrocarbon exploration, stratigraphic problems, etc. The consortium decided in 1982 to make this tool available to all palynologists. A computer firm will provide the facility for access on a pay as you go basis.

The program developed at the Atlantic Geoscience Centre for these palynological data can be used by any group of paleontologists to build similar data bases for their particular field.

EAMES: the Arctic archive - G. Seibert

The Eastern Arctic Marine Environment Studies (EAMES) program produced one of the largest collections of new biophysical data on a remote northern environment. The program was conducted from 1976 to 1980 in Baffin Island and Lancaster Sound, a region with strong petroleum production potential. The program's primary objectives were: to collect, collate, and interpret environmental data necessary for an Environmental Impact Statement (EARP, see chapter 4); to provide data for the development of oil spill contingency plans; and to gain an appreciation of the factors that could affect the efficiency and safety of drilling operations.

Physical oceanographic data archived are limited to those collected during the summer of 1978, winter of 1978-79, and summer of 1979. They include:

- time series measurements of subsurface currents, temperature, and salinity obtained from moored current meters
- vertical profiles of current shear
- geographical positions of satellite-tracked surface drifter buoys and iceberg floes
- geographical positions of icebergs derived from land-based radar tracking stations
- time series measurements of water level fluctuations obtained from submerged pressure gauges
- remote sensing measurements of type and amount of ice cover
- and auxiliary meteorological information such as surface winds, atmospheric pressure, cloud types and cover, and air temperature.

Subsurface currents were obtained at 14 locations in the summer of 1978, at 18 locations in the summer of 1979, and at 5 locations in the winter of 1978-79. Currents were sampled at 10 minute intervals in summer and hourly in winter using an Aanderaa RCM-4 model current meter deployed at depths of about 35, 125, 250, 500, and 750 m. Due to variations in bathymetry, only the 35 m depth was sampled at all locations; depths of the other meters varied with location, with each mooring having from two to five current meters.

Some systematic and accidental errors must be removed before the data are archived. Timing errors caused by too few or too many data cycles can usually be corrected for. Magnetic disturbances that affect compasses are a major source of error in directional measurements. In southern latitudes, these disturbances are negligible relative to the strong horizontal field strength of the earth's magnetic field. But in the Arctic, particularly in the vicinity of the magnetic pole, these disturbances introduce a bias that cannot be easily removed at the analysis stage. Errors resulting from mooring motion may be compensated for if currents and pressure have been measured with adequate vertical resolution.

In 1978, 193 CTD profiles were obtained at 85 stations and in 1979 this was increased to 328 profiles at 144 stations. Station locations in 1979 were concentrated near the entrance to Lancaster Sound. The Guildline digital CTD used in these observations, usually a reliable instrument, did experience a number of problems, some of which could be corrected for later in the analysis. Calibration of the temperature, conductivity, and pressure sensors against bottle samples compensated for long term drift of the sensors, while problems of noise (electronic signal dropouts) were partially overcome by numerically smoothing the profiles.

Although the EAMES data were collected within the limited objectives of providing information for Environmental Impact Statements, oil spill contingency plans, and design parameters, scientists will find them a valuable resource when formulating process-oriented research programs in sea ice physics, circulation studies, and climatology.

East coast drilling and WELLSYS - G.L. Williams

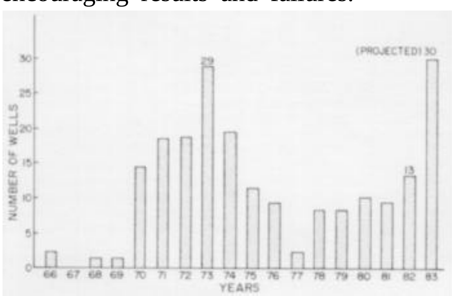
The search for oil and gas in offshore eastern Canada officially began in 1966 when the American Oil Company (then Pan American Petroleum Corporation) and Imperial Oil Company drilled the first wells on the Grand Banks. Although the wells - Tors Cove D-52 and Grand Falls H-08 - proved disappointing, interest remained high.

A year later, Mobil Oil started Scotian Shelf exploration when they drilled the Sable Island C-67 well. This 4,606 m well indicated a very promising reservoir section with oil and gas shows, and provided considerable momentum for future drilling.

Since 1967, the number of wells drilled annually has fluctuated considerably. A peak of 29 was reached in 1974 followed by a low of only two in 1977. Total annual footage, which is a more accurate indication of drilling activity, followed a similar pattern. This lull in drilling during 1977 partly reflected disappointment in the results and partly difficulties with the political situation. Fortunately for offshore exploration, the situation improved in the following year.

Success was guaranteed in 1979 with two dramatic discoveries: the Hibernia P-15 well in the East Newfoundland Basin, and the Venture D-23 well on the Scotian Shelf. In tests, Hibernia P-15 produced more than 11,000 barrels per day and was estimated to be capable of a daily production of 20,000 barrels. This was the first major oil discovery in offshore eastern Canada. Subsequent wells have confirmed Hibernia as a giant oil field. with recoverable reserves of about 1.8 billion barrels. Other structures drilled in the East Newfoundland Basin also contain oil and may be producing by the next decade.

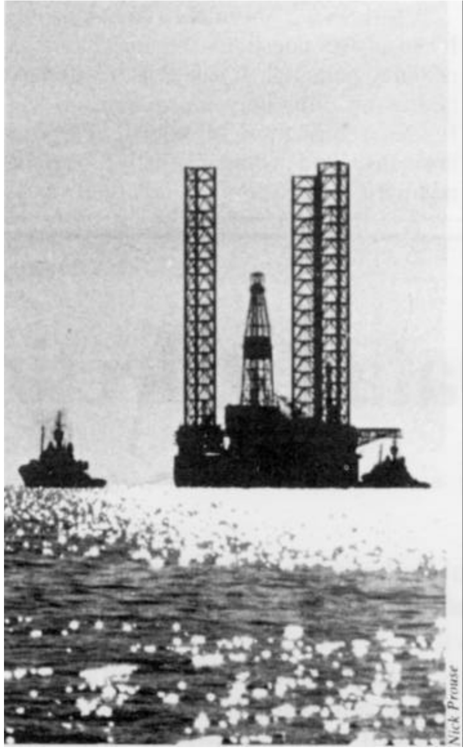
Venture D-23 was a major gas discovery and provided a boost to nagging exploration on the Scotian Shelf. During the years 1967-1978. drilling on the Scotian Shelf was an alternating series of encouraging results and failures.



Wells drilled in offshore Eastern Canada (total = 173).

In 1971 the *Halifax Herald* trumpeted. “Its Oil”. The headlines were based on results of tests of the Sable island E-48 well. But that first well on the west Sable structure proved the best: the rest were bitter disappointments. In subsequent years, there were several significant gas discoveries such as Primrose N-50. Thebaud P-84, and Citnalta I-59, but none were large enough to justify development. Then came Venture D-23, which suddenly made production feasible by producing more than 2 million cubic metres of gas per day in tests. Later wells on the same structure confirmed the magnitude of the Venture field and resulted in Mobil Oil drawing up production plans. The Venture discovery opened a new play on the Scotian Shelf: the search for gas in the overpressured zones. Wells drilled on similar structures such as South Venture and Olympia are confirming this success and indicate that the Scotian Shelf will be a major gas producer.

The Venture and Hibernia discoveries have had a major impact on offshore drill-



The *Zapata Scotian* oil-drilling rig under tow off Halifax Harbour.

ing. The number of projected wells for 1983 is 30 and the projected footage adds up to 120,000 m. This gives a cumulative figure of about 202 wells and an estimated 711,248 m by the end of 1983. Where are all the samples from the wells curated, and how can engineering, geographical, and geological data be stored in a retrievable fashion?

The federal government has always closely supervised offshore drilling and ensured that data generated are in the public domain. The branch of Energy, Mines and Resources Canada that enforces the regulations is the Canada Oil and Gas Lands Administration (COGLA). It controls and monitors offshore drilling, and curates well history reports and samples.

The samples from east coast wells are presently curated at BIO. These may be cuttings samples, sidewall cores, or conventional cores. Specialized biostratigraphic and lithostratigraphic studies are carried out on the well samples by AGC’s Eastern Petroleum Geology Subdivision. All company reports, samples, and processed material can be examined by the public at the end of the confidential period. This is 2 years in the case of wildcat wells. but only 90 days for a development well.

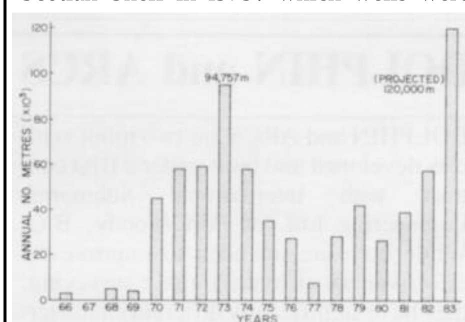
The increased drilling in recent years has resulted in a significant increase in well data. To cope with this. scientists and system analysts at the Atlantic Geoscience Centre developed WELLSYS, a computer file on all east coast offshore wells. The data management system used for WELLSYS is the user friendly System 2000.

Development of WELLSYS started in 1981. Well history reports on about 140 wells were abstracted and loaded into the data base. Added to this were all nonconfidential, internal reports produced by scientists in the Eastern Petroleum Geology Subdivision. Such reports include lithostratigraphic, biostratigraphic, and maturation (Vitrinite reflectance and visual kerogen) studies carried out over the last decade. Before WELLSYS, comparison of all these data would have been time consuming and impractical.

The WELLSYS data base must be continually upgraded and expanded to keep pace with new drilling. Since 1981 we have loaded data on another 35 wells and entered all the oil, gas, and condensate test figures, including all published information on Hibernia and Venture wells. We are now in a position to input data abstracted from scientific papers on the subsurface geology of offshore eastern Canada. The relevant information will be abstracted and loaded later in the next few years.

There are three classes of information in WELLSYS. One consists of basic information such as geographic and engineering data. The second class, interpretive information, is based upon scientific studies. Examples would include lithostratigraphy and biostratigraphy. The third class is the citation index. This includes all publications containing well data and provides an invaluable reference for further studies.

What can WELLSYS do for you and me? It will provide answers to such questions as: which wells were drilled on the Scotian Shelf in l979? which wells were



The annual footage is the best indication of drilling activity. Note that the high projections shown for 1983 are a result of the Venture and Hibernia finds.

drilled at what water depths on the Labrador Shelf? what wells have been drilled in water depths of more than 1000 m? It will allow collation and comparison of geological data. Without WELLSYS, it would take days to compile a list of all wells plus footages in which the Wyandot Formation is known to occur. Alternatively, we can find out where maturation levels are highest on the Scotian Shelf, or whether a particular zone is consistent in occurrence. WELLSYS can facilitate studies on basin evolution, and provide the impetus for maturation models of passive margins.

WELLSYS is not solely a research tool. It can answer questions of management on resource potential. It can assist regulatory bodies by providing information on test figures, correlation of known reservoir horizons, and comparisons of various maturation indicators. It can field questions from oil company geologists that presently demand laborious research. It can help university researchers who want answers on the subsurface geology. And it can help the layman who wishes to learn about the offshore.

CHAPTER 3

Designing Data Collecting Instruments

Because position fixes and numerical data must now be of an accuracy almost undreamed of only a few decades ago, the constant search for new techniques is inherent to all our activities at BIO. Some instruments and techniques are best developed in-house, subsequently to be manufactured commercially by Canadian industry, while others are best contracted out initially. In this chapter we discuss several new instruments being developed by both routes. We hope that this account will show the reader how instrumental 'state-of-the-art' must be a dynamic, rather than a static concept. It is no longer good enough - if we wish to make the best contribution possible to describing and understanding the ocean - simply to rely on off-the-shelf or turn-key data gathering instruments.

While no single institute can lead across the board in instrument development, BIO has always considered the invention of new techniques to be a central and important part of its role, and adequate resources have always been centralized in the Institute to ensure that this occurs. We hope that the few examples discussed in this chapter will serve to give the reader a flavour of the extent to which innovation is alive and well at BIO and illustrate that increasingly scarce resources are not wasted through continued dependence on inadequate instrumentation at sea.

DOLPHIN and ARCS

- A.J. Kerr

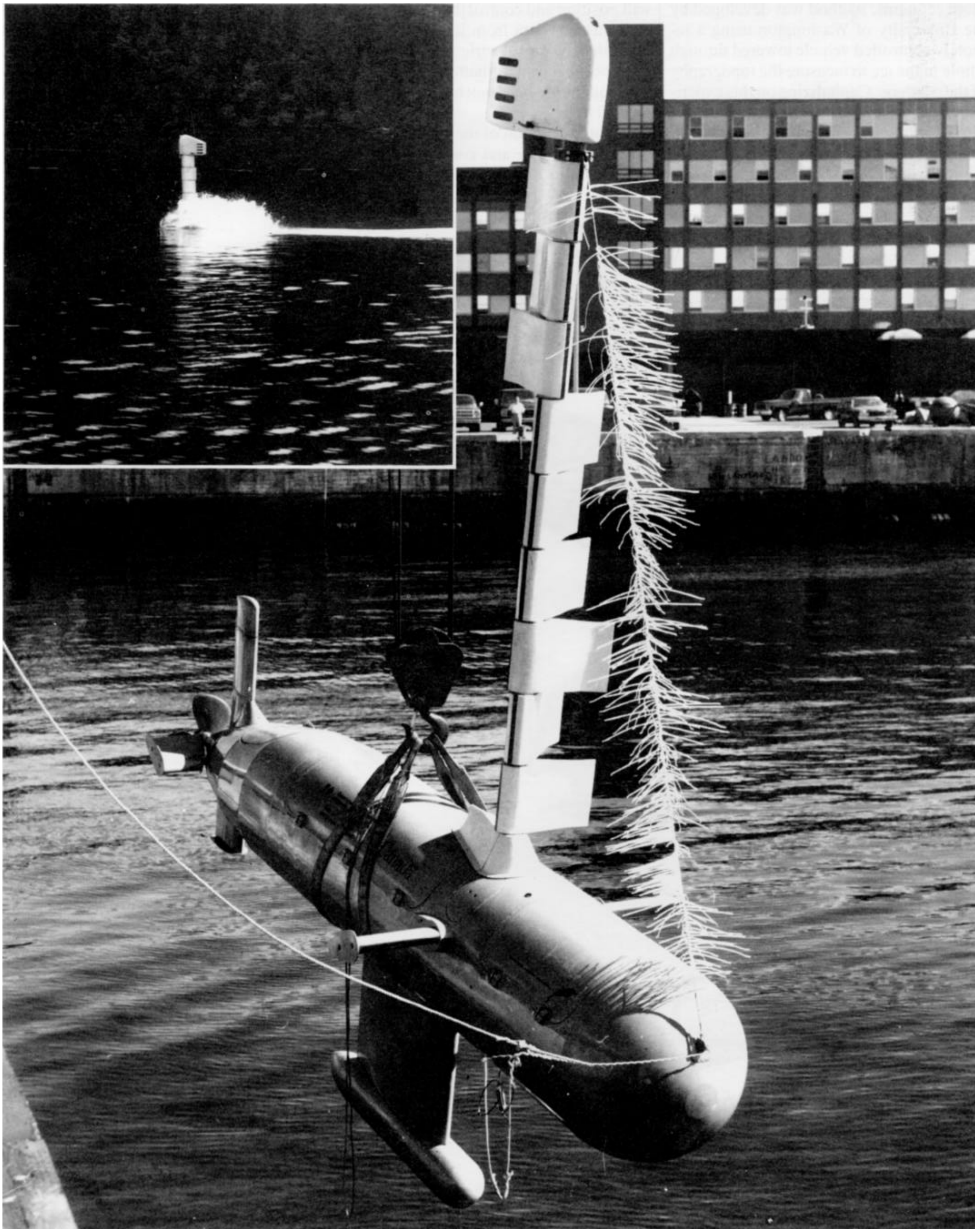
DOLPHIN and ARCS are two robot vehicles developed and built under a BIO contract with International Submarine Engineering Ltd. of Port Moody, B.C. While both are intended to improve the effectiveness of hydrographic surveying, they have significantly different characteristics.

DOLPHIN (Deep Ocean Logging Profiler Hydrographic Instrumentation and Navigation) is designed to operate on Canada's Atlantic continental margin. This margin is one of the largest in the world: it needs to be systematically surveyed not only as a basis for navigation, but also to help plan routes for transporting petroleum resources ashore and to assist fishermen. Currently, the area is surveyed by running parallel profiles across the margin at intervals of 8 to 32 km using a large and costly survey vessel. With DOLPHINs, several robot vehicles can be equipped with echo sounders and run on courses parallel to a large vessel. In this way, a large area of seafloor can be charted in one pass of the ship.

These robot vehicles are 7 m long and torpedo shaped with a snorkel that extends above the water surface. The snorkel provides combustion air to the diesel engine that powers each vehicle. To overcome problems of wave motion while sounding in rough seas, DOLPHINs are run 2 to 3 m deep, and a radio link from the parent vessel controls the vehicles. Probably the most significant hurdle to overcome in building DOLPHIN was the hydrodynamic difficulty of propelling such long vessels underwater at speeds of up to 14 knots.

ARCS (Autonomous Remote Controlled System) is being designed for use in the Arctic where the sea is frozen for most or all of the year and ice is commonly 2.5 m thick. Large hydrocarbon deposits that could be exported by either ship or pipeline have been found in these areas. As no survey ship or even Coast Guard icebreaker is capable of operating there, it has been necessary to develop new technology.

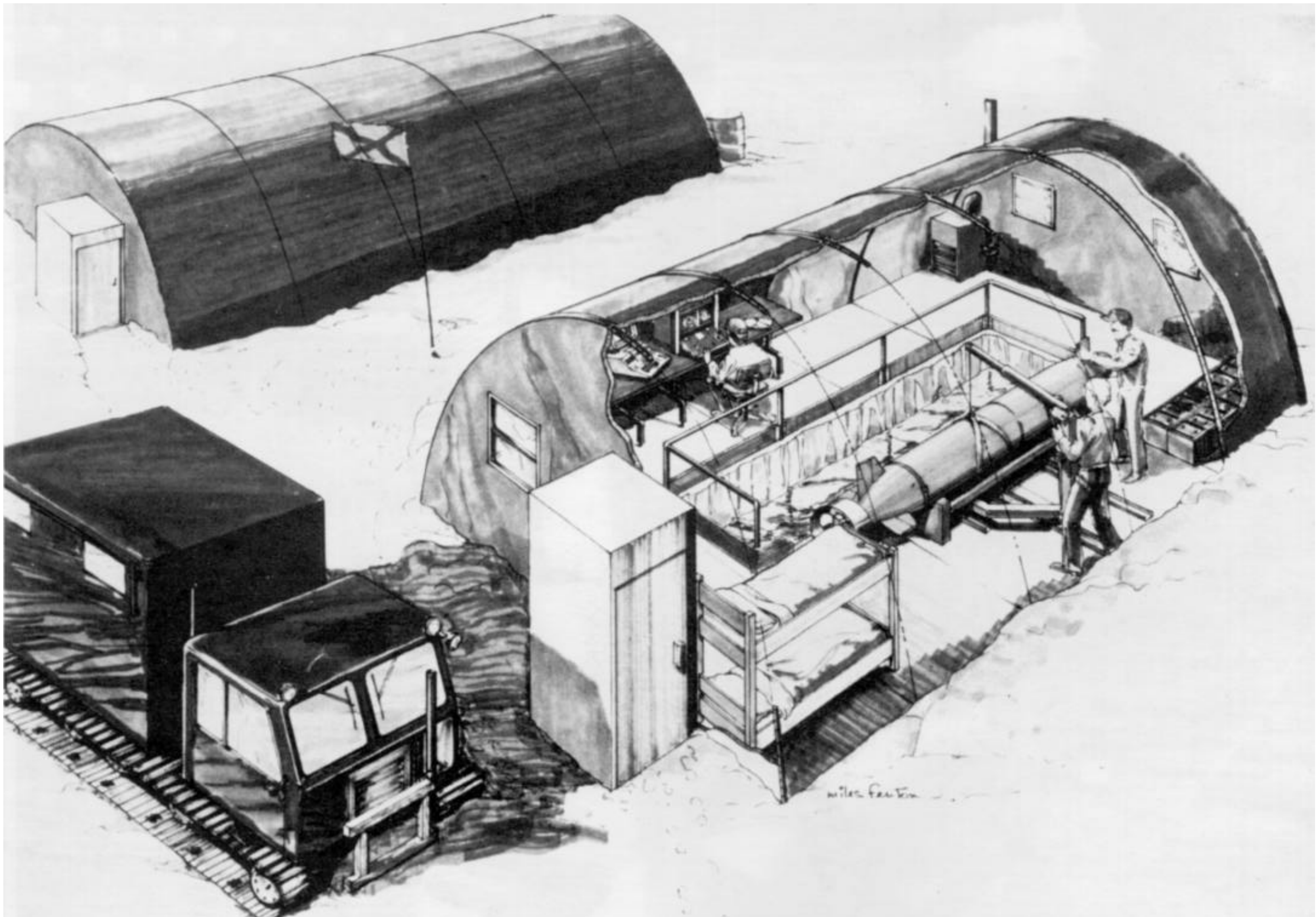
Current methods of echo sounding through the ice can only take depth measurements at discrete points. Accurate descriptions of seafloor topography, however, require continuous profiles. Nuclear submarines travelling beneath the ice could do this, but they are costly to run. A

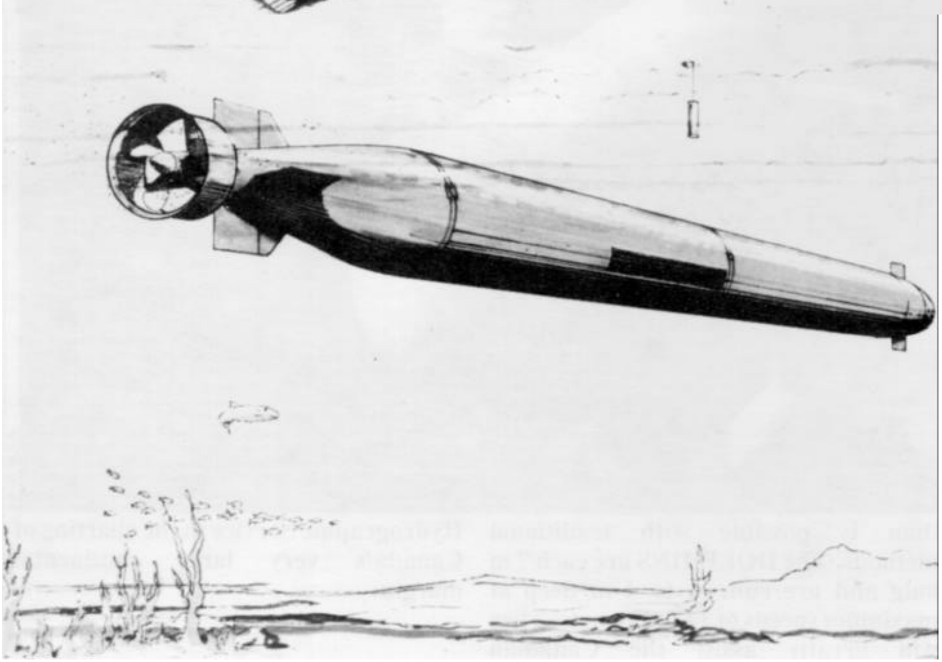


By running as many as six DOLPHIN radio-controlled vehicles equipped with echo sounders on courses parallel to a large survey vessel, hydrographers can chart a much larger area of seafloor than is possible with traditional methods. The DOLPHINS are each 7 m long and are run up to 4 m deep at maximum speeds of 14 to 15 knots. They will greatly assist the Canadian Hydrographic Service in the charting of Canada's very large continental margin.

more economic method was developed by the University of Washington using a remotely controlled vehicle lowered through a hole in the ice to measure the topography of the seafloor. Capitalizing on this experience, the ARCS vehicle will also be deployed through a hole in the ice and will run a parallel survey pattern over an area of approximately 8 km^2. An acoustic system will position and control the vehicle and as well monitor data from it. ARCS will be propelled by an electric motor powered by nickel-cadmium batteries and will consequently be much slower than DOLPHIN.

The transmission of the acoustic signals that will navigate and control ARCS is a key factor in the system's development. This transmission is likely to be very difficult since the signals will be scattered as they reflect off the irregular ice surfaces. For operation, the vehicle will be transported to the survey site by aircraft in several sections. Researchers will bolt it together on site. and deploy it through a man-made hole in the ice.





The ARCS vehicle will provide continuous echo sounding profiles of the ocean bottom below ice covered waters. Flown to a survey site in several sections, the vehicle will then be assembled and lowered through a man-made hole in the ice as depicted above. Once below the ice, the ARCS vehicle will be controlled from the surface by an acoustic system that will also guide it along a parallel survey pattern over an area of about 64 km^2. ***(Drawings by Miles Fenton.)***

Seabed II

- G.B. Fader

Roger Belanger

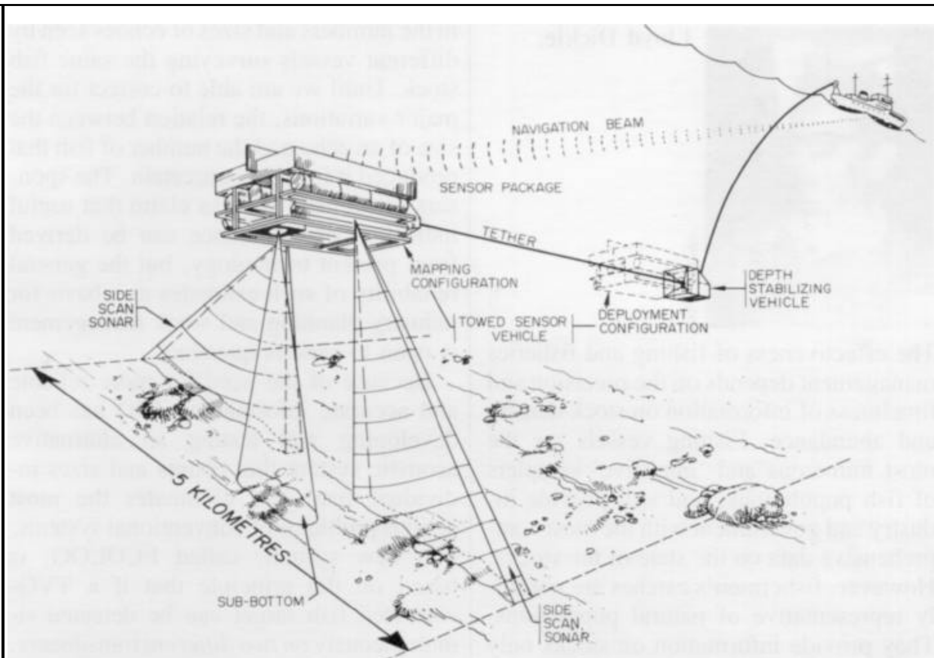
Gordon Fader.

Towfishes have been designed to carry sophisticated electronic equipment that helps chart the ocean floor and provides data on what lies underneath. The towfish Seabed 1, developed by the Department of Energy. Mines and Resources and Huntec ('70) Ltd. of Toronto, pioneered the use of acoustic remote sensing for analyzing the composition of seafloor sediments. It produces high resolution seismic reflection pictures of the ocean floor and subfloor and information on sediment characteristics. The system operates in water depths of up to 300 m, and is now used routinely in geological, geophysical, and seabed engineering studies.

Seabed II is a 5 year project to produce a new generation submersible capable of operating at greater depths and ranges than Seabed I. With it, marine geologists will be able to study the geology of the deeper areas of the continental shelf, continental slope. and the deep ocean.

Seabed II will be equipped with side-scan sonar capable of measuring seabed characteristics up to 2.5 km on either side of the towfish. A 'boomer' will send sonar signals directly downward and provide information on sediment characteristics. A track recovery system will measure the position of the towfish relative to the ship to ensure accurate readings. Once in the water, a winch system on the towfish will allow the instrumented section of Seabed II to separate about 90 m from a weighed front section. This two-section configuration will help maintain the towfish in proper orientation and provide suitable stability. Data will be sent along the tow cable to the ship and will be processed by an onboard computer.

The project, jointly funded by the National Research Council and the Department of Energy, Mines and Resources will cost 5.5 million dollars. The departments of Energy, Mines and Resources, Fisheries and Oceans, and National Defence as well as the National Research Council of Canada are supporting the project with technological and scientific guidance and project management. The Department of Fisheries and Oceans is providing ship time for system evaluation and testing.



A schematic depicting the principle of operation of the two-stage Seabed II integrated mapping system.

Huntec ('70) Ltd. will design and build two systems: a slow speed deep ocean (2000 m) system and a higher speed shallow water (500 m) one. For the deep ocean system, novel approaches such as the two-stage integrated towed body and a pressure-compensated boomer (seismic sound source) are integral parts.

Seabed II will provide information on sediment type and distribution, seabed stability, and seabed morphology. Such data will enhance our understanding of the ocean floor's geologic history and of the processes acting upon it. Detailed maps of various sediment parameters, and of bedforms, morphology, stability, and seafloor hazards may be produced from the data collected. This data base will enable us to advise industry and government on activities such as the laying of pipelines, mineral exploration, waste disposal. danger from seismic activity, and defence intelligence.

The first tests of the 2000 m system were conducted from the C.S.S. *Hudson* on the edge of the continental shelf off Nova Scotia in July 1983. Further test cruises of the deep and shallow systems are scheduled for 1984.

The Seabed II system during its first sea trials in July 1983.

Acoustic analyses of fish populations

- L.M. Dickie

Lloyd Dickie.

The effectiveness of fishing and fisheries management depends on the precision and timeliness of information on stock density and abundance. Fishing vessels are the most numerous and 'intensive' samplers of fish populations, and still provide industry and government with the most comprehensive data on the state of the stocks. However, fishermen's catches are not fully representative of natural populations. They provide information on stocks only after these have been fished. With the current high catch rates, it has become necessary to develop more direct methods. Industry now maintains increasingly detailed records of catches and government has begun to supplement their data with fisheries surveys conducted from research vessels. The effectiveness of these data, however, would be remarkably enhanced if echo sounding records could be substituted for the actual catching of fish.

Commercial fishing operations and research vessels already use echo sounders and fish sonars to help locate fish concentrations. Companies in Norway, Germany, Japan, England, USSR, and France manufacture equipment, and almost every fishing vessel in the world longer than 12 m has at least one echo sounder on board. In addition, the Simrad company of Norway has developed a special line of echo-sounders for use on scientific surveys. Scientific survey ships from many countries have employed them in experimental 'echo-sounder' fisheries surveys throughout the world.

There are nonetheless serious problems with present-day echo-sounder systems that limit their usefulness. The most serious is the high variability in the strength of echoes returned from a fish target. A small fish gives a weaker echo than a large one. Any fish at the centre of the sound beam gives a much stronger echo than a fish at the edge. Target strength variations with depth are now routinely compensated for by electronically controlled time-varied gain (TVG), but other sources of variation are less easily handled. Large differences seem to occur in the numbers and sizes of echoes seen by different vessels surveying the same fish stock. Until we are able to correct for the major variations, the relation between the size of an echo and the number of fish that produced it is highly uncertain. The sponsors of acoustic surveys claim that useful indicators of abundance can be derived from present technology, but the general reliability of such estimates as a basis for industry planning and stock management is open to serious question.

Because of the need for more reliable and accurate information, BIO has been developing and testing an alternative acoustic system that counts and sizes individual fish, and eliminates the most serious problems of conventional systems. The new system, called ECOLOG. is based on the principle that if a TVG-corrected fish target can be detected simultaneously *on two different* transducers. the effects of a fish's position in the beam on the echo can be eliminated. For this purpose, a special transducer arrangement was commissioned from Ametek Straza; it consists of two precisely aligned transducers, one inside the other. The inside or central transducer operates over a relatively wide sound beam, while the outer transducer ring receives signals from only a narrow 'inner' beam. A target within this inner beam is recorded by both transducers, but as the object occurs at greater distances from the common axis the returned echo falls off more quickly for the narrow than for the wide beam. A central region of the dual beam is chosen such that for any object the ratio of the two signals is constant, irrespective of beam position. Differences in the ratio may then be interpreted directly in terms of the size of the target. By eliminating positional echo variation such a system permits us to study the relation of the remaining variations to fish size.

In addition, we have carried out laboratory experiments to examine the effects of behaviour and density on apparent target strength. Initially, acoustic calibration of fish targets used devices for artificially tethering fish in the sound beam or used dead fish. The resulting echoes were highly variable. In Dalhousie University's (Halifax) aquatron, we have observed single fish and fish schools swimming naturally under a floating transducer. Our low variances in repeated signals from the same fish suggest that the high variability encountered earlier was largely due to the technique used by researchers.

During the past 3 years, we have been field testing the dual-beam transducer as part of an echo sounding and recording system designed primarily for research and fish inventory applications. To eliminate effects of the ship's motion and noise on the echo strength, the transducer is suspended over the side of the vessel in a special deep-diving towed body designed and built by Fathom Oceanology. The suspension employs a winch and slip-ring electrical connector assembly specially built for the unit by the Nova Scotia Research Foundation Corporation. We generate acoustic pulses from a commercial transmitter and receive them on a TVG receiver specially designed and built at BIO. Signals are processed by a microprocessor-based data acquisition system built jointly by BIO staff and a local company. This unit samples signals more precisely than commercial equipment, and allows us to interpret and record on digital tape detailed echo data from each signal transmission. Analytical computer programs written by BIO staff feed the taped data directly into the BIO computer and read the processed signals for the size, depth, and position of each fish target encountered on the survey cruises.

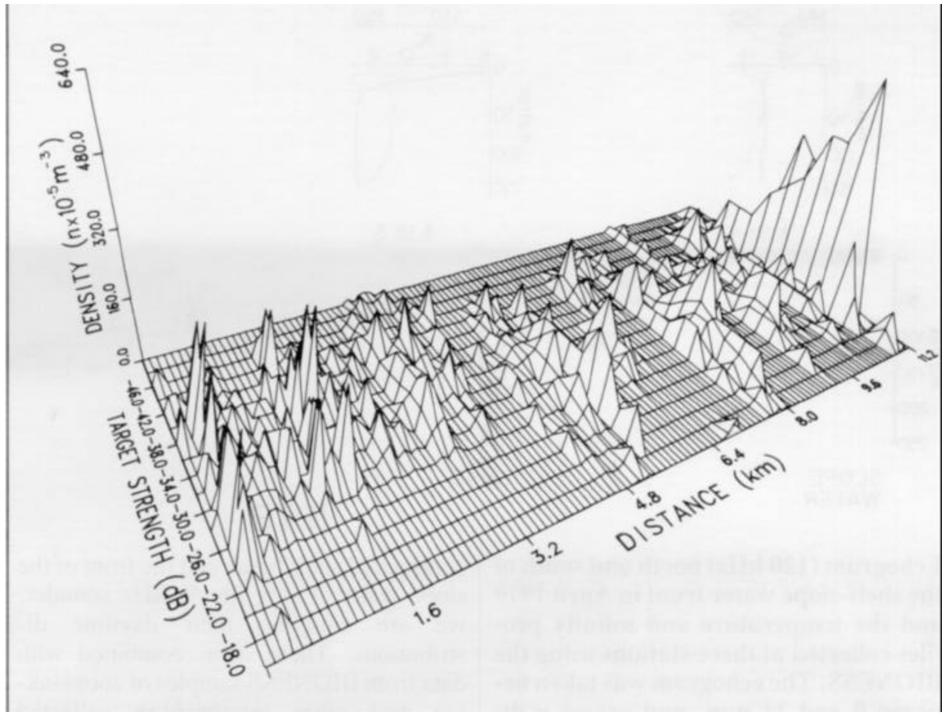
The sample of processed data output shown in the accompanying diagram gives the size-frequency of single fish echoes obtained in the 3 m bottom layer of water of each 100 m section of an 11 km transect. This transect was run in 70 fathoms of water southeast of Brown's Bank in February 1982. Otter-trawl tows showed that the catch was dominated by a single species - haddock - and that our acoustical estimate of fish density and size composition agreed well with samples of fish caught in the same area.

Further cruises are being undertaken to provide better estimates of the precision of this new system, and additional laboratory tests in the Dalhousie aquatron are planned to help with fine-tuning of the echo signals and the computer processing techniques.

Some problems remain. On the scientific side, for example, the transect data shown in the figure are for relatively large haddock at a depth of 70 m. Since commercial catches made in the area corroborate our results, we feel confident the equipment is satisfactory for surveys of large fish. Without further trials though, we cannot be sure the system will be satisfactory for the higher densities that occur with small fish.

The operational reliability of the system, and the quality of the data are highly satisfactory. This suggests that, in addition to providing better inventory data, ECOLOG could offer improved estimates of local densities and sizes. Such information would help researchers with their sampling work and fishermen to better estimate catchable densities of fish. But for more general applications our system would require further development.

The information output is now being simplified to permit more effective shipboard usage. It should be possible to adapt the system for use in electronically stabilized hull-mounted transducers, which would likely make it more effective on commercial and survey vessels.



The density (numbers per 10,000 cubic metres of water) of different sizes of fish reflected in different target strengths at 100 m intervals along an 11 km transect south of Brown's Bank off Nova Scotia. The density has been calculated from fish echos recorded on ECOLOG from the bottom 3 m of water. Sampling with nets showed that the fish were almost entirely haddock.

Measuring plankton and micronekton distributions acoustically

- D.D. Sameoto

Doug Sameoto.

Roger Belanger

The Marine Ecology Laboratory has been using high frequency (120 kHz) acoustic sounders to locate and map distributions of zooplankton and euphausiids since 1971. The acoustic methods were developed because of the severe limitations of net sampling methods in estimating euphausiid biomass. The euphausiids easily avoided the standard ring nets we used at the time, so we greatly underestimated their biomass.

Our first acoustic studies were carried out in the St. Lawrence estuary where large concentrations of euphausiids are associated with the Gaspe current during the early spring and summer. Using acoustic means to locate the concentrations and nets to sample them, we found the highest concentrations of euphausiids in regions with the highest concentrations of chlorophyll *a*.

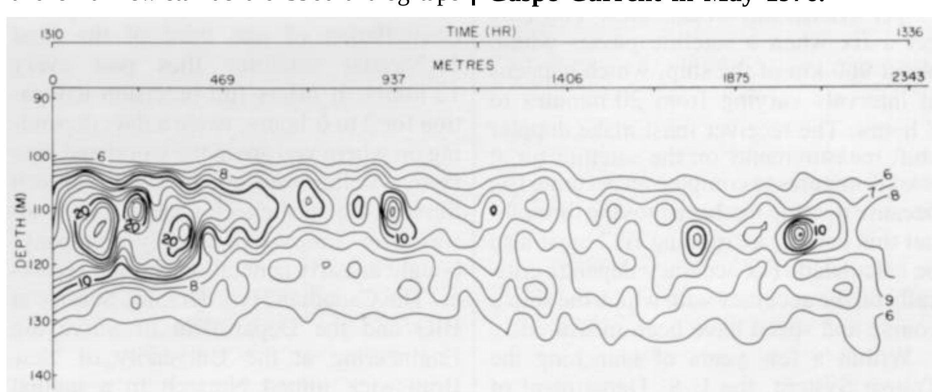
With the development of the BIONESS (described later in this chapter) we could collect many euphausiid samples and also record acoustic signals from the collection area. We could then quantify the density and biomass of the euphausiids from the acoustic data, and thus accurately map the concentrations of euphausiids and estimate their frequency and size.

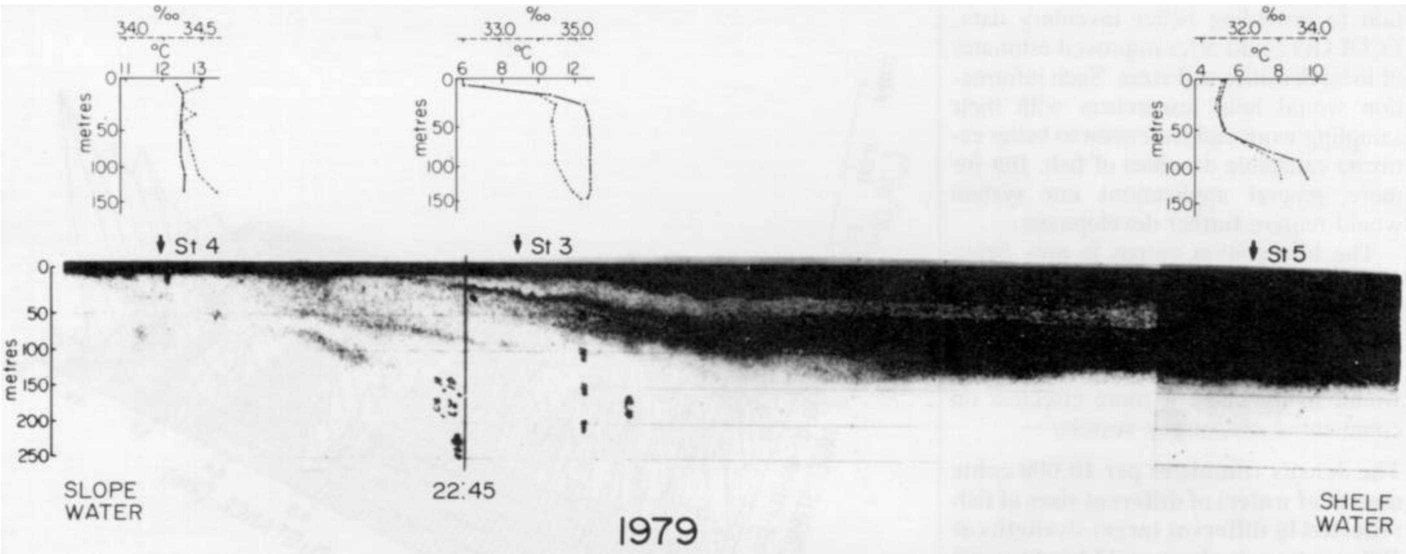
The acoustic system includes a vehicle containing transducers. It is towed from a crane on the ship's side and lowered to the desired depth by a small winch on the crane. The depth of operation normally varies between 3 and 5 m. but can go as deep as 100 m.

The sounder currently used is the Datasonics Model DFS-210 Dual Frequency System. which simultaneously operates at frequencies of 120 and 50 kHz. The returning acoustic signals are recorded on two EPC model 1600 graphic recorders and on a Hewlett Packard 3960 analog tape recorder. In addition, the signals are digitized and recorded on a nine track tape by a Hewlett Packard 21 MX/F computer. The effective operating range of the 120 kHz frequency is 3 to 300 m, and of the 50 kHz frequency, 5 to 600 m. With these two frequencies, we can locate concentrations of zooplankton and micronekton in the upper water column (top 200 m) as well as concentrations of mesopelagic micronekton at depths to 600 m.

The present research emphasis is on the vertical distribution of zooplankton and mesopelagic fish in the shelf water region of the Nova Scotia slope. High night-time concentrations of the mesopelagic fish,

Contours of the wet biomass of euphausiids (in grams per cubic metre) in the acoustic scattering layer of the Gaspe Current in May 1976.





Echogram (120 kHz) north and south of the shelf-slope water front in April 1979 and the temperature and salinity profiles collected at three stations using the BIONESS. The echogram was taken between 9 and 11 p.m. and covers a distance of about 20 km.

Benthosema glaciale, have been located in this region. Acoustic soundings show they are confined to the shelf water between the continental shelf break and the front of the slope water. Using the 50 kHz sounder, we are studying their daytime distributions. These data, combined with data from BIONESS samples of zooplankton and other micronekton collected simultaneously, will provide information on their densities at various depths and their associations with other forms of micronekton and zooplankton. In addition, the biological samples will give information on the size distribution of B. *glaciule* and other organisms that scatter acoustic signals. This in turn, with density estimates, will permit calculation of their acoustic target strengths. By knowing the target strengths of the dominant micronekton species, we can estimate the biomass of these animals from acoustic data alone.

Navstar - A global positioning system

- R.M. Eaton

When Transit Satellite Navigation came in during the late sixties, it was probably the greatest step forward in ocean navigation since John Harrison perfected his chronometer in 1759. Here was a navigation system ten times more accurate than the best star-sight: it fixed your position to within 120 m every hour or so, anywhere in the world, and regardless of the weather. Now we could do many things we could not have considered before, such as survey seabed features or sample at 100 m intervals. We could also lay instrument moorings on Flemish Cap. 480 km east of St. John’s, Newfoundland, and recover them 6 months later with virtually the same accuracy that we know our position going through the narrows of St. John’s Harbour itself.

Yet Transit has weaknesses. You only get a fix when a satellite passes within about 960 km of the ship. which happens at intervals varying from 20 minutes to 8 hours. The receiver must make doppler shift measurements on the satellite for at least 8 minutes to compute an accurate fix; because the ship has been moving throughout this period, a “running fix” must also be calculated. Fix accuracy depends critically on the accuracy with which the ship’s course and speed have been measured.

Within a few years of launching the Transit System, the U.S. Department of Defence was working on a better satellite navigation system: NAVSTAR - GPS (Navigational Satellite Timing and Ranging - Global Positioning System). By the late seventies. reports circulated that an accuracy of ± 10 m had been achieved in initial tests of the new system, and people returned from navigation workshops and conferences wearing buttons proudly proclaiming that “Navstar is coming”. Now we know that this jubilation was a little premature. Navstar will be fully operational around 1989, giving continuous and worldwide fixing; but at this stage, because it is a military system, the accuracy for civilian users (and, of course, the enemy) will be reduced by 500 m. or less, depending on security considerations.

Meanwhile, a test and development constellation of one third of the final 18 Navstar satellites flies past every 12 hours. It offers full precision navigation for 2 to 6 hours, twice a day, depending on where you are in the world and how many satellites are up. In 1980, Nortech Surveys (then Sheltech Canada Ltd.), always an innovative survey company, bought an early generation Navstar receiver. The Canadian Hydrographic Service at BIO and the Department of Surveying Engineering at the University of New Brunswick joined Nortech in a mutual effort to introduce Navstar fixing for marine surveying and science as soon as possible. This early receiver, a Stanford Telecommunications Inc. (STI) 5010. takes several minutes to cycle between the three satellites required for a fix, and so, like the old transit system, it is fed ship’s velocity from BIO’s integrated navigation system to compute a “running fix”. Its first test at sea was in November 1981. By June 1982, the STI receiver was giving 50 m positioning accuracy, as good as the accuracy of Loran-C, the standard coastal navigation aid. In a November 1982 comparison against the 15 m accuracy of the Mini-Ranger, Navstar showed a ± 30 m accuracy. Nortech is currently buying new, fast-cycling, Texas Instruments 4100 receivers, which should improve the accuracy of the two sea tests planned for 1983. By summer 1984, we may be surveying northern Baffin Bay by Navstar with an accuracy of ± 20-30 m for two 6 hour periods per day.

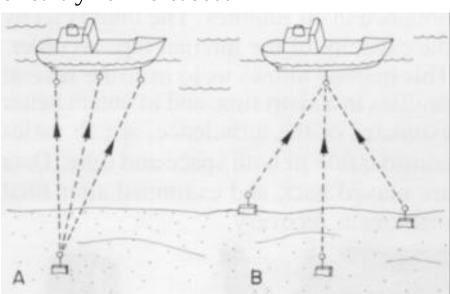
Acoustic positioning developments

— D.L. McKeown

Ocean engineers and scientists need to know the exact location of oceanographic instruments relative to a fixed point or a research vessel. This information helps engineers to describe the behaviour of instruments being developed and scientists to locate sample sites precisely.

Conventional positioning methods such as Loran-C or radar) employ electromagnetic waves that cannot be used below the sea surface. Sound, however, propagates well through water. We therefore embarked on a program to develop or require relatively unsophisticated positioning systems based on acoustic waves.

There are two basic schemes for creating an underwater acoustic positioning system. For ship referenced systems, a single device on the seafloor (or towed by the ship) emits an acoustic signal. Its position with respect to the ship is determined by measuring the difference in the signal's arrival time at three or more hydrophones spaced some 10 to 20 m apart on the ship's hull. This arrangement is called a short baseline system. A variant of this is the ultra-short baseline system where the spacing between the hydrophones is reduced to a few centimetres. but the complexity of the associated signal processing circuitry is increased.



Configurations of the ship-referenced (a) and bottom-referenced (b) acoustic positioning systems.

The alternative scheme. a bottom referenced system, uses an array of acoustic sources on the seafloor separated from one another by hundreds or thousands of metres. The position of the ship (or any other device) is determined with respect to these seafloor markers by measuring transit times from the acoustic devices to the ship. This configuration is called a long baseline system.

Until quite recently, all short baseline and many ultra-short baseline systems were 'home made' - that is, they could not be bought as a complete system. At BIO we developed a short-baseline system for the C.S.S. *Hudson* to help hold it on sta-. tion while obtaining seafloor core samples. This system is now used extensively by the Atlantic Geoscience Centre and Dalhousie University in their geological sampling programs. We also developed a portable variant of this system first used in 1973 to position a manned submersible involved in the recovery of a sunken helicopter off Halifax Harbour.

Dave McKeown.

Roger Belanger

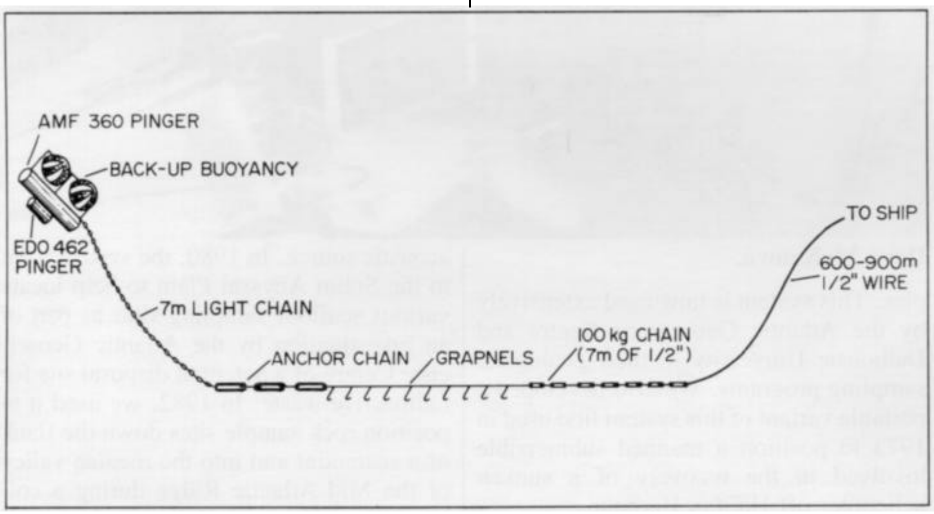
We are presently looking for a commercial ultra-short baseline system to replace our existing short baseline one. The advantages of ultra-short baseline systems are ease of maintenance and operation and portability.

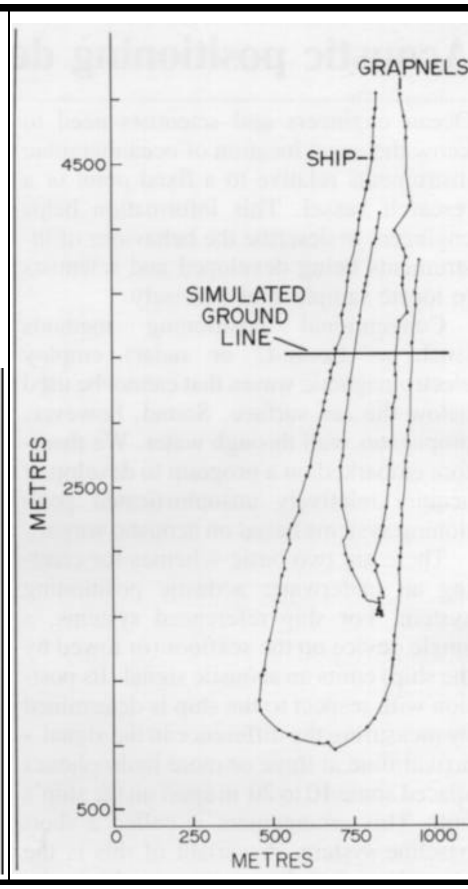
While developing our ship referenced system, we have been putting together a bottom referenced or long baseline system. The emphasis here has been on purchasing available hardware compatible with other BIO equipment. As a result, our long baseline system utilizes the same acoustic transponders as we use for current meter moorings. Aboard ship, much of the acoustic equipment is again the same as that used in the mooring operations, and is interfaced to the standard shipboard computer rather than to a computing unit of its own. We have tried to design a system that is easily operable by end users at the Insititute rather than one restricted to specialists in acoustic navigation. We have succeeded in producing hardware and a positioning methodology that meet this criterion, but the positioning software must be revised to make it more 'user friendly'.

The long baseline system has been employed in a variety of operations in the last few years. In 1978, we used it to position a remotely controlled seafloor vehicle designed to measure the oil remaining in the tanks of a sunken oil barge. In 1979, we obtained continuous current profiles to a depth of 5,500 m by tracking a free-falling acoustic source. In 1980, the system went to the Sohm Abyssal Plain to help locate various seafloor sampling sites as part of an investigation by the Atlantic Geoscience Centre of a potential disposal site for radioactive waste. In 1982, we used it to position rock sample sites down the flank of a Seamount and into the median valley of the Mid-Atlantic Ridge during a collaborative effort with Dalhousie University.

The equipment has, in addition, been employed since 1981 to investigate the behaviour of certain current meter mooring recovery equipment. When moorings are laid on the continental shelf, a long length of buoyant rope is attached to the anchor, stretched out across the seafloor, and secured to a second anchor. If the release mechanism on the mooring fails to operate when commanded, the ship deploys a dragline consisting of a length of cable, a weight. and some grapnel hooks and tows this back and forth until it snags the rope. In an effort to quantify the behaviour of the drag and to understand its behaviour so companion deep-water recovery techniques can be developed, we added an acoustic pinger to the end of the grapnels. The long baseline system was used to monitor the position of the grapnels and ship during several passes across a simulated ground line. The accompanying figure is indicative of the information obtained on one such pass. In this case, it is apparent that the grapnels towed about 50 m to starboard of the ship. When the ship proceeded through a 180° turn, the grapnels remained stationary on the bottom from about minute 147 to minute 160 and did not settle down again behind the ship until minute 170. We are presently making arrangements to develop deep water mooring recovery technology with a local engineering consulting firm. Our acoustic positioning expertise will be an important component in this endeavour. Since deep water moorings can cost $50,000 or more and contain invaluable data, it would take few successful recoveries to offset development costs.

If the release mechanism on a mooring fails to operate when commanded, the ship deploys a dragline with the configuration shown below and tows this until the grapnels snag the current meter mooring's ground line. The pinger was added to the configuration to investigate the behaviour of the dragline during the operation. A long baseline system was used to monitor the position of the grapnels and ship during several passes across a simulated ground line. Shown in the right figure are the track of the ship and grapnels during two such passes across a simulated ground line.

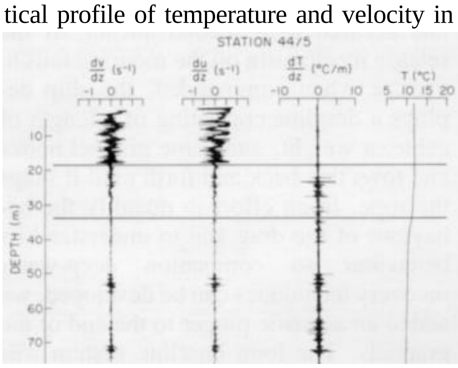




Near surface turbulence measurements

- N.S. Oakey

As oceanographers developed new techniques to measure temperature, salinity, and velocity they found that these quantities were extremely variable. The accompanying figure shows a typical vertical profile of temperature and velocity in the upper 70 m of the ocean. The temperature is relatively uniform near the surface in the surface mixed layer, which overlies the colder waters below. However. if we examine our temperature records more closely. we find considerable changes in temperature over very small vertical scales. At the same time, turbulent velocity measurements show large fluctuations. A simple description of these observations is as follows. Surface winds interacting with the ocean transfer energy to waves and surface currents: this energy stirs the mixed layer, and generates a wide range of sizes of turbulent eddies that mix warmer, lighter water from above with colder, heavier water from below. When a sensitive instrument is dropped through this turbulent field, we are able to examine this fluctuating velocity field and see the alternate warmer and colder filaments produced in the mixing process. These studies yield fundamental information about the mixing of heat, salt, and nutrients in the upper ocean.



A typical microstructure profile obtained with OCTUPROBE (during the JASIN experiment in this case). The turbulent velocity structure (dv/dz and du/dz) is shown at the left: the temperature profile (T) is shown to the right along with the corresponding temperature gradient (dT/dz).

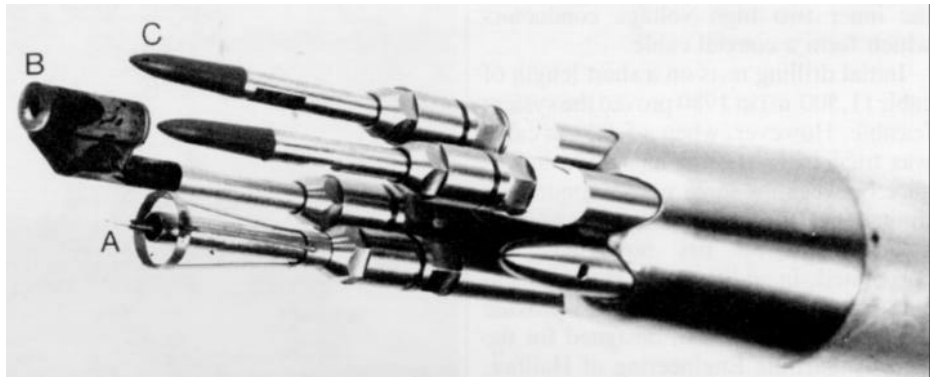
One such instrument, the OCTUPROBE (Oceanic Turbulence PROBE), which is approximately 2 m long, measures and records temperature and temperature gradient, velocity and velocity shear. pressure, instrument tilt. and other instrument diagnostic variables. Data are recorded internally on a magnetic tape recorder. OCTUPROBE free-falls through the water at a speed of approximately 0.5 ms^{-1} trailing a nearly neutrally buoyant nylon line. When the required deployment depth is reached. the instrument is pulled to the surface and another profile is commenced. In this tethered-free-fall method, 5 to 7 profiles to a depth of 100 m can be obtained in 30 minutes. The limit is set by the capacity of the internal tape recorder. This method allows us to measure several profiles in a short time and to obtain better estimates of the turbulence. which varies considerably in both space and time. Data are played back and examined after final

The OCTUPROBE being deployed from the C.S.S. *Dawson* during a recent study of the spatial variability of turbulence in the mixed layer.

Temperature gradients are measured using a platinum thin-film thermometer, which, with special electronics, can measure fluctuations of 0.05°C with a spatial resolution of less than 0.5 cm. Sensors to measure turbulent velocity fluctuations at sea have been developed at BIO in parallel to developments by scientists in other institutions. These 'Lift Probes' are able to measure turbulent velocity fluctuations of less than 1 mm s^{-1} with a spatial resolution of about 2 cm, which is adequate for all but the most turbulent regimes in the ocean. The "Lift Probes" are constructed with a flexible axially symmetric rubber tip covering a crystal sensor. As the probe drops through the water, turbulent flow causes a lift (similar to that on the wing of an airplane), which is sensed by the crystal. The amplified sensor output is a varying voltage proportional to the time varying turbulent field.

Within the last year, a new profiler, known as EPSONDE, has been developed with improved characteristics. EPSONDE uses the same sensors as OCTUPROBE and similar signal processing electronics, but has additional electronics to telemeter the data to the surface. EPSONDE is deployed using the tethered-free-fall technique, but the tether line also serves as the telemetry link to the ship. EPSONDE has the facility to multiplex and submultiplex 23 data channels and convert them to digital format at sampling speeds from 256 Hz to 32 Hz; these data are sent to the surface at a bit rate of 38.4 kHz. Data received on board ship are processed to monitor the instrument's performance and recorded on nine-track digital tape using an HP 21MX computer. This new generation of turbulence-measuring instrumentation has improved signal-to-noise ratio and greater flexibility than OCTUPROBE.

Over the past few years, OCTUPROBE has been used extensively in a variety of different studies of the mixed layer turbulence. Some of the highlights of these efforts are as follows. In an experiment near Emerald Basin on the Scotian shelf. the turbulent energy dissipation averaged over the mixed layer was measured for a period of a week in winds up to 20 ms. The dissipation of turbulent energy into heat was found to be strongly correlated with the wind speed. During the Joint Air Sea Interaction experiment. the intensity and characteristics of the temperature microstructure were compared to those expected from theory for the intensity of the simultaneously measured turbulence. The results were used to compute the efficiency of mixing. Future experiments using these instruments will include studies of the spatial and temporal variability of turbulence, the relationship of the turbulent mixing to biological productivity, and further investigation of the physics of mixing processes.



The microstructure sensors used on OCTUPROBE are shown: (A) the thin-film sensor used to measure temperature microstructure; (B) the conductivity sensor; and (C) two lift probes used to measure two perpendicular components of velocity microstructure or turbulence.

Power transmission in the deep ocean

- G.A. Fowler

George Fowler.

While the advent of low power electronics and accurate sensors has dramatically increased our ability to make sophisticated measurements, our sampling capabilities have not undergone the same revolutionary growth. This is because considerable power is required to collect samples from the deep ocean and the ocean floor. The difficulty of transmitting power over long distances has hampered the development of sampling equipment.

Traditionally, power has been supplied by stored energy systems such as batteries or various types of springs in conjunction with ingenious electromechanical actuators. These energy systems accomplished the desired tasks, but their power capability was limited.

For applications requiring considerable power, we can take advantage of the force of gravity (as in various types of corers) or hydrostatic power (used on the BIO hydrostatic rock core drill). However, for applications requiring power over an extended period with some measure of control - such as drilling rock samples-power must be supplied from the surface vessel. In deep water, the only practical power system is electricity. For continental shelf depths up to 600 m. it is possible to run 575 V deep well pump motors using a separate load line and umbilical cable for power and control. But beyond these depths, handling becomes a severe problem, and losses from electrical resistance degrade the power transmitted dramatically. Larger conductors could be used, but the best way of reducing losses is to increase the supply voltage. This makes power transmission more efficient and allows the conductor to be smaller and lighter.

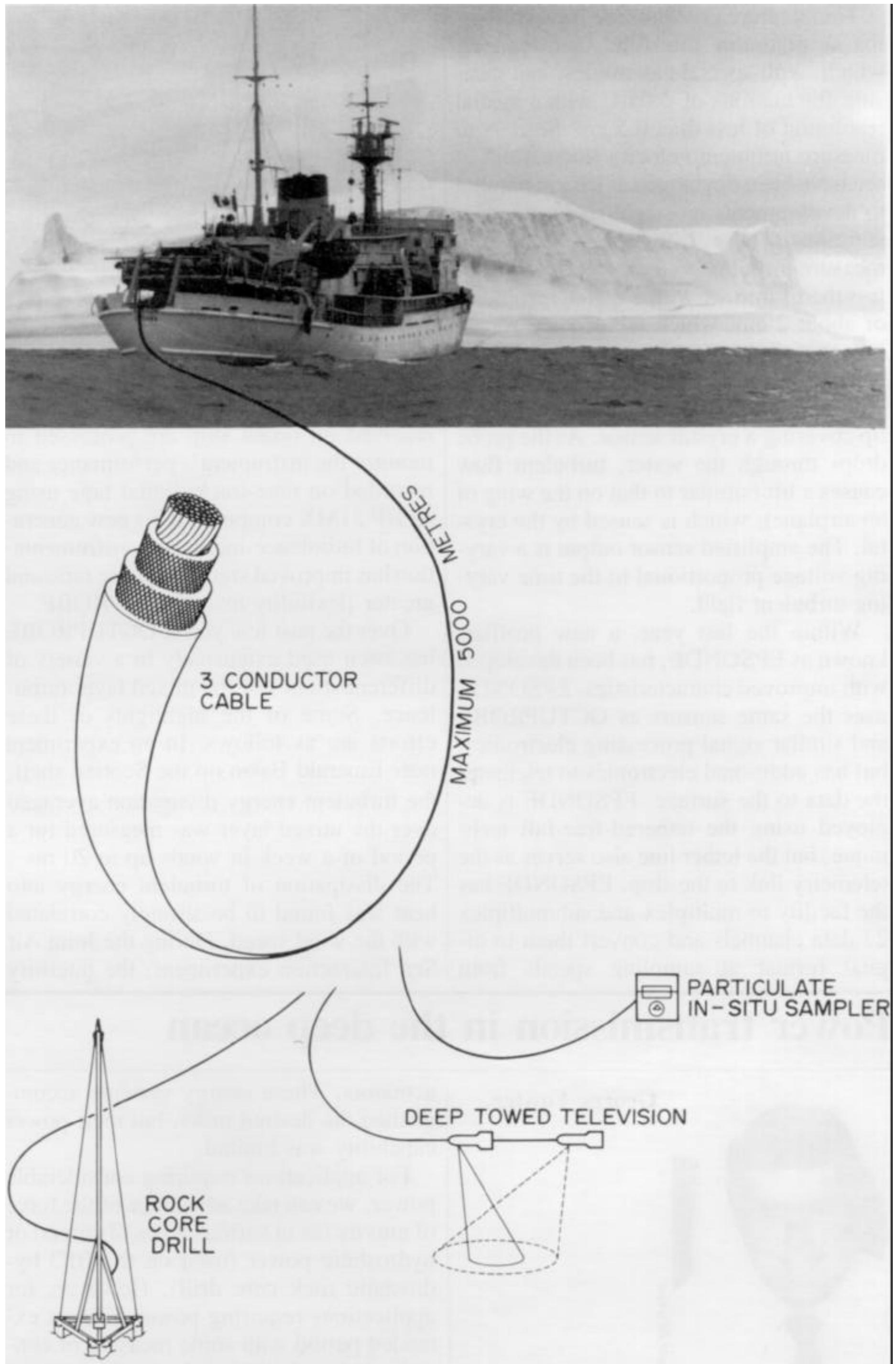
Such an alternative was chosen to power the BIO rock core drill, now being re-engineered by Dalhousie University and the Atlantic Geoscience Center to operate in mid-ocean ridge depths of up to 3,500 m. While the decision to go to a high supply voltage of 2,400 V was an easy one, its application at sea is not. Fortunately, commercial electric motors and connectors are now available to operate at the desired voltage and depth. The cable is the major stumbling block to developing the system. Not only must it be capable of lifting heavy equipment, it must also carry the high voltage current safely and reliably. In addition, it must be a small 'package'. Conventional conductor cabling systems were discarded (because they were too bulky) in favour of a "triaxial" construction allowing the three conductors required by a three phase motor to be fitted into a very small diameter. Signals to and from the unit are handled by a multiplexing system (specially designed by the Nova Scotia Research Foundation Corporation) that is inductively coupled to the inner two high voltage conductors which form a coaxial cable.

Initial drilling tests on a short length of cable (1,500 m) in 1980 proved the system feasible. However, when a 5,000 m cable was tried in 1981, a compacitive imbalance between the three power conductors limited the drilling capability; a capacitive balancing circuit has now been incorporated. In addition, a system to measure 'real' power consumed and provide ground fault protection, designed for the drill by Surfline Engineering of Halifax, has also been added. Full protected power is now available to the drill for field operations.

The power system is also capable of driving other devices thus allowing operations in the deep sea that have hitherto been difficult. One such application is the sampling of large quantities of water for trace element analysis. The physical recovery of large volumes of waterl, up to 1,000 litres, from depth is impractical. With the power supply, particles of interest can be filtered out *in situ*, using an electrically driven pump. In this way, samples at several different depths may be taken, or alternately, multiple samples may be recovered at a given depth. Such a device, the "particulate in-situ sampler", is presently being tested. Also, a smaller version of this system will be further refined to run on a CTD cable.

Underwater TV surveys could be improved by converting up to 15 KW of power into light. The increased light allows greater distances between the camera, the light source, and the object being filmed thereby increasing the camera's field of view. A small scale prototype system will be tested in 1983 to determine its feasibility for future development.

Now that a system for supplying moderate amounts of power to the ocean depths has been shown to be practicable, the potential applications are many. Sampling and survey problems considered to be impossible because of lack of power may now become a reality.



Potential applications of high-voltage power in the deep sea.

Baited traps

- B.T. Hargrave

Barry Hargrave.

Dead animals are seldom observed in the sea. Once an animal of any size dies, it becomes immediately vulnerable to a variety of predators, and it is usually consumed very rapidly. Many species of scavenging fish and invertebrates have evolved adaptations that allow them to locate and rapidly consume carcasses. Lobsters get captured by traps because of their well developed ability to locate bait.

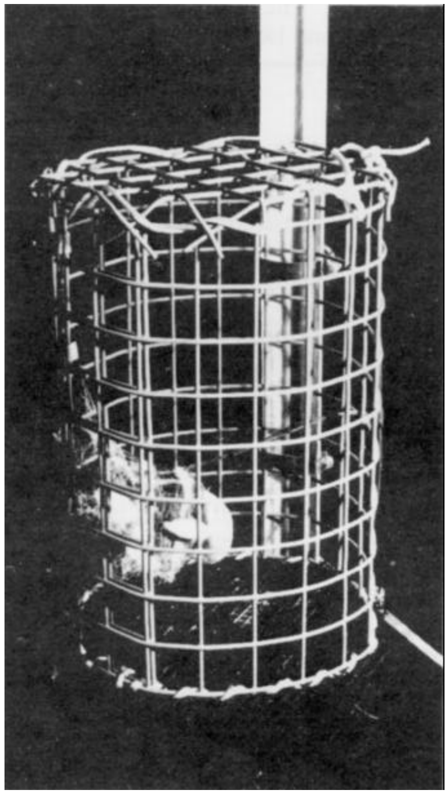
Carnivorous and scavenging species are common in the deep sea, and their attraction to bait provides a method of collection. Other sampling methods prove difficult because of the ability of these animals to avoid nets. Little is known about the biology of this fauna, whose range of movement and rates of food consumption and growth have not been measured directly. Without these data, the role of mobile animals in biological cycling of material in the deep sea cannot be assessed.

Previous workers in the deep sea have photographed these animals using cameras and traps placed on or near the sea bottom, baited with relatively large amounts of bait. Recent studies show that even small pieces of bait hundreds of metres above the bottom attract animals, though in smaller numbers. We required a device to record the arrival rate of animals at the bait, such as a time-lapse camera with bait moored at variable heights off the sea bottom. Thus, we assembled a Benthos camera, flash, and power supply in an aluminum frame around an acoustic release. A cylindrical wire mesh cage was designed to hold a small amount of bait at a fixed position in front of the camera. The cage prevented large fish from consuming the bait during the descent of the mooring, and the attachment of the camera assembly to the release allowed exposure of bait at a variable distance above bottom.

In June 1982, the moored camera system was deployed at 5,850 m (20 m above bottom) in the Nares Abyssal Plain in the North Atlantic. Seven hundred and twenty photographs were taken at 10 minute intervals over 5 days. One hundred prams of mackerel used as bait was completely consumed by scavenging amphipods *(Eurythenes gryllus)* within 38 hours. The time-lapse camera recorded pictures at a rate that allowed individual animals on the bait to be identified. Positions of these individuals often did not change between successive frames of 30-40 minutes.

This study provided the first estimates of feeding rates for any deep sea animal. Amphipods of different size, for instance, could ingest up to half their body equivalent weight in less than an hour - a remarkably high feeding rate. These initial results need to be verified by exposing the moored camera in other deep sea locations.

If the arrival rates observed in the Nares Abyssal Plain are typical of other areas, the time-lapse frequency should be increased to 2 or 3 minutes. This would allow a higher resolution of individual animal feeding behaviour, and a more accurate assessment of their feeding rate.



The lysianassid amphipod *Erythenes gryllus* photographed at a depth of 5,850 m at the Nares Abyssal Plain. The two amphipods are shown feeding on a morsel of mackerel left in the trap to bait the animals to the camera.

Ocean bottom seismometers

- D.E. Heffler

Roger Bélanger

Dave Heffler.

Ocean Bottom Seismometers (OBSs) have been an ongoing development at the Atlantic Geoscience Centre since 1975. An OBS provides data on the structure of the earth's crust by recording very tiny sounds on the ocean floor - sounds which come from distant earthquakes or man-made sources. We drop an OBS freely to the sea floor where it continuously records for up to 10 days. It then releases an anchor weight and floats to the surface to be picked up by a research vessel. If anything fails, we not only lose the instrument but as well the data it contains. We also never find out exactly what caused the failure so reliable operation is crucial.

Normally, we deploy an array of up to six OBSs, then steam away either dropping explosives (up to 1 ton) or using an air gun sound source. The sounds travel down through the ocean and the seafloor, and refracts along layers of rock deep in the earth's crust. By studying arrival times of the sounds to the OBSs, seismologists can determine the thicknesses of the layers and make predictions on the rock types. This information helps explain the details of plate tectonics and tells us how our oceans and continents were formed.

The OBSs developed at BIO can withstand the pressure of water 6 km deep, which makes them useful in all but the deepest parts of the world's oceans. After deploying the devices, a ship will spend several days dropping explosives before commanding the OBSs to return to the surface. The OBSs are usually deployed and recovered several times in a cruise that may last 3 to 4 weeks. Often we work with OBS groups from other countries to fully utilize sound sources and to increase the range of our measurements.

One of our most exciting projects was the Lesser Antilles Deep Lithosphere Experiment (LADLE) in 1980. We co-operated with two OBS groups from Great Britian and one from France to maintain an array of 18 OBSs on a line 1,000 km long. We detonated charges as large as 5 tons and were able to detect signals travelling 700 km through the crust, These data revealed structures as deep as 100 km, well into the mantle of the earth.

Our OBSs are also used in an unusual way to study the crust under the polar ice pack. This work is done from ice stations set up on the ice pack. Floats, a release, and an OBS without its anchor are lowered through the ice to the sea floor using a small winch with a special Kevlar cable. We then fly a helicopter up to 100 km away from camp and drop explosives through the ice. Crustal measurements from five different ice stations have been made in this way.

More recently, we have been using our OBSs to record sounds from earthquakes. We must record for longer periods when studying earthquakes because of course we cannot control when and where they will occur. To facilitate this we have recently extended the OBS's tape recorder time to 18 days.

Some studies are carried out to gather information on the size and frequency of small earthquakes occurring in seismically active regions offshore. This information is used to help set construction standards for offshore structures used in petroleum exploration and production. We have used our OBSs for this work in both the Beaufort Sea and on the Grand Banks.

Several groups around the world build and use OBSs. The products of each group are different, as they are designed for slightly different applications. Our OBSs are small and simple, so we can easily deploy and recover them. They have proven themselves to be reliable and have provided data that will require years to analyze. The University of British Columbia and Dalhousie University have chosen to copy our design for their own use.

RALPH

- D.E. Heffler & D.L. Forbes

Don Forbes.

Wind-driven waves, storms, and tidal currents produce considerable movement in the sediments on the seafloor, yet despite major research efforts worldwide, we know very little about these movements. Research in this area has been hampered by the lack of instrumentation to measure sediment transport. For this reason, the Atlantic Geoscience Centre initiated in 1978 the development of RALPH, an instrument for the study of coastal sedimentary systems and the mechanics of sediment transport.

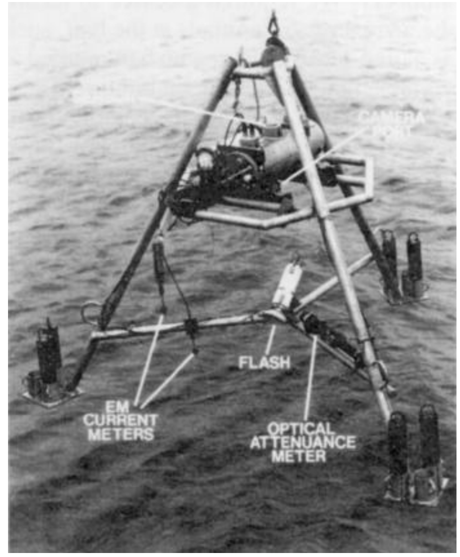
The most important variables affecting scdiment transport are water velocities. bottom bedforms, and suspended sediment concentrations. RALPH is equipped with an array of sensors that include electromagnetic current meters, wave sensors (a pressure transducer and an upward-looking sonar), an optical attenuance meter, and a time-lapse camera for bottom photography. These sensors sample up to once per second and their data are preprocessed and stored internally on digital magnetic tape. The instrument package is mounted on a tripod and deployed on the seafloor.

Because a single large storm may move more sediment than a year of moderate weather, it is important that RALPH be able to stay on the seafloor long enough to have a good probabilitv of gathering data under storm conditions. Therefore, RALPH was designed to he an autonomous instrument with low power requirements and the ability to sample local conditions. It can operate for more than a month with no connection to shore or ship.

RALPH data may be co-ordinated with data from other sources. In many ocean deployments, we moor supplementary current meters or collect meteorological and wave climate data. Sediments in the area may he sampled to determine the size distribution, density, and other properties hat affect sediment transport phenomena. In shallow water. scuba divers may make direct observations of the bottom bedforms, collect core samples, or do other tasks under non-storm conditions. In nearshore and shelf waters, bathymetric and side-scan sonar surveys are conducted in the area of the instrument to assess the applicability of RALPH data to conditions at other nearby locations.

RALPH was first used in November 1981 during a nearshore study in Aspy Bay, Nova Scotia. This experiment yielded valuable information on bottom bedform stability and reworking of seafloor sediments by organisms. The experience also led to some redesign of the instrument: a larger, more stable but less intrusive support structure was introduced, and data logging rates and the degree of on-board preprocessing were increased.

For 3 years we have attempted unsuccessfully to deploy RALPH during the winter storm season at the Hibernia well site on the Grand Banks. Storms, ice, the sinking of the *Ocean Ranger*, and logistical and other problems have precluded success in this important area. Since then, however, RALPH has been deployed twice near the Venture site off Sable Island. The first deployment yielded excellent photographs of tide-generated ripple migration. RALPH was redeployed in July 1982 and yielded more photographs of bedform changes as well as coincident current and wave data. We have also used RALPH on the Nova Scotia eastern shore and in the Beaufort Sea. The deployments at Sable Island and in the Beaufort Sea were undertaken in co-operation with the petroleum industry. Future deployments are anticipated in the Gulf of St. Lawrence (in support of the Canadian Coastal Sediment Study), in the Bay of Fundy, and on the Labrador Shelf.



RALPH is the name of an instrument package developed and built by the Atlantic Geoscience Centre to study coastal sediment features and the mechanics of sediment transport.

The floc camera

- J.P.M. Syvitski & D.E. Heffler

James Syvitski.

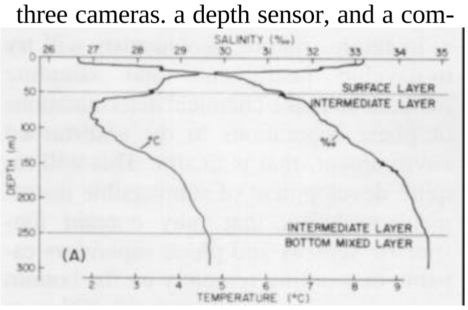
Suspended particles in the ocean, both individual and flocculated, organic and inorganic, are difficult to study. We can measure the bulk concentration of suspended sediment, its composition and its chemistry, but we have only been able to guess at the floc density and size distribution of these particles in the ocean itself.

The analytical methods used to study particles in the ocean have many problems and their use has led to gross errors in estimating the rate of sediment accumulation on the ocean floor. Previous research on suspended particles has been limited to water samples collected at depth and gently filtered aboard ship. However, the properties of such particles can be altered in the process of sampling them: normal water samplers can break up delicate flocs, increased particle concentration in the bottom of samplers can cause the material to interact more than it actually does in the ocean, and filtering of particles using submerged pumps can destroy the characteristics of the flocculated particles.

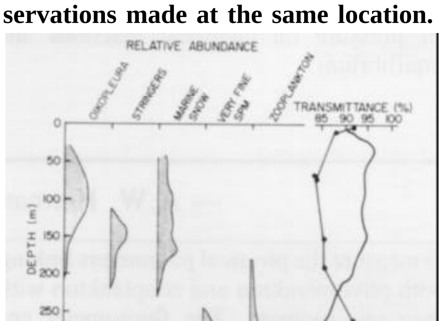
Little information is available on the instantaneous settling velocity of the many types of sediment particles suspended in the water; appropriate theory to describe this behaviour is almost non-existent. Suspended particles have been observed from the portholes of submersibles, observatons useful in that they indicated that conventional sampling of the particles gave a misleading picture, but these 'eye' observations are qualitative and reflect only gross changes in suspended particle types.

A need exists, then, for an instrument that can be lowered over the side of a ship to record the suspended sediment structure for later quantitative analyses. Specifically we want to know: (1) the number of particles in a given water volume; (2) the volume-size distribution of the particles within that volume; (3) the spacing between the particles; (4) the relative or absolute settling velocity of the various particles; and (5) the variation with time or depth of these properties.

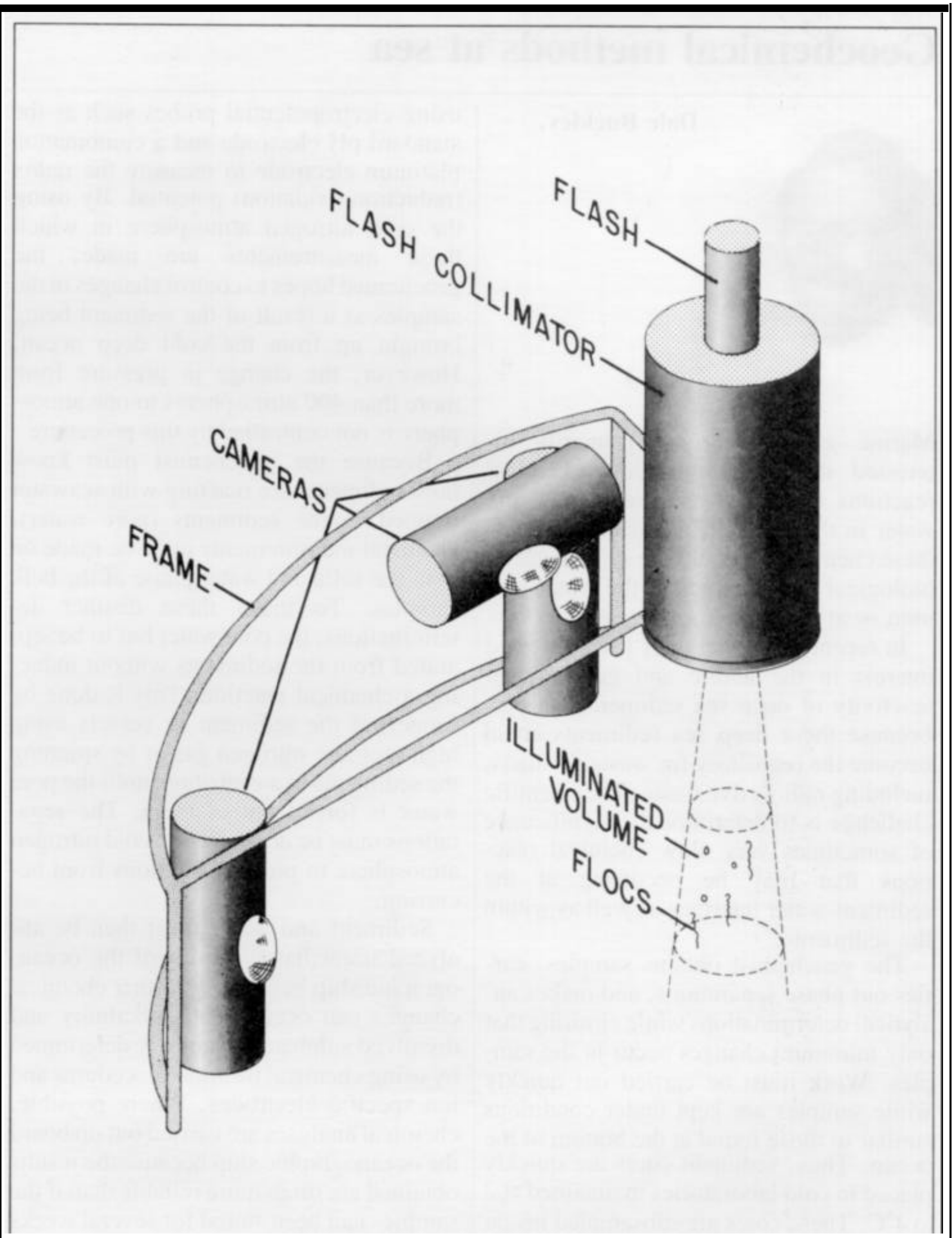
We have designed a camera package that consists of a collimated Xenon flash. three cameras. a depth sensor, and a com-



Shown in the upper figure is a typical salinity-temperature profile for the lower St. Lawrence estuary. Below is a summary of the sediment particle observations made at the same location.



puter controller to link and operate the components in a programmable manner. The package design will allow us to photograph of particles in an area unaffected by the instrument's descent. The collimated light source will avoid out-of-focus foreground and background particles that interfere with later image analysis (submersible photos are not useful for quantitative



A schematic of the floc camera assembly.

valuation because of this problem). The frame is designed to allow the cameras to be moveable so the camera geometry can be changed to suit the volume of illuminated particles. The position of the cameras will ensure adequate coverage of the illuminated particles' geometry. Each 35 mm camera is motor-driven, has a long-back, and is in a specially designed pressure-resistant container. The computer circuitry triggers the cameras and flash, recording the picture number, date, time, and depth. The trigger mechanism is programmable by time (to allow a number of shots at a given depth) and by depth. Intially, the system will be lowered with a portable hydrographic winch, but we hope to modify it so as to allow programmable and wireless descents and recovery. The instrument may be deployed from a small vessel with minimum handling equipment.

Initially the film is being converted into enlarged prints and we are digitizing the position co-ordinates and size of particles. We hope to use image analysis systems in future to enable the automated digitization of the image. The co-ordinate and particle-size information from the three cameras is next merged into a computer file and the particle matrix trigonometrically analyzed. At the time of writing, the camera package has been tested in a marine tank where objects were photographed to calibrate the instrument. Its lower resolution of particle size is less than 50 microns. Such resolution is quite acceptable: most 'marine snow' particles are at least two times larger. We plan to field test and calibrate the camera system soon and to define its field limitations by September 1984.

Geochemical methods at sea

- D.E. Buckley

Roger Belanger

Dale Buckley.

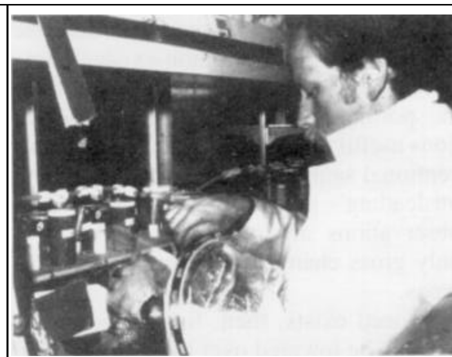
Marine geochemists are primarily interested in determining how chemical reactions occur between sediments and water in the ocean. They also study how these chemical reactions are influenced by biological communities in the water column or at the bottom of the sea.

In recent years there has been renewed interest in the nature and geochemical reactivity of deep sea sediments, in part because these deep sea sediments could become the repository for waste products, including radioactive waste. The scientific challenge is to determine the significance of sometimes very slow chemical reactions that may be occurring at the sediment-water Interface as well as within the sediments.

The geochemist obtains samples, carries out phase separations, and makes analytical determinations while ensuring that only minimum changes occur in the samples. Work must be carried out quickly while samples arc kept under conditions similar to those found at the bottom of the ocean. Thus. sediment cores are quickly placed in cold laboratories maintained at 2 to 4°C. These cores are subsampled inside a glove box flooded with inert nitrogen gas to prevent the normal atmospheric oxygen from causing chemical changes in the sampales. Several chemical tests or measurenents are carried out inside the glove box using electropotential probes such as the standard pH electrode and a combination platinum electrode to measure the redox (reduction-oxidation) potential. By using the cold nitrogen atmosphere in which these measurements are made, the geochemist hopes to control changes in the samples as a result of the sediment being brought up from the cold deep ocean. However, the change in pressure from more than 400 atmospheres to one atmosphere is not controlled by this procedure.

Because the geochemist must know how sediments are reacting with seawater trapped in the sediments (pore water), chemical measurements must be made on both the solid and water phase of the bulk samples. To make these distinct determinations, the pore water has to be separated from the sediments without inducing a chemical reaction. This is done by squeezing the sediment in vessels using high pressure nitrogen gas or by spinning the sediments in a centrifuge until the pore water is forced out of them. The separations must be done under a cold nitrogen atmosphere to prevent reactions from occurring.

Sediment and water must then be analyzed immediately on board the oceanographic ship before any further chemical changes can occur. Total alkalinity and dissolved sulphate are quickly determined by using chemical titration procedures and ion specific electrodes. Where possible, chemical analyses are carried out on board the oceanographic ship because the results obtained are often more reliable than if the samples had been stored for several weeks before they were analyzed. To carry out these analyses at sea, whole laboratories may be equipped with automatic analyzers to measure the concentration of dissolved nutrient elements such as nitrates, nitrites,



Dale Buckley

Geochemist Ray Cranston prepares samples fur extraction of pure water. The operation is carried out inside a glove box flooded with inert nitrogen gas which prevents oxidation that might alter the samples.

phosphates, and silicates. In some cases. even trace elements at concentrations of a few parts per billion may be determined at sea. Elements such as Hg, Zn, Cu, Cd, and Pb may be analyzed using a fully equipped atomic absorption spectroscopy laboratory.

In future, marine geochemists will try to develop instruments and sampling methods to make chemical determinations or phase separations in the undisturbed environments that is *in situ.* This will require development of submersible instrument packages that may contain ion-specific sensors and phase separators capable of working remotely on the bottom of the ocean at water depths of 6,000 m or more. If this sort of development can be achieved, the geochemist will be able to evaluate one of the most difficult variables to control - the effect of 600 atmospheres of pressure on chemical reactions and equilibrium.

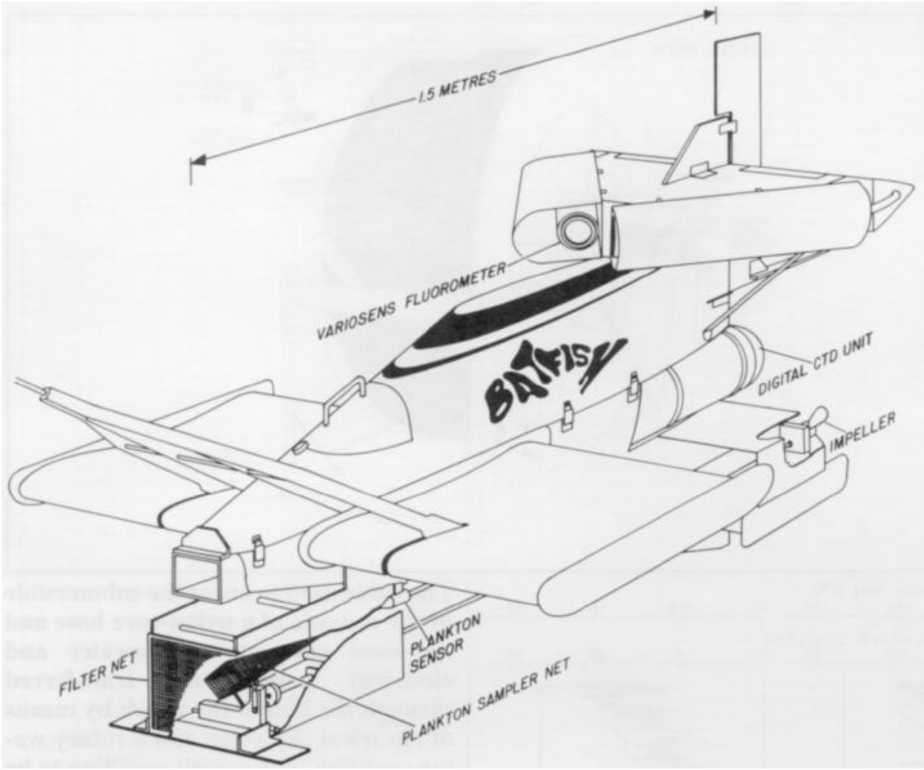
Biological oceanographic sensors

- A.W. Herman

Oceanographers realized 20 years ago that ocean processes occur at finer scales than those their instruments could then measure. Biological oceanographers were becoming concerned at that time with the statistical reliability of their samples as they came to realize that distributions of both phytoplankton and zooplankton were highly uneven and patchy. Patchiness in the horizontal dimension was of particular interest and in order to describe it and its characteristics, towed instruments providing profiles approximately 1 km apart were needed. To resolve the vertical interactions between phytoplankton and the zooplankton that feed on them, a vertical resolution of approximately 1 m was needed.

The Batfish vehicle was developed at BIO in the early seventies to sample these horizontal and vertical scales. This vehicle is towed behind a ship at controlled speeds of 5 to 12 knots: it follows a sawtooth pattern and produces a vertical profile of the water column to a maximum depth of 400 m. Batfish is mainly a platform for transporting oceanographic sensors used in the biological and physical sciences (see first figure). Its CTD unit measures salinity, temperature, and depth and allows us to measure the physical parameters linking both phytoplankton and zooplankton with their environment. The Fluorometer enables us to measure chlorophvll *a* fluorescence, which is an indicator of the biomass of phytoplankton present. A conical zooplankton sampler net mounted on the undercarriage of the Batfish concentrates small copepods and transfers them to a conductivity sensor which not only counts the animals but sizes them as well.

Examples of Batfish data sampled on the outer edge of the Nova Scotia shelf are shown in the second figure. Here we towed the Batfish across the continental



The Batfish vehicle with its full complement of biological oceanographic sensors.

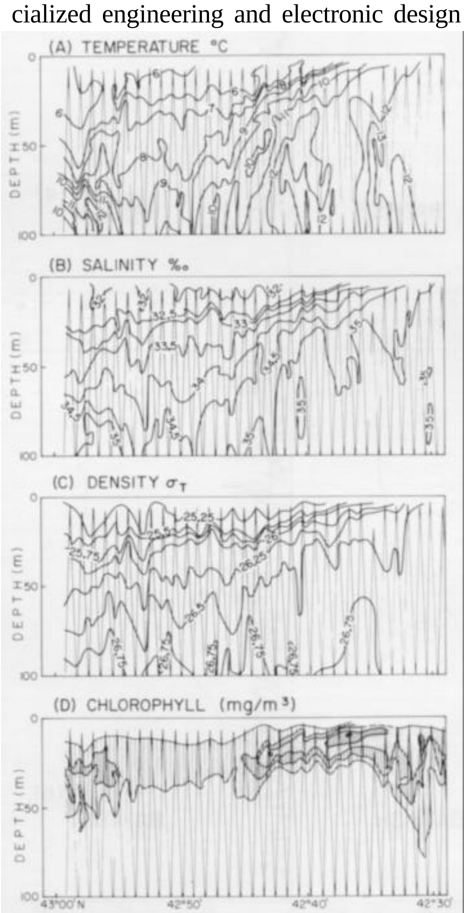
shelf edge along a north-south transect to a maximum depth of approximately 110 m. The depth trace or sawtooth pattern outlined by the Batfish indicates cycles separated by approximately 1 km, and therefore each oblique profile results in a horizontal resolution of approximately 0.5 km. Data on temperature, salinity, density, and chlorophyll *a* were contoured on depth in the figure, and the resulting sections illustrate the capability of the Batfish system to resolve small-scale features in a frontal region where considerable gradients are present.

As reported in *BIO Review '82* (in an article beginning on page 28), the analysis of Batfish profiles collected from many areas has shown that copepods aggregate at depths approximately 8 to 10 m shallower than the chlorophyll *a* maximum. This observation is only now beginning to find general scientific support, however, because such measurements were not possible in the past when available samplers had only coarse vertical resolution (>10 m).

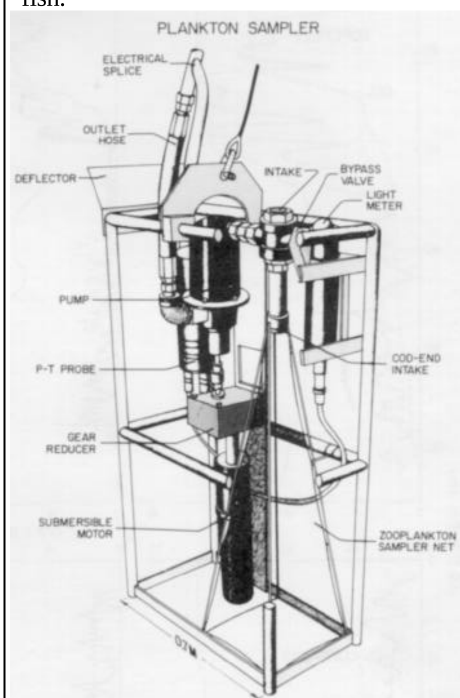
The technology for the Batfish system has been transferred to industry and is marketed by Guildline Instruments Ltd.. Smiths Palls, Ontario. Batfish systems have been sold locally and abroad to China, Japan, UK, Holland, and West Germany, and France, Italy, and Australia have shown an interest in the system. Although Batfish development is completed, the potential for the development of sensors mounted on Batfish is limitless.

Sensor development, such as that of the zooplankton counter, has required technical input from industry. We obtain specialized engineering and electronic design assistance from Sea-Met Sciences Ltd. and biological analyses of samples (to check the operation of the counter) from two local Maritime firms - Hardy Associates Ltd. and McLaren Plansearch Ltd. We have also had excellent technical assistance and co-operation from other Maritime firms, such as Imperial Optical Ltd., in the design of lenses used in our newly developed optical plankton counter.

Although outside interest in the Batfish is increasing. the system does possess a limitation in that it does not provide seawater samples on-deck for biological analyses. To do this, we developed the continuous profiling pumping system. which provides large quantities of seawater on-deck while measuring biological/ physical profiles of temperature, pressure, light irradiance chlorophyll *a* and copepods. Profiles are obtained while the ship is stationary and therefore the pumping system does not provide the same horizontal resolution and spatial coverage as Batfish.

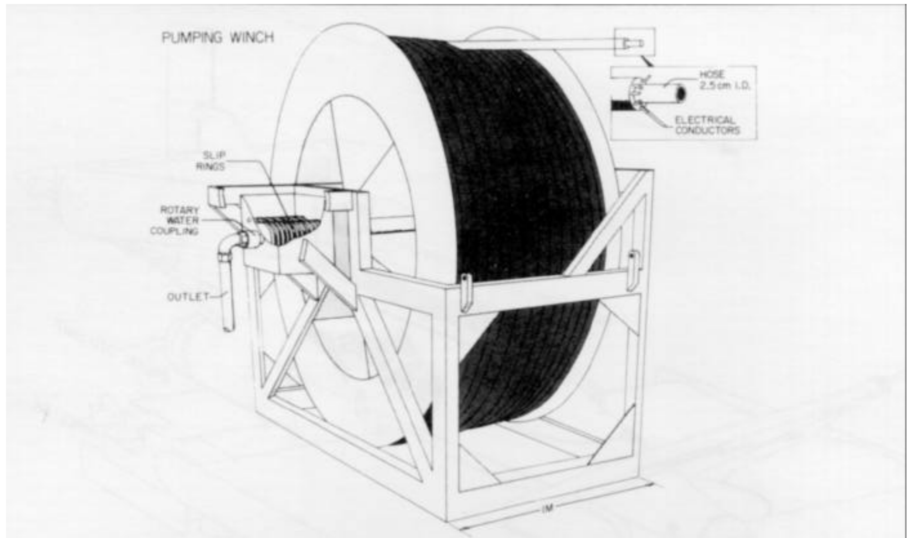


Examples of Batfish data for the outer edge of the Nova Scotia Shelf.



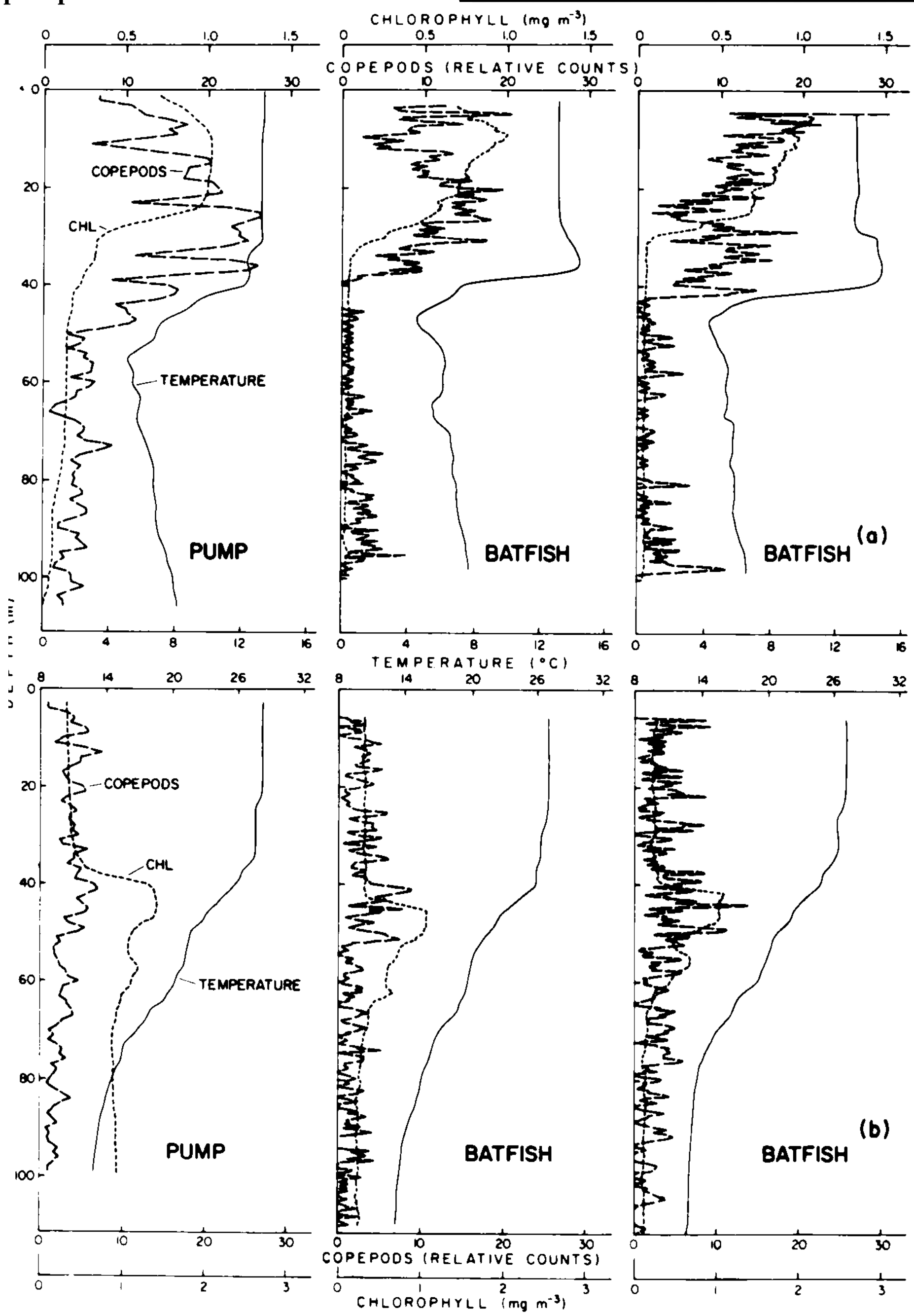
The instrumented submersible probe traps and concentrates zooplankton samples at the cod-end intake where they are removed by the pump's suction.

The third figure shows the instrumented submersible probe. During the probe's descent, the sampler net entraps and concentrates zooplankton at the cod-end of the net where they are removed by the pump's suction. This method of trapping zooplankton prior to pumping reduces the traditional problem encountered of having the zooplankton avoid the pump intake. The submersible probe is lowered on a hose/conductor cable (fourth figure) con-



The cable used to lower the submersible probe consists of a nylon-core hose and electrical conductors. Seawater and electrical power are transferred through the hub of the winch by mean of electrical slip rings and a rotary water coupling that permit profiling to be done continuously.

Sample profile from Nova Scotia Shelf waters (a) and the Eastern Tropical Pacific (b). In each case, the two Batfish profiles sampled the same area that had been sampled an hour earlier by the instrumented submersible probe's pump.



sisting of a nylon core hose and electrical conductors. The hose conductor bundle is then sheathed in an extruded polyurethane jacket. Seawater, and electrical power and signals are transferred through the hub of the winch by means of electrical slip rings and a rotary water coupling that permits continuous profiling. The pumping system can provide a flow capacity of approximately 50-60 litres per minute and is capable of profiling to a depth of approximately 110 m. The last illustration shows sample profiles from the Nova Scotia shelf waters (a) and the Eastern Tropical Pacific (b).

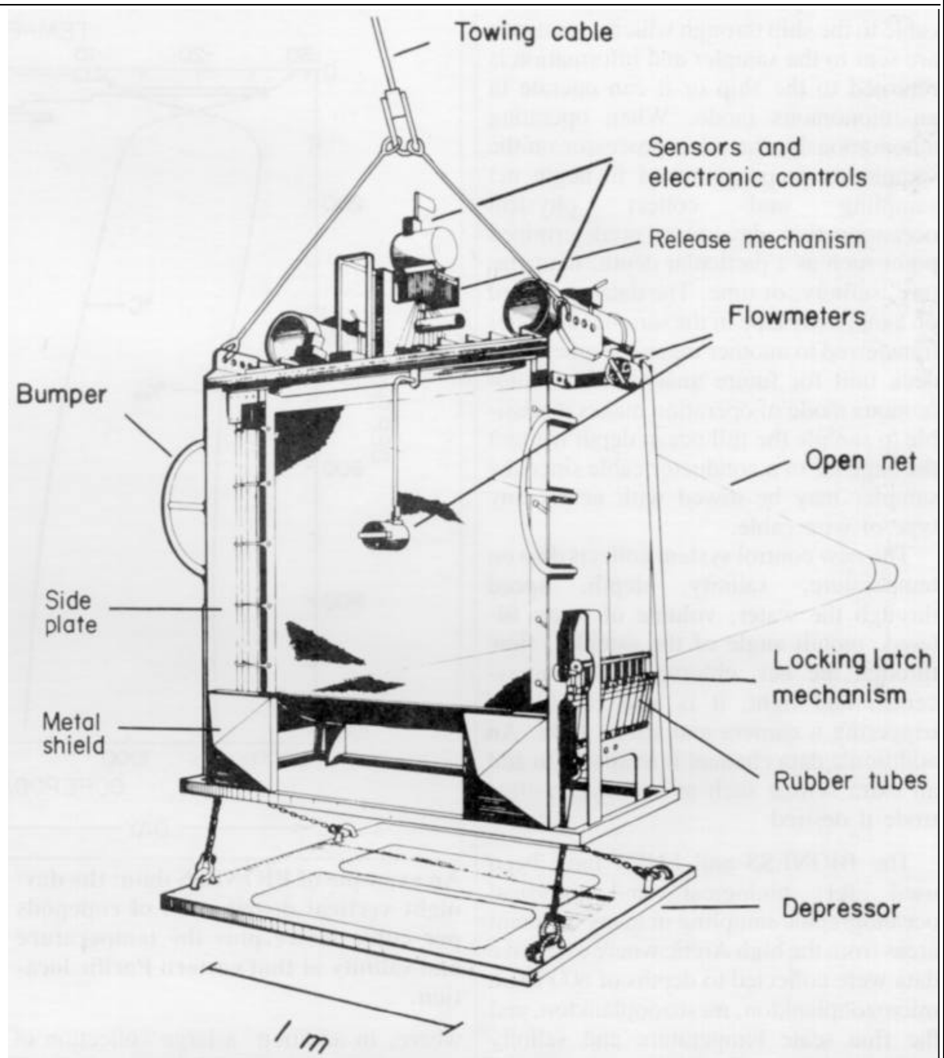
Industry provided various levels of input to the design of components for the profiling pump system. The hose/conductor cable shown in the fourth figure was custom-built for BIO by an outside firm (Shaw Industries Ltd.) whose technical staff and engineers assisted us in the design of each generation of cable construction. The analyses of phytoplankton samples obtained from the pump system are also performed by local firms. The technology of operating the profiling pumping system has been transferred to biologists in the Marine Ecology Laboratory and, as interest continues to grow, the design and fabrication technology will be transferred to local industry.

BIONESS

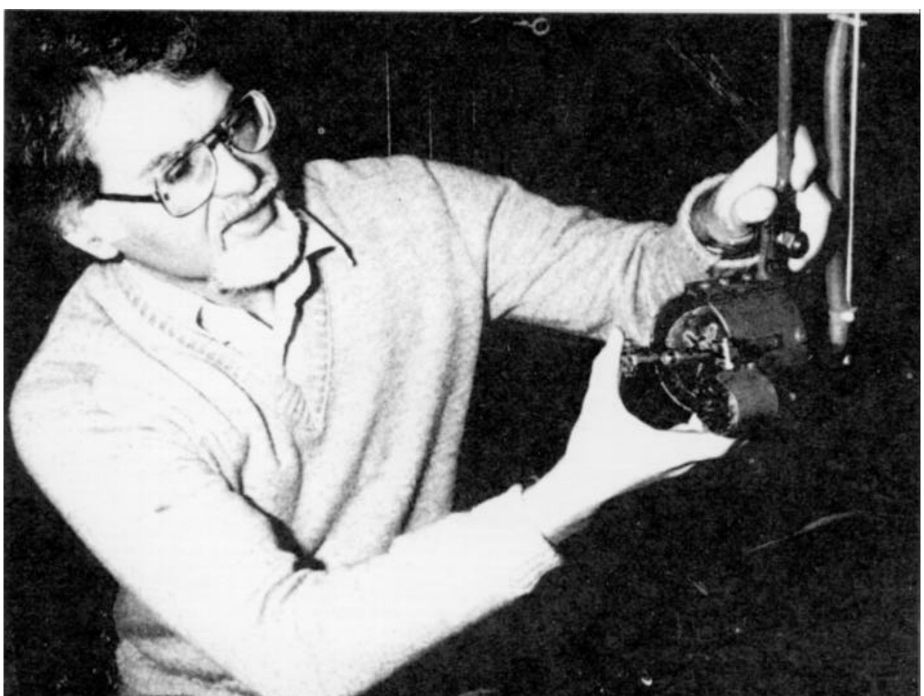
- D.D. Sameoto

To understand the relationships between phytoplankton and zooplankton, as well as fish larvae and juvenile fish, it is essential that sampling gear capture or at least provide information on their concentrations. Until recently, samplers were extremely limited in their ability to do this. This lack led BIO to develop in 1977 a new type of sampler capable of collecting animals as short as 30 microns to as long as 10 cm and also of providing accurate high resolution data on various physical oceanographic parameters. This sampler is called BIONESS.

The BIONESS (Bedford Institute of Oceanography Net and Environment Sensing System) and the LHPR (Longhurst-Hardy Plankton Recorder) have been the main zooplankton sampling instruments at BIO during the last 5 years. The BIONESS (see first figure) has a system of ten opening and closing nets, each with a mouth opening of 1 m^2 and a mesh size of 243 microns. The nets are attached to steel bars and stacked behind one another. By opening and closing these nets. samples can be taken from ten different depths, which provides us with information on the vertical distributions of animals in the ocean. In addition. within the mouth of each of the 1 m^2 nets. a smaller net 15 cm diameter, 30 micron mesh size) can be mounted to collect microzooplankton that are normally lost through the 243 micron mesh nets. Using the two mesh sizes, 20 separate samples can be collected in a single tow.



BIONESS as it would appear being towed with the first net open. For simplicity, the conductor cables from the towing line to the various pressure cases are omitted.



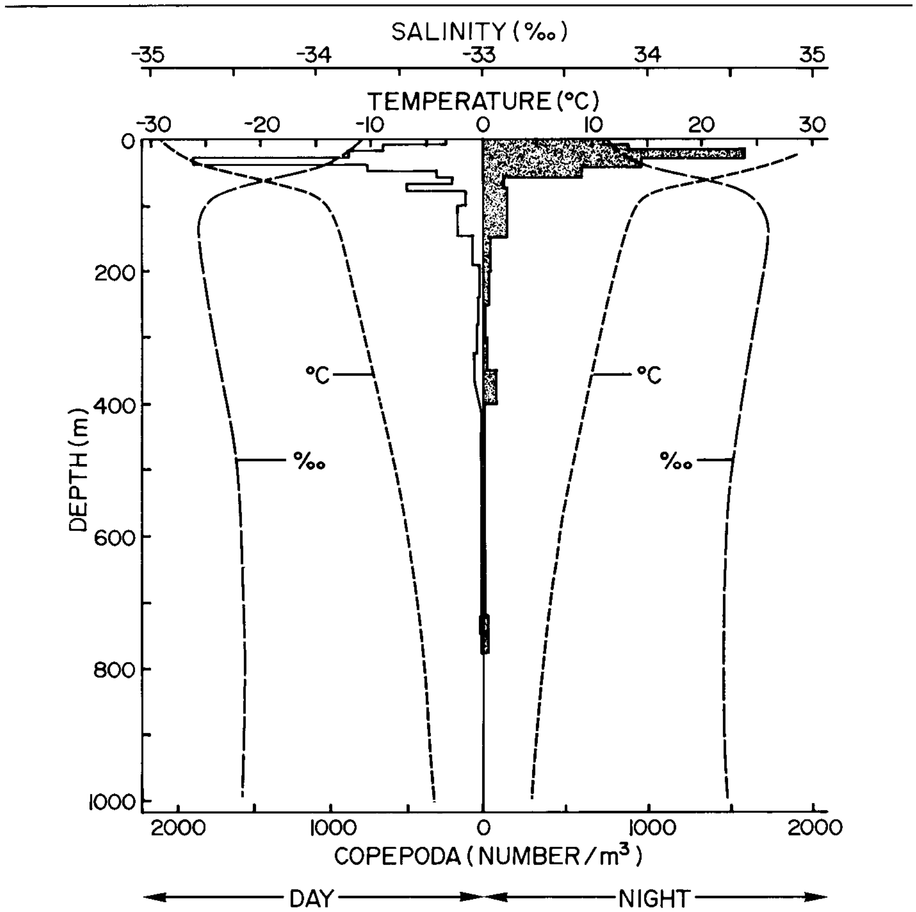
Doug Sameoto adjusts the BIONESS's internal flow meter.

BIONESS weighs about 780 kg. It is usually towed by a ship at 1.5 ms^{-1} but can be towed as fast as 3 ms^{-1}. BIONESS is a small but effective system. In fact, it compared favourably to the much large (80 m^2 open mouth) Engel trawl in a comparison test. BIONESS with its 243 micron nets collected large specimen of the myctophid *Benthosema glacile* and the pelagic shrimp *Sergestes arctica* as efficiently as did the larger trawl, a result that many would not have thought possible.

A new electronic control system has now been built to operate both the BIONESS and LHPR. It incorporates an underwater unit comprised of a microcomputer and interface unit that gathers data from an array of sensors. while a deck unit, which employs two closely coupled microcomputers, controls the underwater unit and reduces, displays, and logs the data. This system has two modes of operation: it can operate via an eight-conductor cable to the ship through which commands are sent to the sampler and information is returned to the ship or it can operate in an autonomous mode. When operating autonomously, the microprocessor on the sampler is preprogrammed to begin net sampling and collect physical oceanographic data at a predetermined point such as a particular depth, temperature, salinity, or time. The data are stored on a magnetic tape in the sampler and later transferred to another magnetic tape in the deck unit for future analysis. The autonomous mode of operation makes it possible to sample the full ocean depth without the expense of a conductor cable since the sampler may be towed with nearly any type of wire cable.

The new control system collects data on temperature, salinity, depth, speed through the water, volume of water filtered, mouth angle of the sampler, flow through the net, chlorophyll *a* fluorescence, and light; it is also capable of triggering a camera and strobe light. An additional data channel is available to add an extra sensor such as an oxygen electrode if desired.

The BIONESS and LHPR have been used for biological and physical oceanographic sampling in many different areas from the high Arctic where extensive data were collected to depths of 600 m on microzooplankton, mesozooplankton, and the fine scale temperature and salinity structure of the water column to the eastern tropical Pacific where similar data were collected down to a depth of 1,000 m and where, in addition, a large collection of mesopelagic fish and fish larvae were collected from all depths. These two samplers were also used to study the vertical and horizontal distribution of different sizes of zooplankton and micronekton at the Scotian Shelf-Slope boundary.



An example of BIONESS data: the day/night vertical distribution of copepods per cubic metre plus the temperature and salinity at that eastern Pacific location.

The BIONESS is being commercially manufactured by Eastern Marine Services Ltd. of Nova Scotia, and some units have been sold to other Canadian laboratories.

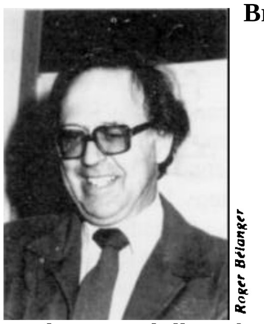
CHAPTER 4

Advising on Environmental and Fisheries Concerns

For the protection of the environment and in the general public interest, the Government of Canada has established a set of formal procedures to evaluate the impact of any proposed new development. Different administrative regimes north and south of 60°N, the complexities of federal-provincial relations, and the inter-linked and differing mandates of government departments make the procedures difficult to understand. In the first part of this chapter we review how the various components of BIO fulfill their responsibilities in the environmental field and guide the outsider through the maze of committees by means of which the work is co-ordinated in the Atlantic and Arctic offshore regions of Canada.

ENVIRONMENTAL CONCERNS

- H.B. Nicholls



Brian Nicholls.

Exploratory drilling began off the east coast in 1966, and since then the search for oil and gas in the Canadian offshore including the Arctic has steadily increased. Public concern especially over the danger of oil spills has also increased and so BIO scientists and hydrographers are today becoming more and more involved in reviewing and assessing the projected environmental impacts of these developments. This section discusses the various links and mechanisms that are in place at BIO to respond to environmental issues.

Marine emergencies

BIO's ability to respond is based on the knowledge acquired from the long-term research and survey programs of the Institute that seek to describe the offshore environment and gain an understanding of the processes involved: some of these programs directly address environmental issues such as sublethal contamination. These programs are undertaken with the specific objectives in mind of satisfying future needs and being able to answer the questions that will likely be asked in the future by government, industry, and society in such fields as resource and environmental management.

In marine emergencies, the Institute must quickly try to answer a variety of questions such as what will be the likely track of an oil slick and what effect will a particular spill likely have on marine life. The response of BIO to marine emergencies such as oil spills and blowouts is governed by special Internal Procedures for Response to Marine Emergencies. These outline the procedures to be followed and name the scientific experts who will be involved in the response. There are two main objectives:

(1) to respond with advice and action to requests from the on-scene commander of the department charged with overall responsibility for dealing with the emergency; and

(2) to investigate marine environmental contamination and other topics as much as possible in the emergency. This research furthers the Institute's aim of understanding the effects on the ocean environment of such incidents, and therefore is normally undertaken by a co-ordinated team of BIO investigators.

For most major emergencies. the Atlantic REET (Regional Environmental Emergency Team) mechanism is implemented. The team includes members from federal government departments, the provinces and other agencies: both Ocean Science and Surveys (OSS) Atlantic of DFO and DEMR's Atlantic Geoscience Centre have members on this team. REET reviews sensitive areas and priorities, and advises the on-scene commander. The Institute is also represented on the regional senior-level Government Policy Group whose task is to ensure effective interaction between the various federal departments involved in the response to the emergency and the on-scene commander. Another mechanism in which the Institute is involved is the Joint Canada - United States Plan, which provides a framework for Canada-USA co-operation in response to pollution incidents threatening the waters or coastal areas of both parties. In addition to participating in the co-ordinated BIO response, each component of the Institute also has responsibilities through its respective department. For example, OSS Atlantic has an important role to play under the DFO East Coast Marine Emergency Plan, and is responsible for the overall maintenance of that plan.

The Institute plays yet another role in relation to marine emergencies: it reviews oil company offshore emergency/ contingency plans. Section 79 of the Canada Oil and Gas Drilling Regulations requires in part that every operator shall ensure that contingency plans have been formulated to cope with any foreseeable emergency during a drilling program, ineluding oil spills; these plans must also be co-ordinated with existing local and national contingency plans. Prior to the commencement of drilling, copies of the plans are sent to appropriate federal departments and establishments such as BIO for review. These plans comprise volumes covering: the response or action plan; environmental information pertaining to the drilling site and the area that may be affected by a spill; biological, socioeconomic, and shoreline sensitivities; and equipment and clean-up information. It is in the review of the environmental information and sensitivities that the Institute plays a major role. Here, experts in physical oceanography, chemical oceanography, marine ecology, marine geology, sea ice including permafrost and icebergs, fisheries, and seabirds review the relevant sections. Certain response operations for which the Institute has special expertise such as oil-spill trajectory modelling are examined in detail. Finally, steps are taken to ensure that the plans are compatible as appropriate with other plans like DFO's East Coast Marine Emergency Plan.

Environmental assessment in Canada

An environmental impact assessment determines the likely impact of a proposed development. While institutional procedures for such assessments are formalized in many countries - Canada has the federal Environmental and Review Process and its provincial equivalents - the methods for undertaking such assessments are less developed. Van Winkle *et al.* (1976) summarized the situation facing those involved in the field, noting that these persons "cannot help but be aware of the limitations in the state of the art of impact assessment . . . when they are asked to play substantive roles in a decision making process which stands at the controversial interface between industrial or economic progress and environmental protection".

The Canadian Environmental Assessment and Review Process (EARP) was established by a Cabinet decision in 1973. Its purpose is to ensure that the environmental consequences of all federal projects - those undertaken or sponsored by federal departments or agencies, those for which federal funds are solicited, and those involving federal property - are assessed before final decisions are made, and to incorporate the results of these assessments into project planning, decision making, and implementation. Because the Canadian offshore regions as defined under the Canada Oil and Gas Act constitute federal property (Canada Lands), all developments in these areas are subject to EARP. Under EARP, the initiator is defined as the federal department or agency that intends to undertake or sponsor a project that may affect the environment; the proponent is an agency (other than the federal government), company, or other organization that is subject to EARP because of the involvement of a federal department (the initiator) through funding, property, or regulatory considerations. In the case of the Sable Island Venture offshore gas development, for example, the Canada Oil and Gas Lands Administration (COGLA) is the initiator, while Mobil Oil Canada Ltd. is the proponent. When, after formal screening, and possibly an Initial Environmental Evaluation, the initiator determines that a proposed undertaking may have significant impacts, FEARO - the Federal Environmental Assessment Review Office that administers EARP - must formally review the undertaking. A panel is appointed to issue guidelines for the preparation of an Environmental Impact Statement (EIS). The EIS is prepared by the proponent, submitted to the Panel (via the initiator), and released for review. After public hearings, the panel prepares a report to advise the federal Minister of the Environment on whether the project should be allowed to proceed as is, to proceed but with modifications, or to be halted. In addition to FEARO, the National Energy Board (NEB) ensures that projects do not result in significant environmental impacts; the NEB regulates energy projects, while FEARO is concerned with federal projects.

Review of environmental impact documents

The Institute is involved in all stages of the environmental assessment and review process: providing advice, data, and information; reviewing documentation; preparing position statements; and attending meetings and hearings. This involvement often starts well before the screening process takes place; staff are approached by the proponent for data and advice and such co-operation with the proponent, usually on a scientist-to-scientist basis, invariably continues throughout the entire process. Subsequently, there is participation in: the screening activity; the review of the Initial Environmental Evaluation; the preparation of guidelines for the EIS; the review of the EIS and its supporting documents; preparation of technical reviews and position statements; involvement in panel hearings and associated meetings; and the review of supplementary material. All Institute reviews consider both the impact of the project on the environment and the impact of the environment on the project. In addition to co-operation with the proponent's staff, there is also frequent contact with staff of the initiator, FEARO, and NEB. Because technical reviews and position papers pertaining to environmental impact statements are invariably compiled along departmental lines, Bedford Institute of Oceanography reviews as such are not prepared: instead, the contributions from the Institute will be found in the reviews and positions of the three federal departments represented at BIO - DEMR, DFO, and DOE. Nevertheless, during the technical reviews and other activities there is close co-operation among BIO staff of the three departments to ensure full and complete coverage in the marine sciences field.

As the largest of the organizational units at BIO, OSS Atlantic has organized its environmental assessment and review activities under a special mechanism known as ENACT (ENvironmental Assessment Co-ordinating Team). The objectives of ENACT are to advise regional senior management on environmental impact assessment and review, and to co-ordinate regional activities in this field. It comprises:

- Head, Ocean Information Division (Chairman);
- Head, Coastal Oceanography Division, Atlantic Oceanographic Laboratory;
- Head, Environmental Quality Division, Marine Ecology Laboratory; and
- Planning Officer, Canadian Hydrographic Service, Atlantic Region.

ENACT sets up working groups of experts to review specific EISs, etc., and the Chairman of ENACT, assisted by the members, compiles the consolidated regional review (which is incorporated in turn in the DFO review). The Atlantic Geoscience Centre sets up ad hoc review teams for each project; their reviews are channelled through the headquarters of the Geological Survey of Canada and co-ordinated within DEMR by the Office of Environmental Affairs. The Seabird Research Unit channels its input through the Regional office of the Canadian Wildlife Service of DOE, while the Marine Fish Division of the Atlantic Fisheries Service of DFO channels its input through the Fisheries Environmental Co-ordination office of DFO's Scotia-Fundy Region. As previously stated, close co-operation is maintained within BIO among all the scientists involved in the review of a particular project. Co-ordination is also achieved through various interdepartmental Atlantic Region committees such as the Interdepartmental Committee on Environmental Issues and the Regional Screening and Co-ordinating Committee.

The offshore environment is a complex, dynamic system involving interactions that are difficult to determine and often poorly understood. Longhurst (1980) notes that "a new set of questions has been posed by the prospect of offshore development of major oil and gas fields on our eastern continental shelves. Previously. our marine environmental assessment has concentrated very largely on coastal effects . . . Environmental assessment and the prediction of effects in the open ocean is now required, and we have very little previous experience in this task." This represents the situation facing Institute scientists as they are called upon to review the impact assessments prepared by the oil industry and others.

The first reference in the Institute's *Biennial Review* to involvement in formal environmental assessment processes appears in the l975/76 edition (Neu, 1977). Prior to this, of course, there had been significant involvement in the environmental assessment of industrial developments (e.g.. in 1973 of the marine aspects of the Eastport, Maine, Oil refinery proposal, which required tankers to travel through Canadian waters to reach its terminal) but these were not part of any formal process. Under the heading Environmental Impact Statement (Neu, 1977. p. 31) it is stated that "at the request of federal and provincial agencies. a large number of environmental investigations and assessments were made. The major projects were the Lepreau Atomic Power Station (New Brunswick), the intake and outfall design of the cooling water system of the Coleson Cove steam power plant (New Brunswick), Miramichi Channel Improvement (New Brunswick), Gabarus breakwater design (Nova Scotia), Strait of Canso Public Wharf development (Nova Scotia), the second Halifax Container Pier, and the Tiner Point deep-sea oil terminal (New Brunswick)". All of these are coastal projects. Only one, the Point Lepreau nuclear station, is a panel project under the federal EARP (the first EARP project).

The Institute has played a major role in the environmental review of all projects pertaining to offshore oil and gas. and one project involving onshore gas that had a major marine transportation component (the Arctic Pilot Project). The first was the Eastern Arctic Offshore Drilling, South Davis Strait project, proposed in the summer of 1976, with the FEARO Panel Report to the Minister of the Environment being dated November 1978. The EIS and supporting documents for the project were received for review at the Institute in May 1978. These were examined by scientists from all BIO components and two scientists, Dr. R. Brown of the CWS Seabird Research Unit and Dr. H. Sandstrom of OSS Atlantic, attended the public hearings in Frobisher Bay. In its report to the Minister of the Environment, the panel recommended that the project be allowed to proceed only if certain conditions were met to the satisfaction of the relevant regulatory agencies. A Supplementary EIS was issued by the proponent in response to the concerns raised by the panel: this was also reviewed at the Institute. Subsequently BIO played a major role in the following projects:

- Lancaster Sound Drilling (Proposed 1977; panel report to the Minister of DOE 1979)
- Arctic Pilot Project referred to EARP 1977; separate panels established for the northern components (north of 60°N) and the alternative southern terminals (two); panel reports submitted to the Minister of DOE in 1980 and 1981
- Eastern Arctic Offshore Drilling - North Davis Strait (Referred to EARP in 1977; EIS under preparation)
- Beaufort Sea Hydrocarbon Development (Referred to EARP in 1980; EIS issued in 1982)
- Grand Banks Possible Oil Production (Referred to EARP in 1980; EIS in preparation)
- Sable Island Venture Gas Development (Referred to EARP in 1982: EIS issued in 1983)

Betty Gidney

The final public meetings of the panel reviewing the Sable Island Venture Gas Development were held recently in Port Hawkesbury, Sydney, and New Glasgow. Nova Scotia.

Institute staff have also been involved in several other panel projects (e.g.. the Polar Gas Project), in projects where an Initial Environmental Evaluation has been prepared but where the project has not (as yet) been submitted to FEARO (e.g.. offshore Labrador), and in many projects at the screening stage. In some panel projects, OSS Atlantic and/or the Atlantic Geoscience Centre are designated as the lead on behalf of their respective departments for the preparation of the departmental technical review and position statement - for example, OSS Atlantic in the case of the Sable Island Venture EIS.

Other environmental assessment and review activities

The review of EIS's and associated documents is one of several activities in the ongoing response to environmental issues arising from offshore developments. With regard to specific developments, the overall response starts when the project is first conceived and continues through the planning, develoment, and operational phases through to abandonment. However there is also involvement in broader issues of a national, regional nature or subject-specific issues, and in the development of policy. Thus, for example, the Institute is actively involved in:

- the Lancaster Sound Green Paper exercise
- the Arctic Pilot Project integrated route analysis
- development of Arctic marine conservation and marine habitat protection policy
- classification of areas in the Arctic and off the east coast for use in the renegotiation of oil and gas exploration agreements
- development of environmental guidelines for offshore seabed mining; and
- research and discussions pertaining to the disposal of radioactive waste in the deep ocean (an activity in which Canada is not involved but for which it has environmental concerns)

Another responsibility is the scientific and technical evaluation of requests for permission to dump substances at sea. It is illegal to dump any materials at sea without a permit, and a permit will not normally be granted (by DOE) to dump substances that are likely to harm the marine environment. Requests for permits are referred to the Institute by the Atlantic Regional Ocean Dumping Advisory Committee (RODAC). At BIO these are scrutinized by experts in marine geology, marine biology, chemical oceanography, physical oceanography, and hydrography to ensure that the proposed dumping is not detrimental to the environment and is in accordance with the regulations set out under the Ocean Dumping Control Act. A co-ordinated Institute response is provided for each application.

The supply of BIO-generated data and interpretation to other government departments and agencies, such as COGLA, and the performance of special mission-oriented studies on their behalf (and with their resources) are important components of the BIO response to environmental issues. An example of the latter is research in support of the National Energy Program, administered by the Office of Energy Research and Development (OERD). In 1982-83, over $2 million was received by the Atlantic Geoscience Centre and the Atlantic Oceanographic Laboratory for research in support of this program. Projects included geological studies in the Beaufort Sea and at Hibernia, research on sediment slumping on the continental slope (pertaining to drilling in deep water), east coast sea-ice and iceberg studies. and an investigation of wave forces on large fixed structures. The level of activity will increase in 1983-84 and will include the involvement of the Marine Ecology Laboratory in the development of models for assessing hydrocarbon effects on fisheries. Other national programs in which the Institute undertakes such mission-oriented research include Ocean Dumping and the Northern Oil and Gas Action Program (NOGAP). Elsewhere. research (sponsored by the Canadian Coast Guard and the Canadian Offshore Oil Spill Research Association) continues on the movement and fate of oil from the tanker *Kurdistan*, which broke up in heavy ice in Cabot Strait In 1979. The Institute is also advising the new Environmental Studies Revolving Fund on priority research areas and will have an important role to play in the evolution of this mission-oriented program.

Committees and consultations

To respond effectively to such environmental issues as are outlined in this paper, it is necessary to maintain strong links within the federal government and with outside organizations - the provinces, industry, etc. This is achieved through formal committees and informal contacts with individuals. The range of committees includes: internal committees such as DFO's East Coast Offshore Developments Committee and Arctic Offshore Developments Committee: interdepartmental committees such as the Atlantic Regional Screening and Co-ordinating Committee and the Arctic Waters Advisory Committee: joint federal/provincial committees such as the Nova Scotia/Canada Environmental Co-ordinating Committee and the Intergovernmental Environmental Committee on Annapolis Tidal Power: and committees involving industry such as the Environmental Advisory Committee on Arctic Marine Transportation, the Sable Island Environmental Advisory Committee, and the Environmental Studies Revolving Fund Program Study committees.

One of DFO's major concerns is the effects of offshore developments on offshore fish stocks and fishing operations. With this in mind, a consultation was held at BIO in 1980 on the probable consequences for the offshore fishery of offshore hydrocarbon development. It centred around ten specialists from BIO (Marine Ecology Laboratory, Marine Fish Division, and COGLA) and two other laboratories (St. Andrews Biological Station and Northwest Atlantic Fisheries Centre, both of the Atlantic Fisheries Service of DFO). Topics covered included: probable statistics of accidental release of hydrocarbons; the levels of contamination to be expected in water and biota; the probability of an effect on fish recruitment; the consequences for the offshore fishery; and the effectiveness of various countermeasures. The consultation was organized by the Marine Environment and Ecosystems Subcommittee of the Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC), whose role is discussed in the next section. The report of this consultation (Longhurst. 1982) and other similar exercises [the Arctic Research Directors' Committee of DFO. which includes several BIO members, is currently preparing position papers on the effects of oil on Arctic marine fish and marine mammals and the effects of vessel traffic in the Arctic on marine mammals] represent important tools in the environmental impact assessment and review of offshore developments.

Environmental impact assessment literature is largely unpublished and receives limited distribution yet it represents an important source of information pertaining to the offshore. The BIO Library has established a special collection of this material. It endeavours to obtain all documents containing environmental information that

Audrey Samson peruses the newly established collection of largely unpublished environmental impact assessment literature in BIO's library.

arise from the activities described in this paper and for all offshore development projects from Georges Bank to the Beaufort Sea (some 30 projects in all). The collection will continue to grow as new projects are initiated and the reports generated by existing projects continue to appear. The documents are fully catalogued and can be retrieved through the Library's author-title and subject indexes. On-Line access to the collection will be available in the near future. The collection, probably the most complete set of such documents available in Canada in the public domain, is of use to persons from government, industry, and other organizations who are involved in coastal and offshore projects, as well as to concerned members of the public.

In recent years, there has been a great increase at BIO in all aspects of the tasks outlined here, especially the documentation, co-ordination, and committee work associated with environmental impact assessments arising from northern and offshore development work. This is expected to continue. As the developments become operational note that no major offshore oil/gas projects have yet reached this stage although some coastal projects such as the Point Lepreau nuclear power station have, there will be the opportunity, providing adequate post-project monitoring is undertaken, to evaluate the projected impacts made in the assessments. In their report on an ecological framework for environmental impact assessment in Canada (Institute for Resource and Environmental Studies, Dalhousie University, and Federal Environmental Assessment Review Office. 1983). G.E. Beanlands and P.N. Duinker note that "impact assessment will not be completed until the results from monitoring are known". It is anticipated that establishments such as BIO will have an important role to play in such evaluations.

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THE FISHERIES MANAGEMENT ADVISORY PROCESS

- R.G. Halliday

It is largely a coincidence that the secretariats of the two organizations responsible for provision of scientific advice for fisheries management in Atlantic Canada are located at BIO, but a fortunate one that makes available in a single location all background information and documentation associated with this process. The Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC) is an entity of the Canadian Department of Fisheries and Oceans whereas the Scientific Council of the Northwest Atlantic Fisheries Organization (NAFO) is an international organization, but both play a major role in the co-ordination of research input to fisheries management in the area.

NAFO's predecessor, the International Commission for Northwest Atlantic Fisheries (ICNAF), was formed soon after the Second World War and for 30 years provided the focus for international co-operation in fisheries management. It supported a Standing Committee on Research and Statistics that promoted and co-ordinated scientific research on fisheries problems and advised the Fisheries Commission of ICNAF on appropriate management measures to control exploitation of fish stocks. ICNAF proved to be among the most progressive of international fisheries commissions and developed in the early seventies a comprehensive system of fishery controls based on total allowable catch (TAC) regulations for each species in each stock area throughout the northwestern Atlantic, along with a wide variety of complementary measures. In contrast, Canadian domestic management was dealt with largely on an *ad hoc* basis as problems arose. Scientists frequently contributed to the solution of these problems but there was no organized basis for providing and documenting scientific input, or for routinely reviewing biological implications of fisheries developments and identifying incipient problems before a crisis developed.

Extension of fisheries jurisdiction at the beginning of 1977 brought a large proportion of what had been international high-seas fisheries under Canadian control. Radical changes had to be made in management procedures. ICNAF was no longer an appropriate forum for dealing with international fisheries problems and so a new convention was negotiated, which established the Northwest Atlantic Fisheries Organization. This convention, for which Canada is the depository government, came into effect in 1979. It created a Fisheries Commission to deal with regulatory matters in waters outside 200 n. mile limits. The Scientific Council of NAFO, however, was given broad responsibilities to provide a forum for consultation and co-operation in scientific matters within a Convention Area that encompasses most of the marine waters of the northwest Atlantic, as well as to provide scientific advice on fisheries management to the Fisheries Commission and, on request, to coastal states. Canada has taken advantage of the services of the Scientific Council by requesting advice for fish stocks that overlap the Canadian boundary and for those still subject to some foreign fishing. The Council allows all countries enjoying benefits from fishing a resource the opportunity to contribute to data collection and scientific analysis and to participate in the formulation of advice, and it ensures that all available knowledge and expertise are brought to bear on a problem. The European Economic Community and Canada have jointly also used the Scientific Council as an advisory forum in addressing their common problems with fish resources in the Davis Strait area and with harp and hooded seal management.

The new convention notwithstanding, many important resources previously managed through ICNAF now became a purely Canadian management concern. Canadian fishery biologists proposed to create the Canadian Atlantic Fisheries Scientific Advisory Committee to deal with the scientific aspects of this new job, an initiative that received wide support within DFO. The opportunity was taken not only to solve the scientific advisory problems for marine finfish created by extension of jurisdiction, but to rationalize the advisory system for all domestic aspects of Atlantic coast fisheries management. CAFSAC's terms of reference include provision of scientific advice on "all stocks of interest or potential interest to Atlantic coast fishermen" and advisory activities include freshwater, anadromous and catadromous finfish, shellfish, marine mammal and marine plant resources, as well as groundfish and pelagic fish species.

The ICNAF Commission decided to establish its permanent headquarters in Halifax, and in 1953 its Secretariat established offices at Dalhousie University after spending a brief period in temporary accomodation at the Biological Station in St. Andrews, N.B. Soon after BIO was built, the Commission was invited to move its headquarters here and did so in 1963. Accomodation shortages at BIO in the mid-seventies required the Secretariat to rent accomodation nearby for a number of years, but with completion of the most recent BIO expansion in 1980 the Secretariat returned to BIO. It had, in the inter-

Ron Myers leaves the offices of the Northwest Atlantic Fisheries Organization at BIO bearing a load of new publications printed there.

vening period. been transformed from the Secretariat of ICNAF to that for NAFO.

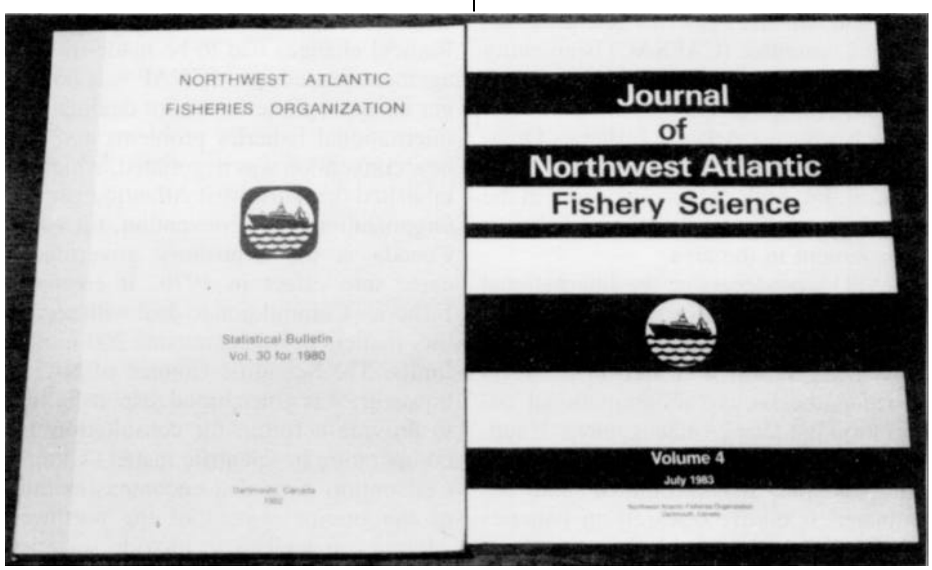
One of the first tasks undertaken by ICNAF was development of a comprehensive information system for northwest Atlantic fisheries. From the early fifties, records have been maintained of national fleet composition and characterisics and of their fishing activities in terms of catch and fishing effort based on a detailed statistical grid of 'Divisions'. These Divisions correspond as closely as is practical to fish stock distributional areas and are also used, singly or in combination, as management areas. Records are also maintained of biological sampling data from fish catches collected by national laboratories of member countries. These data are now maintained on computerized files by the NAFO Secretariat for use by the Scientific Council and its members. Statistical data on catch and fishing effort are published annually in the NAFO Statistical Bulletin, and these volumes form the Official record of fishing activities in the northwest Atlantic. The Secretariat also reports these data to the UN's Food and Agriculture Organization (FAO), and they become part of the world fisheries statistics published by that organization.

The NAFO Scientific Council, again following on in the tradition of ICNAF. maintains detailed public records of its scientific activities. All substantive information considered by the Council is submitted in the form of Research Documents. The results of its deliberations are published annually. The Council also supports two professional publications. The Scientific Council Studies series is an organ of the Council in which it publishes selected papers from its meetings and the proceedings of symposia it has sponsored. Its *Journal of Northwest Atlantic Fisheries Science* is established as a primary journal of regional scope that will accept, from all quarters, high-quality original research papers and notes on northwest Atlantic fisheries science with emphasis on the environmental, biological, ecological, and fishery aspects of living marine resources and ecosystems: it is available through a modest subscription. The journal has an editorial board, which functions under the auspices of the Council's Standing Committee on Publications. The production and distribution of all Council documents are handled by the Secretariat. These documents, along with its statistical activities, make the Secretariat an invaluable source of information on Atlantic coast fisheries.

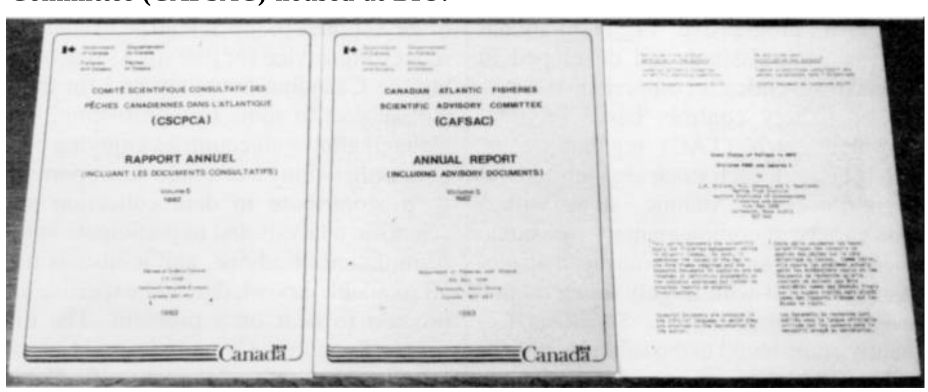
CAFSAC, which also adopted the ICNAF tradition of maintaining detailed public records of its activities, quickly found that it needed a centralized secretariat. One was first established at BIO in association with the Marine Fish Division of DFO's Scotia-Fundy Region Fisheries Research Branch. As the organization matured and with the appointment of a full-time chairman (rotated every two years). CAFSAC established separate offices at BIO in 1982. All substantive information used by CAFSAC in formulation of management advice is produced in a scientific Research Document series. Management advice itself is published in an Advisory Document series. Advisory Documents are distributed to clients in the fishing industry as produced and also incorporated in a report of the organization's activities published annually. CAFSAC documentation, which covers freshwater and coastal fisheries as well as many of the offshore marine fisheries, complements that produced by NAFO and, together, these provide comprehensive data sources on Atlantic region fisheries and fish stocks, and their management.

One of the primary activities of the NAFO Scientific Council and CAFSAC. and the one most visible to the public, is the advisory function they perform in relation to fisheries management. This func-

Sample NAFO publications.



Sample publications of the Canadian Atlantic Fisheries Scientific Advisory Committee (CAFSAC) housed at BIO.



Diane Geddes of the CAFSAC Secretariat edits a draft manuscript for one of the Committee's publication series.

tion, in the Canadian context, is the direct responsibility of scientists in the fisheries research branches of DFO's Atlantic Fisheries Service (AFS) and thus involves staff from departmental laboratories in the Newfoundland, Gulf, and Scotia-Fundy Regions, and from departmental headquarters in Ottawa. Among BIO-based organizations, the Marine Fish Division has a very substantial involvement in this process. In the NAFO context, scientists from other member governments do of course play an equal part in the process and CAFSAC encourages participation by as broad a spectrum of DFO scientists as possible and also of university and provincial scientists if they are actively working in relevant fields. Both these organizations are active in promoting scientific information exchange, co-ordinating research programs, and sponsoring co-operative research activities. These activities, which lay the basis for improved management advice in the future. are as essential as the immediate advisory process. They attract interest from scientists in diverse branches of oceanography and ecology as well as in applied fisheries research. Some BIO scientists from DFO's Ocean Science and Surveys organization are actively involved in, for example, the Standing Committee on Fisheries Science of NAFO, and particularly its Environmental Subcommittee, which promotes the application of oceanography in fisheries research, and the Marine Environment and Ecosystems Subcommittee of CAFSAC. This latter subcommittee recently sponsored a review of the fisheries ecology of the Scotian Shelf that focused on ichthyoplankton research programs and deeply involved OSS and Marine Fish Division staff at BIO as well as attracting extensive participation by AFS staff from the other regions and by faculty from local universities.

Thus, the advisory process for fisheries management involves a wide spectrum of scientists from DFO's various Atlantic coast laboratories as well as outside experts on an individual basis and also. in the case of NAFO, scientists from other member governments. The primary involvement of BIO staff in these organizations is through the Marine Fish Division but OSS staff, particularly from the Marine Ecology Laboratory, actively participate in their more general scientific work. Most NAFO Scientific Council meetings are held at BIO, the organization's headquarters.

CAFSAC's Theresa Dugas prepares to enter fisheries statistics on her word processor.

Location of CAFSAC meetings is rotated among member laboratories, including BIO. Thus, these organizations indirectly serve the purpose of bringing a diverse group of scientists to BIO and of fostering informal, as well as formal, scientific interchange. The location of the secretariats of CAFSAC and NAFO at BIO make the Institute the primary depository of scientific information on northwest Atlantic fisheries. Parties interested in further information on these organizations or in acquiring documents or publications should direct enquiries to: CAFSAC Secretariat, Bedford Institute of Oceanography, P.O. Box 1006. Dartmouth, Nova Scotia B2Y 4A2 (Telephone: 902-426-8486); and/or Northwest Atlantic Fisheries Organization. BIO, P.O. Box 638, Dartmouth. Nova Scotia B2Y 3Y9 (Telephone: 902-469-9105).

CHAPTER 5

Charts and Publications

CHART PRODUCTION

The Atlantic Region of the Canadian Hydrographic Service has a cartographic staff of 25 with the responsibility for 436 navigational charts covering the region from the Bay of Fundy to Prince of Wales Strait in the Arctic.

With new charting in full swing in 1982, 10 new charts were produced and 18 were in various stages of production. Seven new editions were produced: two in the Arctic, one in Nova Scotia, two in New Brunswick, and two in Newfoundland. Eight more were also put into production. Apart from the new editions and corrections listed below, over 80 reprints and overprints were produced during 1982 to meet demand for navigation and fishery charts.

New Charts

4142-1 Evandale to/à Ram Island
4142-2 Ram Island to/à Ross Island
4142-3 Washademoak Lake
4142-4 Grand Lake
4275 St. Peters Bay
4276 Little Bras d'Or
4278 Great Bras d'Or and/et St. Patricks Channel
4279 Bras d'Or Lake
4842 Cape Pine to/à Cape St. Mary's
4910 Miramichi
4514 St. Anthony Bight and Harbour
5138 Sandwich Bay
7405 Repulse Bay and Approaches/et les Approches
7829 Barrow Strait - Western Portion

New Editions

4335 Strait of Canso and Approaches (Loran-C)
4439 Caraquet, Shippegan, and Miscou Harbours
4486 Baie des Chaleurs

Large Corrections (Patches)

4020 Strait of Belle Isle
4212 Port Mouton
4307 Canso Harbour to Strait of Canso
4308 St. Peters to Strait of Canso
4310 Bedford Basin
4316 Halifax Harbour
4581 Long Pond
4647 Port Harmon (2)
7250 Pond Inlet

PUBLICATIONS

We present below an alphabetical listing by author of BIO publications during 1982, as well as some earlier publications not included in previous listings. Articles published in scientific and hydrographic journals, books, conference proceedings, and various series of technical reports are included. For further information on any publication listed here contact: Publication Services, Bedford Institute of Oceanography, P.O. Box 1006, Dartmouth, Nova Scotia, Canada B2Y 4A2.

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Shore party at Big Island, Saglek Bay, Labrador during the fall of 1982: C.S.S. *Hudson* lies at anchor in the background.

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In the background is the Point Lepreau nuclear generating station on the Bay of Fundy coast of New Brunswick. The inset shows Jim Abriel collecting samples of particulate matter at one of the air monitoring stations in the Point Lepreau area.

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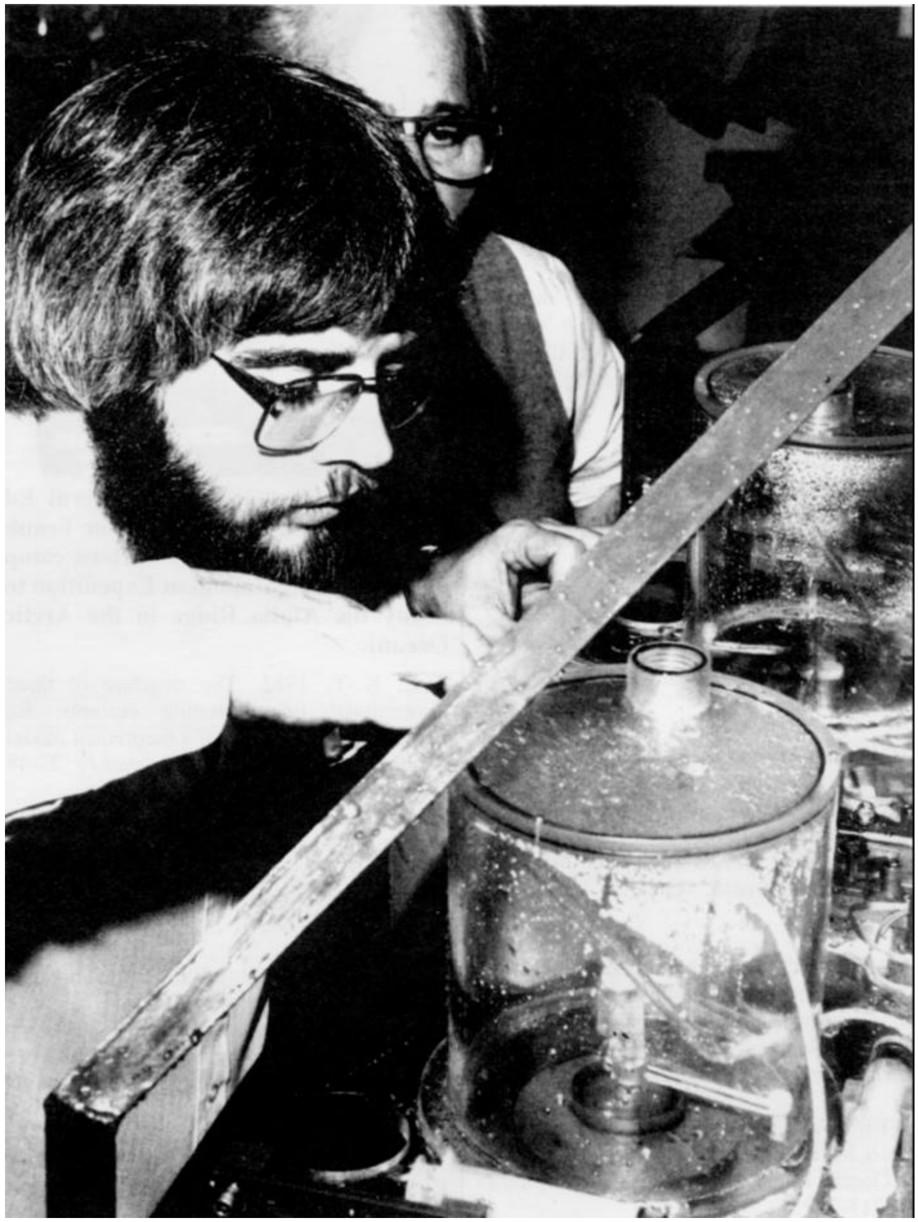

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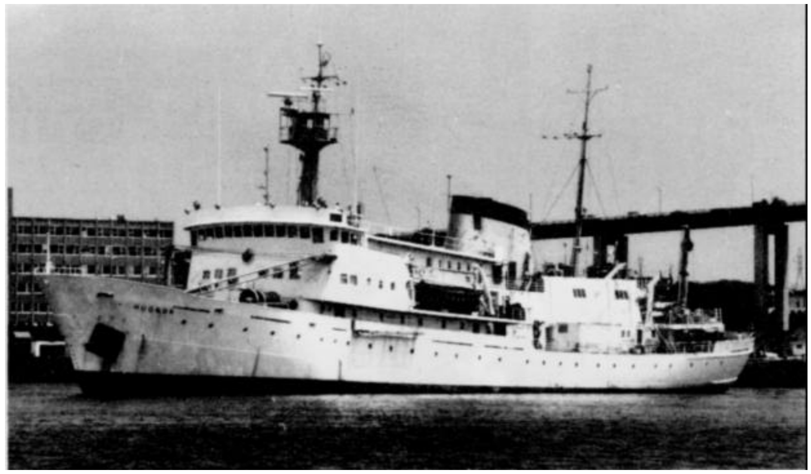
CHAPTER 6

1982 Ship Voyages

C.S.S. HUDSON

- The C.S.S. *Hudson* is a diesel-electric driven ship designed and used for multidisciplinary oceanographic research. The ship is owned and operated by the federal Department of Fisheries and Oceans
- Principal Statistics - Lloyds Ice Class I hull . . . built in 1963 . . . 90.4 m overall length . . 15.3 m overall beam . . . 6.3 m maximum draft . . . 4870 tonne displacement . . . 3721 gross registered tons . . . 17 knot full speed . . . 13 knot cruising speed in Sea State 3 . . . 80 day endurance and 23,000 n. mile range at cruising speed . . . scientific complement of 26 . . . 205 m^2 of space in four laboratories . . . two HP1000 computer systems . . . heliport and hangar . . . twin screws and bow thruster for position holding . . . four survey launches
- 239 days at sea and 35,412 n. miles steamed in 1982



VOYAGE YEAR - NUMBER	VOYAGE DATES	OFFICER IN CHARGE	AREA OF OPERATION	VOYAGE OBJECTIVES
82-001	Feb. 14 to Apr. 6	A.R. Clarke, AOL	Norwegian Sea: Greenland Sea	Deep sea winter hydrography: deep convection studies
82-002	Apr. 11 to May 2	R.M. Hendry, AOL	North Atlantic at 48°N	Baseline hydrography: ocean heat flux studies
82-014	May 25 to Jun. 10	K.S. Manchester, AGC	Scotian shelf and Slope	Equipment evaluation; acoustic survey of slope
82-018	Jun. 15 to Jul. 5	D.E. Buckley, AGC	Nares Abyssal Plain	Study history of deposition and geochemical reactivity of deep sea sediments
82-022	Jul. 7 to 26	P.J.C. Ryall, Dalhousie University	Azores to Nova Scotia	Rock core sampling; test positioning systems
82-027	Aug. 12 to Sep. 8	E.P. Jones, AOL	Labrador Shelf: Hudson Strait: Hudson Bay	Chemical oceanographic survey: investigations of biological processes, water mass sources, and mixing processes
82-031	Sep. 9 to 24	C.T. Schafer, AGC	East Baffin Island fiords	Investigation of Arctic fjord geological processes
82-034	Sep. 24 to Oct. 17	B. MacLean, AGC	East Baffin Island	Bedrock investigation: high resolution seismic profiling
82-038	Nov. 2 to 27	J.R.N. Lazier, AOL	Labrador Shelf	CTD survey: mooring replacement
82-054	Oct. 18 to Nov. 2	H.W. Josenhans, AGC	Labrador Shelf	Surficial geological surveys

Abbreviations used in this chapter include: *AGC* Atlantic Geoscience Centre; *AOL* Atlantic Oceanographic Laboratory; *BIONESS* Bedford Institute of Oceanography Net and Environment Sensing System; *CHS* Canadian Hydrographic Service; *CSS* Canadian Scientific Ship; *CTD* Conductivity, temperature, depth (profiler); *EPS* Environmental Protection Service; *INRS* Institut National pour la Recherche Scientifique; *LHPR* Longhurst-Hardy Plankton Recorder; MEL Marine Ecology Laboratory; *M.V.* Merchant Vessel; *n.* nautical; NAFO Northwest Atlantic Fisheries Organization; *NSRF* Nova Scotia Research Foundation; *UQUAR* Université de Québec à Rimouski.

C.S.S. BAFFIN

- The C.S.S. *Baffin* is a diesel driven ship designed for hydrographic surveying but also used for general oceanography. The ship is owned and operated by the federal Department of Fisheries and Oceans.
- Principal Statistics - Lloyds Ice Class I hull . . . built in 1956 . . . 87 m overall length . . . 15 m moulded beam . . . 5.7 m maximum draft 4986 tonne displacement . . . 15.5 knot full speed . . . 10 knot cruising speed in Sea State 3 . . . 76 day endurance and 18.000 n. mile range at cruising speed . . . complement of 29 hydrographic staff drafting. plotting. and laboratory spaces provided . . . two HP1000 computer systems . . . heliport and hangar . . . twin screws and bow thruster for position holding . . . six survey launches
- 164 days at sea and 20,657 n. miles steamed in 1982

VOYAGE YEAR - NUMBER	VOYAGE DATES	OFFICER IN CHARGE	AREA OF OPERATION	VOYAGE OBJECTIVES
82-010	Jun. 23 to Oct. 14	V.J. Gaudet, Atlantic Region, CHS	Sable Island: Labrador coast	Standard navigational charting
82-039	Oct. 31 to Dec. 17	M.G. Swim, Atlantic Region, CHS	Scotian Shelf	Hydrographic-Geophysical Resource charting

C.S.S. DAWSON

- The C.S.S. *Dawson* is a diesel-driven shipdesigned and used for multidisciplinary oceanographic research, hydrographic surveying. and handling of moorings in deep and shallow water. The ship is owned and operated by the federal Department of Fisheries and Oceans
- Principal Statistics - built in 1967 . . . 64.5 m overall length . . . 12 m moulded beam . . . 4.9 m maximum draft . . . 1940 tonne displacement . . . 1311 gross registered tons 14 knot full speed . . . 10 knot cruising speed in Sea State 3 . . . 45 day endurance and 11.000 n. mile range at cruising speed . . . scientific complement of 13 . . . 87.3 m^2 of space in four laboratories . . . computer suite provided . . twin screws and bow thruster for position holding . . . one survey launch
- 211 days at sea and 22,681 n. miles steamed in 1982.

VOYAGE YEAR - NUMBER	VOYAGE DATES	OFFICER IN CHARGE	AREA OF OPERATION	VOYAGE OBJECTIVES
82-003	Feb. 28 to Mar. 4	D.B. Scott. Dalhousie University	Northern Scotian Shelf and Slope	Paleo-occanopraphic studies
82-004	Mar. 8 to 18	D.E.T. Bidgood. NSRF	Scotian Shelf and Slope	High resolution seismic surveys

82-005	Mar. 22 to 26	P.C. Smith, AOL	Cape Sable. N.S.	Stereographic bottom photography: mooring retrieval
82-006	Apr. 1 to 8	K. Pocklington, AOL	Scotian Shelf and Slope: Laurentian Channel	Test hypothesis of export of organic carbon
82-007	Apr. 9 to 16	K.-T. Tee, AOL	St. Lawrence Estuary	Current meter moorings and CTD measurements
82-008	Apr. 16 to 26	D. Cossa, INRS	Saguenay Fjord	Study distribution and behaviour of trace pollutants
82-012	May. 3 to 14	R. Haedrich, Memorial University	Laurentian Channel: South Coast of Nfld	Investigate biota and sources of water types in deep basins
82-013	May. 16 to 29	H. Miller, Memorial University	Avalon Peninsula	Underwater gravity survey
82-016	Jun. 2 to 13	R.O. Fournier, Dalhousie University	Halifax Section	Investigate subsurface chlorophyll maximum and marine food chain relationships
82-017	Jun. 15 to 25	T. Koslow, Dalhousie University	Browns Bank: Bay of Fundy entrance	Examine euphausiid biology
82-025	Jul. 15 to 23	D.D. Sameoto, MEL	Emerald Basin and Bank	Testing and sampling with BIONESS and LHPR
82-026	Jul. 25 to Aug. 7	R.W. Sheldon, MEL	St. Georges Bay: Magdalen Shallows	Ecological and physical studies
82-028	Aug. 9 to 16	E. Laberge. INRS	St. Lawrence River	Zooplankton and water sampling
82-029	Aug. 17 to 26	N. Silverberg, UQAR	Gulf and estuary of the St. Lawrence	Evaluate biochemical processes of the benthic boundary layer
82-032	Sep. 8 to 15	K.-T. Tee, AOL	St. Lawrence estuary	Recovery of moorings
82-033	Sep. 22 to Oct. 7	A.S. Bennett, AOL	Northern edge of Gulf Stream	Study frontal zones
82-040	Oct. 12 to 18	C.L. Amos, AGC	Sable Island Bank	Sample and survey bed forms
82-037	Oct. 20 to 25	D.L. McKeown, AOL	Emerald Basin/Bank	Test Ametek acoustic current profiler. and positioning systems
82-035	Oct. 26 to Nov. 1	P.C. Smith, AOL	Southwest Scotian Shelf	Recover and redeploy moorings: test Ametek current profiler: hydrographic surveying
82-042	Nov. 9 to 18	G.L. Bugden, AOL	Gulf of St. Lawrence	CTD survey for annual ice forecasting; sample nutrients and oxygen: deploy satellite thermistor buoy
82-043	Dec. 1 to 8	N.S. Oakey, AOL	Scotian Shelf	Study the spatial and temporal variability of turbulence in the mixed layer

C.S.S. MAXWELL

- The C.S.S. *Maxwell* is a diesel-driven ship designed and used for inshore hydrographic surveying. The ship is owned and operated by the federal Department of Fisheries and Oceans.
- Principal Statistics-built in 1962 . . . 35 m overall length . . . 7.6 m moulded beam . . . 2.1 m maximum draft . . . 270 tonne displacement . . . 262 gross registered tons . . . 12.2 knot full speed . . . 10 knot cruising speed in Sea State 2 . . . 10 day endurance and 2400 n. mile range at cruising speed scientific complement of 7 . . . drafting and plotting facilities . . . two survey launches
- 190 days at sea and 9,902 n. miles steamed in I982

VOYAGE YEAR - NUMBER	VOYAGE DATES	OFFICER IN CHARGE	AREA OF OPERATION	VOYAGE OBJECTIVES
82-009	Apr. 20 to Jun. 24 (Phase I)	V.J. Gaudet, Atlantic Region, CHS	Cape St. Marys: Strait of Belle Isle	Standard navigational charting
82-009	Jul. 6 to Nov. 3 (Phase II)	J.D. Ferguson, Atlantic Region, CHS	Cape St. Marys: Strait of Belle lsle	Standard navigational charting
82-041	Nov. *9* to 26	R.M. Eaton, Atlantic Region, CHS	Mahone Bay. N.S.	Test Navstar, UHF, and Loran-C

NAVICULA

- The *Navicula* is a wooden-hulled fishing vessel owned and operated by the federal Department of Fisheries and Oceans and used for research in biological oceanography
- Principal Statistics - built in 1968 . . . 19.8 m overall length . . . 5.5 m moulded beam . . . 110 ton displacement . . . 78 gross registered tons
- 163 days away and 5,228 n. miles steamed in 1982

VOYAGE YEAR - NUMBER	VOYAGE DATES	OFFICER IN CHARGE	AREA OF OPERATION	VOYAGE OBJECTIVES
82-011	May 4 to Jun. 17 (Phase I)	J. Goodyear, Atlantic Region, CHS	Port Aux Basques to Hermitage Bay, Nfld.	Navigational chart revisions
82-011	Aug. 23 to Oct. 29 (Phase II)	J. Goodyear, Atlantic Region, CHS	Hermitage Bay to St. John's, Nfld.	Navigational chart revisions
82-019	Jun. 21 to Jul. 4	T. Lambert, MEL	St. Georges Bay, N.S.	Biological and physical studies: estimate mackerel spawning population
82-020	Jul. 5 to 14	G. Packman, EPS	Dalhousie, N.B., harbour: Miramichi River, N.B.	Check ocean dump sites
82-023	Jul. 15 to Aug. 18	G.C. Harding, MEL	St. Georges Bay, N.S.	Biological sampling

OTHER VOYAGES

VOYAGE YEAR - NUMBER & VESSEL	VOYAGE DATES	OFFICER IN CHARGE	AREA OF OPERATION	VOYAGE OBJECTIVES
82-015 M.V. *Sigma-T*	Jun. 1 to Aug. 12	B.D. Irwin, MEL	Bedford Basin, N.S.	Biological oceanography; equipment testing
		T. Rowell, Resource Services Directorate	South Shore, N.S.	Quahaug survey

LADY HAMMOND

- The *Lady Hammond*, a converted fishing trawler, is chartered by the Department of Fisheries and Oceans from Northlake Shipping Ltd. and used specifically for fisheries research. Its main user is the Marine Fish Division, which has components at BIO and in St. Andrews, N.B. Except as otherwise noted below in the remainder of this chapter, "officers in charge" are affiliated with the Marine Fish Division.
- Principal Statistics-built in 1972 . . . 54 m overall length . . . 11 m overall beam . . . 5.5 m maximum draft 306 gross registered tons . . . 13.5 knot maximum speed . . . 12 knot cruising speed

VOYAGE NUMBER	VOYAGE DATES	OFFICER IN CHARGE	AREA OF OPERATION	VOYAGE OBJECTIVES
H069	Jan. 6 to 18 Jan. 20 to 29	J. Reid	Georges Bank to Halifax	Standard SSIP survey cruise
H070	Feb. 2 to 12 Feb. 14 to 25	F. Budden	Slope and Gulf Stream Waters	Study distribution, and larval and juvenile abundance of *Illex illecebrosus*
H071	Mar. 1 to 10	J.S. Scott	Emerald Bank to Laurentian Channel	Groundfish inventory, and food habits and fish disease study
H072	Mar. 16 to 24	S. Smith	Emerald Bank to Bay of Fundy	Groundfish inventory, and food habits and fish disease study
H073	Mar. 29 to Apr. 7	K. Zwanenbug	Banquereau Bank to Laurentian Channel	Redfish inventory
H074	Apr. 15 to 21	N.J. McFarlane	Scotian Shelf	Juvenile groundfish survey and silver hake stomach analysis
H075	Apr. 26 to May 7	A.W. Herman. AOL	Scotian Shelf	Study vertical structure of copepods: measure chlorophyll production: and test pump system
H076	May 10 to 28	D. Waldron	Banquereau to Browns Bank	Silver hake survey
H077	May 31 to Jun. 10	G. Young	Scotian Shelf	Estimate pre-season abundance of short-finned squid
H078	Jun. 14 to 25	J. Reid	Scotian Shelf	Gear trials
H079	Jun. 28 to Jul. 2	C.I. Cosper	Emerald Bank	Live fish survey
H080	Jul. 9 to 19	P.A. Koeller	Scotian Shelf and Bay of Fundy	Summer groundfish inventory
H081	Jul. 21 to 30	J.J. Hunt	Scotian Shelf and Bay of Fundy	Summer groundfish inventory
H082	Aug. 4 to 6	S. Walsh	NAFO Division 3NO	Study distribution and abundance of flatfish and their relation to the commercial population
H083	Aug. 23 to Sep. 15	D. Reddin	Godthaab to Holsteinburg. Greenland	Sampling fish plants for biological information of salmon and fish for discriminatory function analysis
H084	Sep. 27 to Oct. 6	J.J. Hunt	Western Bank. Laurentian Channel. and Sydney Bight	Fall groundfish survey and comparative fishing with the *Alfred Needler*
H085	Oct. 12 to 26	K. Waiwood	Western Bank to Bay of Fundy	Fall groundfish survey and comparative fishing with the *Alfred Needler*
H086	Nov. 1 to 12	J. Reid	Scotian Shell	Gear trials
H087	Nov. 15 to Dec. 13	D. Beanlands	Scotian Shelf	Reaffirm pollock spawning areas and study their diurnal variation

E.E. PRINCE

- The *E.E. Prince* is a steel stern trawler used for fisheries research, and experimental and exploratory fishing. The ship is owned and operated by the federal Department of Fisheries and Oceans
- Principal Statistics - built in 1966 . . . 39.9 m overall length . . . 8.2 m overall beam 3.6 m maximum draft . . . 421 ton displacement . . . 406 gross registered tons

VOYAGE NUMBER	VOYAGE DATES	OFFICER IN CHARGE	AKEA OF OPERATION	VOYAGE OBJECTIVES
P264	Jan. 5 to 17	R. Randall	Chedabucto Bay	Abundance of herring
P 265	Jan. 17 to 29	R. Shotton, MEL	Chedabucto Bay	Abundance of herring
P 266	Feb. 15 to 24	M.-L. Dickson	East of Browns Bank & NAFO Division 4X	Collect data by acoustical means on single and multispecies of groundfish
P 267	Mar. 1 to 2	G. Shum	Emerald Bank	Obtain live fish for experimental purposes
P 268	Mar. 9 to I8	P. Hurley	Bay of Fundy	Larval herring. plankton. and microzooplankton survey
P 269	Mar. 30 to Apr. 7	G. Robert	Scotian Shelf	Stock assessment survey of sea scallops
P 270	Apr. 19 to 29	R. Mohn	Canso & Gulf near edge of Scotian Shelf	Shrimp survey
P 271	May 6 to 20	J. Reid	Georges & Browns Banks	Standard SSIP survey
P 272	May 25 to Jun. 1	R. Cormier	Off Cape Breton Island	Identify black crabs with underwater pictures
P 273	Jun. 7 to 21	G. Young	Southern Gulf of St. Lawrence	Estimate total mackerel egg production (1st coverage of grid)
P 274	Jun. 7 to 21	G. Young	Southern Gulf of St. Lawrence	Estimate total mackerel egg production (25 stations of second coverage)
P 275	Jun. 24 to Jul. 9	K. Metuzals	Gulf of St. Lawrence	Mackerel egg survey
P 276	Jul. 12 to 27	B. Charlton	Scotian Shelf	Standard SSIP survey
	Jul. 22 to Aug. 6	J. Reid	Scotian Shelf	Standard SSIP survey
P 277	Aug. 11 to Sep. 2	G. Robert	Georges & Browns Banks	Stock assessment survey of sea scallops
P 278	Sep. 9 to 17	S.J. Smith	Gulf of St. Lawrence	Fall proundfish inventory
P 278	Sep. 20 to Oct. 1	N.J McFarlane	Gulf of St. Lawrence	Fall groundfish inventory
P 279	Oct. 5 to 15	L.M. Dickie, MEL	NW of Bancaro Bank	Acoustic survey
P 280	Oct. 27 to Nov. 9	M. Power	Bay of Fundy: Gulf of Maine: off SW Nova Scotia	Larval herring survey to determine autumn distribution and abundance
P 281	Nov. 16 to 25	R. Mohn	Deep holes, SW Cape Breton	Shrimp abundance and distribution survey

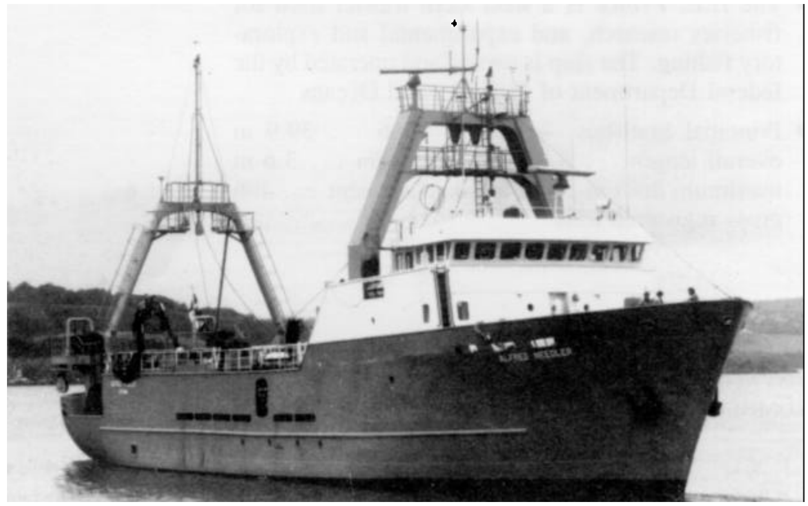
CO-OPERATIVE VOYAGES

During 1982, the Marine Fish Division participated in co-operative voyages aboard the USSR's research vessel *Ekliptika* (abbreviated as EK below)

VOYAGE NUMBER	VOYAGE DATES	OFFICER IN CHARGE	AREA OF OPERATION	VOYAGE OBJECTIVES
EK04	Sep. 22 to Oct. 14	J. Sochasky	Eastern shoals area. N.S.	SSIP cruise
EK05	Oct. 15 to Nov. 15	B Wood	Scotian Shelf	Determine abundance of O-group silver hake

M.V. ALFRED NEEDLER

- The M.V. *Alfred W.H. Needler* is a diesel-driven ship owned and operated by the federal Department of Fisheries and Oceans. and used for fisheries research.
- Principal Statistics - built in 1982 . . . 50.3 m overall length 10.9 m beam . . . 925.03 gross registered tons complement of 10 scientific staff . . . equipped with up-to-date communication systerns. electronics, navigational aids. research equipment. and fishing gear



VOYAGE NUMBER	VOYAGE DATES	OFFICER IN CHARGE	AREA OF OPERATION	VOYAGE OBJECTIVES
N-001	Sep. 13 to 24	D.J. Wildish	Browns Bank	Benthic sampling survey
N-002	Oct. 1 to 15	P.A. Koeller	Scotian Shelf	Comparative groundfish survey with the *Lady Harnmond*
N-003	Oct. 12 to 27	J.S. Scott	Scotian Shelf	Comparative groundfish survey with the *Lady Hammond*
N-004	Nov. 1 to 12	Cancelled voyage due to mechanical failure		
N-005	Nov. 15 to 28	K. Zwanenburg	Scotian Shelf	Redfish Survey (first 100 stations)
N-006	Nov. 15 to 28	K. Zwanenburg	Scotian Shell	Redfish Survey (completion of stations)

VOYAGES ABOARD CHARTERED VESSELS

VESSEL NAME	VOYAGE NUMBER	VOYAGE DATES	OFFICER IN CHARGE	AREA OF OPERATION	VOYAGE OBJECTIVES
Marinus	44	Apr. 13 to 28	J.P. Wheller	Bonavista & Trinity Bays, Nfld.	Acoustic survey
C.C.S. Shamrock	81	Jun. 2 to 17	A. Hay	Fortune Bay, Nfld.	Collect CTD profiles
R.D.R. Enterprise	RE01	Jun. 21 to Jul. 2	D. Beanlands	St. Margaret's Bay. Nova Scotia	Juvenile pollock distribution
J.L. Hart	JH003	Jun. 28 to Jul. 30	U. Buerkle	Bay of Fundy	Acoustic survey
Kevin O.A.	K002	Jul. 26 to Aug. 20	J.S. Scott	Sable Island waters	Juvenile groundfish survey
R/V Cyros	CR01	Aug. 10 to Sep. 2	H. Dupouy	Scotian Shelf	Study Distribution of squid
R/V Cyros	CR02	Sep. 5 to 18	H. Dupouy	Scotian Shelf	Study Distribution of squid
J.L. Hart	GM-82	Sep. 13 to 24	M. Lundy	Grand Manan Island. SW Bank and NE Bank	Stock assessment survey of sea scallops
M/V Shamrock	90	Sep. 16 to Oct. 5	C. George	Notre Dame Bay	Cod tagging
J.L. Hart	JH004	Oct. 4 to 7	K. Abbott	Bay of Fundy and Gulf of Maine	Determine larval herring distribution. relative abundance. and drift
J.L. Hart	-	Nov. 17 to 18	G.E. Fawkes	Grand Manan Basin	Crab survey
J.L. Hurt	-	Nov. 29 to Dec. 3	K. Abbott	Bay of Fundy and Gulf' of Maine	Determine larval herring distribution. relative abundance. and drift
J.L. Hart		Dec. 13 to 15	G.E. Fawkes	South and southeast of Grand Manan	Gonyaulax and crustacean survey

CHAPTER 7

Organization and Staff

BIO is a research institute of the Government of Canada operated by the Department of Fisheries and Oceans (DFO), both on its own behalf and for the other federal departments that maintain laboratories and groups at the Institute. Research, facilities, and services are co-ordinated by a series of special and general committees.

BIO also houses the office of the Northwest Atlantic Fisheries Organization (Executive Secretary - Captain J.C.E. Cardoso); the analytical laboratories of the Department of the Environment's (DOE) Environmental Protection Service (Dr. H.S. Samant); and the Atlantic regional office of the Canada Oil and Gas Lands Administration of the Department of Energy, Mines and Resources (DEMR). In leased accommodation at BIO are the following marine-science related private companies: Huntec Ltd., Wycove Systems Ltd., and Franklin Computers Ltd.

We present below the major groups at BIO together with their managers and a list of Institute staff as at January 1983. Telephone numbers are included in the first list: note that Nova Scotia's area code is 902 and the BIO exchange is 426. the group or division for which an individual works is given in abbreviated form following his/her name: the abbreviations used are defined in the list of major groups immediately below.

OCEAN SCIENCE AND SURVEYS, ATLANTIC (DFO)

A.R. Longhurst
DG - Director-General 3492

OID - Ocean Information Division
H.B. Nicholls, Head 3246

Public Relations
C.E. Murray, Manager 3251

BIOMAIL Officer
G.R.Smith 3251

MS - Management Services
G.C. Bowdridge, Manager 6166

Administrative Services
M.C. Bond, Chief 7060

Financial Services
E. Pottie, Chief 7060

Materiel Management Services
A.R. Mason, Chief 3487

P - Personnel Services
J.G. Feetham, Manager 2366

AOL - Atlantic Oceanographic Laboratory
G.T. Needler, Director 7456

AOL - 1. Chemical Oceanography
J.M. Bewers, Head 2371

AOL - 2. Coastal Oceanography
C.S. Mason, Head 3857

AOL - 3. Metrology
D.L. McKeown, Head 3489

AOL - 4. Ocean Circulation
J.A. Elliott, Head 2502

CHS - Canadian Hydrographic Service (Atlantic Region)
A.J. Kerr, Director 3497

CHS - 1. Field Surveys
T.B. Smith, Head 2432

CHS - 2. Chart Production
Head (position vacant) 7286

CHS - 3. Hydrographic Development
R.G. Burke, Head 3657

CHS - 4. Navigation
R.M. Eaton, Head , ... 2572

CHS - 5. Planning and Records
R.C. Lewis, Head 2477

CHS - 6. Tidal
S.T. Grant, A/Head 3846

MEL - Marine Ecology Laboratory
K.H. Mann, Director 3696

MEL - 1. Biological Oceanography
T.C. Platt, Head , ... 3793

MEL - 2. Environmental Quality
R.F. Addison, Head 3279

MEL - 3. Fisheries Oceanography
S.R. Kerr, Head 3792

IF - Institute Facilities
R.L.G. Gilbert, Manager 3681

IF - 1. Ships
E.S. Smith, Head 7292

IF - 2. Engineering Services
D.F. Dinn, Head 3700

IF - 3. Computing Services
D.M. Porteous, Head 2452

IF - 4. Library Services
J.E. Sutherland, Head 3675

IF - 5. Publication Services
M.P. Latremouille, Head 5947

ATLANTIC FISHERIES SERVICE, MARITIMES (DFO)

MFD - Marine Fish Division
T.D. Iles, A/Chief 8390

CAFSAC - Canadian Atlantic Fisheries Scientific Advisory Committee - Secretariat
D. Geddes 8390

CANADIAN WILDLIFE SERVICE (DOE)

SRU - Seabird Research Unit 3274

GEOLOGICAL SURVEY OF CANADA (DEMR)

AGC - Atlantic Geoscience Centre
M.J. Keen, Director 2367

AGC - 1. Administration
P.G. Stewart, Head 2111

AGC - 2, Eastern Petroleum Geology
G.L. Williams, Head 2730

AGC - 3. Environmental Marine Geology
D.J.W. Piper, Head 7730

AGC - 4. Program Support
K.S. Manchester, Head 3411

AGC - 5. Regional Reconnaissance
R.T. Haworth, Head 3448

STAFF LISTING

ABOU DEBS, Chantal *MEL-3*
ABRIEL, James *AOL-1*
ACKER, Quccnie *MS*
ADAMS, Al *IF-1*
ADDISON, Richard *MEL-2*
AHERN, Patrick *MEL-2*
ALLEN, Lorraine *MEL-3*
AMERO, Roy *CHS-1*
AMIRAULT, Byron *AOL-1*
AMOS, Carl *AGC-3*
ANDERSON, Bob *AOL-4*
ANDERSON, Debbie *MS*
ANDERSON, George *MS*
ANNAND, Christine *MFD*
ARCHER, Barbara *OID*
ARCHIBALD, Chris *MS*
ARMITAGE, Fred *IF-2*
ARMSTRONG, Nancy *MFD*
ASCOLI, Piero *AGC-2*
ASPREY, Ken *AGC-3*
ATKINSON, Karen *AOL-1*
ATKINSON, Tony *AGC-4*
AVERY, Mike *AGC-2*
AVEY, David *Baffin*
AWALT, Garon *IF-2*

BACKMAN, Earl *Dawson*
BAKER, Lloyd *IF-1*
BARRON, John *AOL-4*
BARSS, Sedlcy *AGC-2*
BASDEN, Kelly *IF-l*
BASTIEN, Robert *IF-2*
BEALS, Carol *CHS*
BEANLANDS, Brian *AOL-3*
BEANLANDS, Diane *MFD*
BEAVER, Darrell *AGC-4*
BECK, Brian *MFD*
BECK, Vince *IF-3*
BELANGER, Roger *IF-5*
BELL, Bill *Dawson*
BELLEFONTAINE, Larry *AOL-2*
BELLEFONTAINE, Linda *MS*
BENNETT, Andrew *AOL-3*
BENNETT, Rick *Navicula*
BERKELEY, Tom *CHS-3*
BEST, Neville *Hudson*
BETLEM, Jan *AOL-3*
BEWERS, Michael *AOL-1*
BLAKENEY, Claudia *AGC-3*
BLANCHARD, Elaine *MS*
BLANEY, Dave *CHS-1*
BLASCO, Steve *AGC-3*
BONANG, Faye *MS*
BONANG, Linda *MS*
BOND, Murray *MS*
BOUDREAU, Gerry *AOL-4*
BOUDREAU, Henri *CHS-1*
BOUDREAU, Paul *MEL-3*
BOUTILIER, Gary *MFD*
BOWDRIDGE, Gordon *MS*
BOWEN, Eileen *MS*
BOWMAN, Garnet *CHS-1*
BOWSER, Mike *IF-2*
BOYCE, Rick *AOL-2*
BOYCE, William *AGC-4*
BRANTON, Bob *MFD*
BRINE, Doug *IF-3*
BRODIE, Paul *MEL-3*

BROWN, Dick *SRU*
BUCKLEY, Dale *AGC-3*
BUGDEN, Gary *AOL-2*
BURGESS, Frank *CHS-1*
BURHOE, Meg *MS*
BURKE, Robert *CHS-3*
BURKE, Walter *CHS-1*

CALDWELL, Glen *IF-2*
CAMERON, Ralph *CHS-1*
CAMERON, Rose *MS*
CAMPBELL, Paul *AGC-3*
CARR, Judy *MFD*
CARSON, Bruce *AOL-4*
CASEY, Deborah *IF-3*
CASHIN, Elmo *IF-1*
CASSIVI, Roger *AOL-3*
CAVERHILL, Carla *MEL-1*
CHAMBERLAIN, Duncan *IF-1*
CHAPMAN, Borden *AGC-4*
CHAREST, Janet *IF-4*
CHARLTON, Beverly *MFD*

Ruth Jackson whistling while she works at the CESAR base camp.

CHENIER, Marcel *CHS-2*
CHIN-YEE, Mark *IF-2*
CLARKE, Allyn *AOL-4*
CLARKE, Tom *IF-2*
CLATTENBURG, Donald *AGC-3*
CLIFF, John *Baffin*
CLOTHIER, Rodney *Baffin*
COADY, Vernon *AGC-4*
COCHRANE, Norman *AOL-3*
COLE, Flona *AGC-3*
COLFORD, Brian *MS*
COLLIER, Kathie *AOL-3*
COLLINS, Gary *IF-3*
COMEAU, Ernest *CHS-1*
CONNOLLY, Gerald *AOL-3*
CONOVER, Bob *MEL-1*
CONRAD, Bruce *Hudson*
CONRAD, David *AOL-1*
COOK, Gary *AGC-2*
COOKE, Gary *IF-2*
COOTE, Art *AOL-1*
COSGROVE, Art *IF-5*
COSTELLO, Gerard *CHS- I*
COURNOYER, Jean *IF-2*
COX, Brian *Baffin*
CRANFORD, Peter *MEL-2*
CRANSTON, Ray *AGC-3*

CRAWFORD, Keith *CHS-2*
CREWE, Norman *AOL-1*
CRILLEY, Bernard *AGC-2*
CRONK, Suzanne *AGC-5*
CROWE, Hubert *Hudson*
CRUX-COOK, Elizabeth *CHS-2*
CUNNINGHAM, Carol *AOL-1*
CURRIE, Linda *MFD*
CURRIE, Randy *IF-3*
CUTHBERT, Jim *IF-3*

DAGNALL, Joyce *SRU*
DALE, Carla *MFD*
DALE, Jackie *MEL*
DALZIEL, John *AOL-1*
DANIELS, Marilyn *IF-3*
D'APOLLONIA, Steve *AGC-3*
DAS, Paddy *Baffin*
DAVIES, Ed *AGC-2*
DAWE, Jane *AGC-5*
DEASE, Ann *MS*
DEASE, Gerry *IF-2*

Peter Vass.

DeLONG, Bob *IF-2*
DEMONT, Leaman *IF-2*
DENMAN, Richard *MEL-3*
DENMAN, Shirley *AGC-1*
DENNIS, Pat *AGC-1*
D'ENTREMONT, Paul *AOL-2*
DEONARINE, Bhan *AGC-3*
DESCHENES, Mary Jean *IF-3*
DESSUREAULT, Jean-Guy *AOL-3*
DICKIE, Lloyd *MEL-3*
DICKIE, Paul *MEL-1*
DICKINSON, Ross *Dawson*
DICKSON, Mary Lynn *MFD*
DINN, Donald *IF-2*
DOBSON, Des *AOL-2*
DOBSON, Fred *AOL-4*
DOLLIMOUNT, Ray *Hudson*
DOWD, Dick *MEL-3*
DRINKWATER, Ken *MEL-3*
DUFFY, Sean *CHS-1*
DUGAS, Theresa *CAFSAC*
DUNBRACK, Stu *CHS-1*
DURVASULA, Rao *MEL-1*

EATON, Mike *CHS-4*
EDMONDS, Roy *MEL*
EDWARDS, Bob *P*
EISENER, Don *IF-2*

ELLIOTT, Jim *AOL-4*
ELLIS, Kathy *AOL-1*
ETTER, Jim *IF-2*

FADER, Gordon *AGC-S*
FAHIE, Ted *IF-2*
FAULKNER, Pat *MS*
FEETHAM, Jim *P*
FENERTY, Norman *IF-5*
FENN, Guy *AGC-4*
FERGUSON, Carol *IF-1*
FERGUSON, John *CHS-1*
FINDLEY, Bill *IF-1*
FITZGERALD, Bob *AGC-3*
FLEMING, Dave *CHS-2*
FODA, Azmeralda *MEL-2*
FOOTE, Tom *AOL-2*
FORBES, Donald *AGC-3*
FORBES, Steve *CHS-3*
FOWLER, George *AOL-3*
FOWLER, Mark *MFD*
FRASER, Brian *MEL-1*
FRASER, Jack *Maxwell*
FRASER, Sharalyn *P*
FRASER, Sherry *AOL-4*
FREEMAN, Ken *MEL-3*
FRICKER, Aubrey *AGC-4*
FRIIS, Mike *MS*
FRIZZLE, Doug *CHS-2*
FROBEL, David *AGC-3*
FROST, Jim *MEL-1*
FULLERTON, Anne *MEL-3*

GAGNE, Jacques *MFD*
GALLANT, Celesta *MS*
GALLANT, Roger *IF-2*
GALLIOTT, Jim *AOL-2*
GAMMON, Gary *MS*
GAUDET, Victor *CHS-1*
GAY, Tommy *IF-1*
GEDDES, Dianne *CAFSAC*
GIDNEY, Betty *IF-5*
GILBERT, Reg *IF*
GILROY, Dave *IF-2*
GIROUARD, Paul *AGC-S*
GLAZEBROOK, Sherman *AOL-4*
GOODWIN, Winston *IF-2*
GOODYEAR, Julian *CHS-1*
GORDON, Don *MEL-2*
GORVEATT, Mike *AGC-4*
GRADSTEIN, Felix *AGC-2*
GRANT, Al *AGC-2*
GRANT, Gary *AGC-2*
GRANT, Steve *CHS-4*
GREENBERG, David *AOL-2*
GREGORY, Don *AOL-4*
GREGORY, Doug *AOL-2*
GREIFENEDER, Bruno *AOL-4*
GUILDERSON, Joan *DG*
GUILBAULT, Jean-Picrrc *AGC-3*

HAASE, Bob *CHS-1*
HACQUEBARD, Peter *AGC-2*
HALE, Ken *IF-5*
HALLIDAY, James *IF-1*
HALLIDAY, Ralph *CAFSAC*
HALVERSON, George *IF-2*
HAMILTON, Jim *AOL-3*

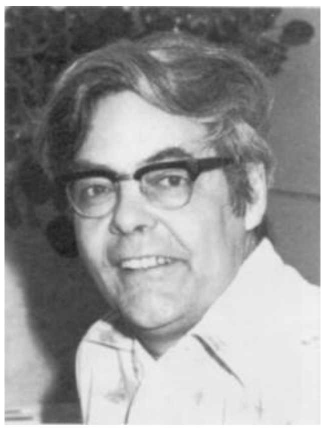
HAMILTON. Phyllis *CHS-6*
HANTZIS, Alex *CHS-2*
HARDING, Gareth MEL-2
HARDY, Iris AGC-5
HARGRAVE, Barry *MEL-2*
HANKINSON, Doug *Baffin*
HARMES, Bob *AGC-2*
HARRIS, Cynthia *MFD*
HARRIS, Jerry *Dawson*
HARRIS, Leslie *MEL-1*
HARRISON, Glen *MEL-1*
HARRISON, Liz *AGC-1*
HARTLING, Bert *AOL-2*
HARVEY, David *AOL-2*
HAWORTH, Richard *AGC-5*
HAYDEN, Helen *AOL-2*
HAYES, Terry *AGC-1*
HEAD, Erica *MEL-1*
HEFFLER, Dave *AGC-4*
HEMPHILL, Milt *CHS-1*
HENDERSON, Gary *CHS-1*
HENDERSON, Terry *AGC-1*
HENDRY, Ross *AOL-4*
HENDSBEE, Dave *AOL,-4*
HENNEBERRY, Andy *MEL-2*
HEPWORTH, Deborah *CHS-2*
HERMAN, Alex *AOL-3*
HILL, Phil *AGC-3*
HILLIER, Blair *AGC-4*
HILTZ, Ray *AOL-1*
HILTZ, Sharon *MS*
HINDS, Jim *Hudson*
HODGSON, Mark *MEL-1*
HOFFER, Darrell *AGC-5*
HOGANSON, Joan *MS*
HOLLAND, Len *Dawson*
HOLMES, Wayne *IF-2*
HORNE, Ed *MEL-1*
HORNE, Jack *IF-2*
HOUSSER, Debbie *AGC-5*
HOWIE, Bob AGC-2
HOYT, Swan *IF-4*
HUBLEY, Susa *AGC-4*
HUGHES, David *CHS-1*
HUGHES, Mike *AGC-4*
HUNTER, Leamond *CHS-2*
HURLEY, Parr *MFD*

JACKSON, Art *AGC-2*
JACKSON, Ruth *AGC-5*
JAMIESON, Steve *P*
JANSA, Lubomir *AGC-2*
JARVIS, Lawrence *Hudson*
JAY, Malcolm *CHS-2*
JENNEX, Rita *MS*
JODREY, Fred *AGC-4*
JOHN, Paulette *MS*
JOHNSON, Sue *SRU*
JOHNSTON, Larry *AGC-4*
JOLLIMORE, Roy *MS*
JOLLIMORE, Shirley *IF-4*
JONES, Peter *AOL-1*
JONES, Roger *CHS-2*
JORDAN, Francis *AOL-2*
JOSENHANS, Heiner *AGC-5*
JULIEN, Diane *MS*

KARG, Marlene *IF-3*
KAVANAUGH, Anita *IF-4*
KAY, William *AGC-5*
KEARNEY, Carl *Dawson*
KEDDY, Lil *MS*

KEEN, Charlotte *AGC-5*
KEEN, Mike *AGC*
KEENAN, Pat *AOL-2*
KEIZER, Paul *MEL-2*
KELLY, Bruce *IF-2*
KENCHINGTON, Trevor *MFD*
KEPKAY, Paul *MEL-2*
KERR, Adam *CHS*
KERR, Steve *MEL-3*
KIERSTEAD, Linda *SRU*
KING, Donna *MFD*
KING, Graeme *CHS-5*
KING, Rollie *IF-1*
KINGSTON, Peter *AOL-3*
KNOX, Don *AOL-3*
KRANCK, Kate *AOL-2*

LAKE, Diana *MS*
LAKE, Paul *AGC-2*
LAMBERT, Tim *MEL-3*
LAMPLUGH, Mike *CHS-1*
LANDRY, Marilyn *MEL-1*
LANGILLE, Neil *Navicula*
LAPIERRE, Mike *IF-2*
LAPIERRE, Richard *IF-1*



Clive Mason.

LAROSE, Jim *CHS-2*
LARSEN, Einer *MEL-1*
LATREMOUILLE, Michael *IF-5*
LAWRENCE, Don *AOL-2*
LAZIER, John *AOL-J*
LeBLANC, Bill *AGC-2*
LcBLANC, Cliff *Maxwell*
LeBLANC, Neil *MS*
LcBLANC, Paul *IF-2*
LEJEUNE, Hans *MS*
LEONARD, Jim *AOL-1*
LEVERMAN, Brian *MFD*
LEVY, Eric *AOL-1*
LEWIS, May *MEL-1*
LEWIS, Mike *AGC-3*
LEWIS, Reg *CHS-5*
LI, Bill *MEL-1*
LINDLEY, Pat *MEL-1*
LISCHENSKI, Ed *CHS-2*
LITTLE, Betty *P*
LIVELY, Bob *AOL-2*
LOCK, Stan *Baffin*
LOCK, Tony *SRU*
LOCKE, Don *AGC-4*
LOCKYER, Roy *Hudson*
LODER, John *AOL-4*
LONCAREVIC, Bosko *AGC-5*
LONGHURST, Alan *DG*

LORD, Gabriel *AOL-1*
LORING, Douglas *AOL-1*
LUTLEY, Judy *MS*
LUTWICK, Graham *CHS-6*

ILES, Derrick *MFD*
IRWIN, Brian *MEL-1*

MacDONALD, Al *MEL-1*
MacDONALD, Barry *MS*
MacDONALD, Gerry *IF-2*
MacDONALD, Kirk *CHS-5*
MacDONALD, Rose *CHS-2*
MacGOWAN, Bruce *CHS-1*
MacHATTIE, George *IF-2*
MacHATTIE, Sheila *P*
MacISAAC, Mary *MFD*
MacKAY, Bob *Hudson*
MacLAREN, Florence *P*
MacLAREN, Oswald *AOL-3*
MacLAUGHLIN, John *IF-2*
MacLEAN, Brian *AGC-5*
MacLEAN, Carleton *Baffin*
MacLEOD, Grant *CHS-2*
MacMILLAN, Bill *AGC-2*

Graham Williams.

MACNAB, Ron *AGC-S*
MAHON, Robin *MFD*
MALONE, Kent *CHS-1*
MANCHESTER, Keith *AGC-4*
MANN, Ken *MEL*
MARTELL, Jim *MS*
MARTIN, Bud *MS*
MARTIN, Harold *Dawson*
MASON, Clive *AOL-2*
MASON, Ralph *MS*
MATTHEWS, Benny *Dawson*
MATTHEWS, Gordon *Hudson*
MAUGER, Fred *Hudson*
MAZERALL, Anne *IF-4*
MCCARTHY, Cathy *AGC-2*
MCCARTHY, Paul *CHS-1*
McCORRISTON, Bert *CHS-2*
McGINN, Pete *CHS-6*
McGLADE, Jackie *MFD*
McKEOWN, Dave *AOL-3*
McMILLAN, Jim *MFD*
MCNEIL, Beverley *CHS*
McRUER, Jeff *MEL-3*
MEHLMAN, Rick *CHS-1*
MEIN, John *Baffin*
MEISNER, Patsy *CHS-2*
MIILBOURNE, Run *CHS-2*
MIDDLETON, Cecilia *AGC-2*

MILLER, Bob *AGC-5*
MILLER, Frank *CHS-2*
MILLETT, David *Buffin*
MILLIGAN, Tim *AOL-2*
MILNE, Mary *AGC-2*
MITCHELL, Carol *AGC-2*
MITCHELL, Michel *AOL-3*
MOFFATT, John *AOL-1*
MOORE, Bill *IF-1*
MORAN, Kate *AGC-3*
MUDIE, Peta *AGC-3*
MUISE, Fred *IF-2*
MUISE, Laura *MS*
MURPHY, Bob *AGC-4*
MURRAY, Ed *OID*
MYRA, Valerie *MFD*
MYERS, Steven *IF-1*

NEEDLER, George *AOL*
NELSON, Rick *AOL-1*
NETTLESHIP, David *SRU*
NEU, Hans *AOL-2*
NICHOLLS, Brian *OID*
NICHOLS, Brian AGC-5
NICKERSON, Bruce *AOL-3*
NICKERSON, Carol *MS*
NICOLL, Michael *IF-1*
NIELSEN, Jes *AGC-4*
NORTON, Neil *Baffin*

OAKEY, Neil *AOL-4*
O'BOYLE, Bob *MFD*
O'REILLY, Charles *CHS-6*
O'ROURKE, Mike *IF-2*
ORR, Ann *MEL-3*

PALMER, Nick *CHS-2*
PALMER, Richard *CHS-1*
PARANJAPE, Madhu *MEL-1*
PARSONS, An *IF-2*
PARSONS, Dave *AOL-2*
PATON, Jim *MS*
PEER, Don *MEL-2*
PELLERINE, Danny *IF-1*
PENNELL, Charles *Hudson*
PERROTTE, Roland *CHS*
PETRIE, Brian *AOL-2*
PETRIE, Liam *MEL-3*
PHILLIPS, Georgina *MEL-2*
PHILLIPS, Ted *AOL-3*
PIETRZAK, Robert *CHS-5*
PIPER, David AGC-2
PLATT, Trevor *MEL-1*
POCKLINGTON, Roger *AOL-1*
POLSON, Carl *IF-2*
PORTEOUS, David *IF-3*
PORTER, Cathy *AOL-4*
POTTIE, Dennis *AOL-1*
POTTIE, Ed *MS*
POWROZ, William *Dawson*
POZDNEKOFF, Peter *AOL-4*
PRIME, Wayne *AGC-4*
PRITCHARD, John *AOL-2*
PROCTOR, Wally *AOL-3*
PROUSE, Nick *MEL-2*
PURDY, Phil *MS*

QUINLAN, Garry *AGC-3*
QUON, Charlie *AOL-4*

RACINE, Carol *AGC-1*

RAFUSE, Phil *Baffin*
RAIT, Sue *MS*
RANTALA, Reydo *AOL-1*
RASHID, Mohammed *AGC-3*
REED, Barry *Dawson*
REID, Ian *AGC-5*
REID, Jim *MFD*
REIMER, Dwight *MEL-3*
REINHARD, Harry *MS*
REINIGER, Bob *AOL-4*
REYNOLDS, Bill *Hudson*
RICHARD, Wayne *IF-3*
RIPPEY, Jim *Hudson*
RITCEY, Jack *Baffin*
RITCEY, Michael *AOL-4*
ROBERTSON, Kevin *AGC-3*
ROCKWELL, Gary *CHS-1*
RODGER, Glen *CHS-1*
ROOP, David *CHS-1*
ROSE, Charlie *IF-2*
ROSS, Charles *AOL-4*
ROSS, Jim *CHS-2*
ROSSE, Ray *MS*
ROZON, Chris *CHS-1*
RCDDERHAM, Dave *MEL-1*
RUMLEY, Betty *AOL-2*
RUSHTON, Laurie *MEL-1*
RUSHTON, Terry *MEL*
RUXTON, Michael *CHS-1*

SABOWITZ, Norman *IF-4*
SADI, Jorge *Buffin*
SAMEOTO, Doug *MEL-1*
SANDSTROM, Hal *AOL-4*
SAUNDERS, Jo-Anne *IF-4*
SAVOY, Rachell *P*
SCHAFFR, Charles *AGC-3*
SCHIPILOW, Catherine *CHS-2*
SCHUTZENMEIER, Marion *AOL-2*
SCHWARTZ, Bernie *IF-2*
SCHWINGHAMER, Peter *MEL-?*
SCOTNEY, Murray *AOL-2*
SEIBERT, Gerald *OID*
SHATFORD, Lester AOL-3
SHAY, Juanita *IF-2*
SHELDON, Ray *MEL-3*
SHERIN, Andy *AGC-4*
SHIH, Keh-Gong *AGC-5*
SHOTTON, Ross *MEL-3*
SILVERT, Bill *MEL-3*
SIMMONS, Carol *MEL-2*
SIMMS, Judy *AOL-1*
SIMON, Jim *MFD*
SIMPSON, Pat *MFD*
SINCLAIR, Allan *MFD*
SISK, Perry *MFD*
SLADE, Harvey *MFD*
SMITH, Alan *CHS-2*
SMITH, Burt *CHS-1*
SMITH, Bill *MFD*
SMITH, Bob MFD
SMITH, Fred *IF-1*
SMITH, John *AOL-1*
SMITH, John *MFD*
SMITH, Peter *AOL-2*
SMITH, Steve *MFD*
SMITH, Stu *AOL-4*
SMITH, Sylvia *MFD*
SMITH Ted *IF-1*
SPARKES, Roy *AGC-4*
SPENCER, Florence *AGC-1*
SPENCER, Sid *IF-2*
SPRINGETT, Joan *MS*
SPRY, Jeff *MEL-1*
SRIVASTAVA, Shiri *AGC-5*
STEAD, Gordon *CHS-2*
STEELE, Trudi *AOL-4*
STEEVES, George *IF-2*
STEPANCZAK, Mike *AOL-3*
STEWART, Pat *AGC-1*
STILO, Carlos *Baffin*
STIRLING, Charles *CHS-1*
STOBO, Wayne *MFD*
STODDART, Stan *Hudson*
STOFFYN, Mark *AGC-3*
STOFFYN, Patricia *AGC-3*
STOLL, Hartmut *IF-2*
STRAIN, Peter *AOL-1*
STRUM, Loran *Hudson*
STUART, Al *IF-2*
STUIFBERGEN, Nick *CHS-4*
SUTHERLAND, Betty *IF-4*
SWIM, Mind *CHS-1*
SWYERS, Bert *AOL-2*
SYMES, Jane *P*
SYVITSKI, James *AGC-2*

Ron Macnab.

TAN, Francis *AOL-1*
TANG, Charles *AOL-2*
TAYLOR, Bill *IF-3*
TAYLOR, Bob *AGC-3*
TAYLOR, George *MEL-3*
TEE, Kim-Tai *AOL-4*
THOMAS, Frank *AGC-2*
TILLMAN, Betty *P*
TOLLIVER, Deloros *AGC-1*
TOPLISS, Brenda *AOL-2*
TOTTEN, Gary *IF-1*
TOWNSEND, Joanne *IF*
TRITES, Ron *MEL-3*

UNDERWOOD, Bob *IF-2*

VANDAL, Bob *IF-2*
VANDERMEULEN, John *MEL-2*
VARBEFF, Boris *IF-2*
VARMA, Herman *CHS-1*
VASS, Peter *MEL-2*
VAUGHAN, Betty *IF-2*
VERGE, Ed *AOL-2*
VETESE, Barb *AGC-1*
VEZINA, Guy *IF-2*
VILKS, Gus *AGC-3*
VINE, Dick *IF-2*

WADE, John *AGC-2*
WAGNER, Frances *AGC-3*
WALDRON, Don *MFD*
WALKER, Bob *AOL-2*
WARD, Brian *IF-2*
WARDROPE, Dick *IF-2*
WARNELL, Margaret *IF-3*
WEBBER, Shirley *MS*
WENTZELL, Cathy *P*
WESTHAVER, Don *IF-2*
WESTON, Sandra *CHS-2*
WHITE, George *MFD*
WHITE, Joe *MS*
WHITE, Keith *CHS-3*
WHITEWAY, Bill *AOL-3*
WHITMAN, John *AOL-3*
WIECHULA, Marek *IF-3*
WIELE, Heinz *IF-5*
WILLIAMS, Doug *MS*
WILLIAMS, Graham *AGC-2*
WILLIAMS, Pat *AOL*
WILLIS, Doug *MEL-2*
WILSON, George *IF-1*
WILSON, Jim *IF-2*
WINTER, Danny *IF-2*
WINTERS, Gary *AGC-2*
WOOD, Bryan *MFD*
WOODHAMS, Lofty *IF-2*
WOODSIDE, John *AGC-5*
WRIGHT, Dan *AOL-4*
WRIGHT, Morley *IF-2*
WTTEWAAL, Joan *IF-3*

YEATS, Phil *AOL-1*
YOULE, Gordon *AOL-3*
YOUNG, Gerry *MFD*
YOUNG, Scott *AOL-3*

ZEMLYAK, Frank *AOL-1*
ZEVENHUIZEN, John *AGC-5*
ZINCK, Maurice *MEL-2*
ZWANENBURG, Kees *MFD*

Claudia Blakeney after a hard day on *C.S.S. Hudson.*

Discussing instrument deployment on *C.S.S. Hudson's* fo'c'sle deck: L. to R. - Chief Officer Loran Strum and scientists Mike Lewis, Tim Foulkes. and Steve d'Appolonia.

CHAPTER 8

Project Listing

We present below a listing of the projects (A,B,C, etc.) and individual investigations (1,2,3, etc.) being undertaken by the four major components of the Bedford Institute of Oceanography; the Atlantic Oceanographic Laboratory, Marine Ecology Laboratory, Atlantic Geoscience Centre, and Atlantic Region of the Canadian Hydrographic Service. The listing was current at the end of December 1982. For more information on these projects and those of other BIO components, feel free to write to Publication Services, Bedford Institute of Oceanography, P.O. Box 1006, Dartmouth, Nova Scotia B2Y 4A2.

ATLANTIC OCEANOGRAPHIC LABORATORY

A. SURFACE AND MIXED-LAYER OCEANOGRAPHY

1. Sea surface wind stress, heat flux, and evaporation *(S.D. Smith, R.J. Anderson, F.W. Dobson)*
2. Arctic polynya experiment *(S.D. Smith, R.J. Anderson)*
3. CO_2 exchange at the air-sea interface *(E.P. Jones, S.D. Smith)*
4. Surface heat flux at OWS Bravo *(S.D. Smith, F.W. Dobson, J.R.N. Lazier)*
5. Wave growth studies *(F.W. Dobson)*
6. Wave climate studies *(H.J.A. Neu)*
7. Oil trajectory analysis *(D.J. Lawrence, J.A. Elliott)*
8. Surface drifters *(D. Gregory)*
9. Iceberg drift track modelling *(S.D. Smith)*
10. Microstructure in the surface layers (N.S. *Oakey, J.A. Elliott)*
11. Near-surface velocity measurements (N.S. *Oakey)*
12. Comparison of long-term mean air-sea fluxes from historical data *(F. W. Dobson, S.D. Smith)*
13. Studies of the Labrador ice edge *(G. Symonds)*
14. Gulf of St. Lawrence ice studies *(G. Symonds, G.L. Bugden)*
15. MIZEX - Marginal Ice Zone Experiment *(R.J. Anderson, S.D. Smith)*
16. Mean wind stress estimates from bulk aerodynamic formulas *(D. Wright, K. Thompson, R.F. Marsden)*
17. Fronts at the edge of Gulf Stream rings *(A.S. Bennett, D.J. Lawrence. C.L. Tang)*

B. LARGE-SCALE DEEP-SEA OCEANOGRAPHY

1. Labrador Sea water formation *(R.A. Clarke. N.S. Oakey, G.C. Gascard)*
2. Dynamics of the Labrador Sea (C. *Quon, R.A. Clarke)*
3. Labrador Current variability *(A. Allen, R.A. Clarke)*
4. Age determination in Baffin Bay bottom water *(E.P. Jones, J.N. Smith, K. Ellis)*
5. Tail of the Banks *(R.A. Clarke. R.F. Reiniger)*
6. Local-scale Gulf Stream structure *(R.M. Hendry, R.F. Reiniger)*
7. Gulf Stream extension studies *(R.M. Hendry. R.F. Reiniger)*
8. Newfoundland Basin experiment *(R.A. Clarke, R.M. Hendry, A.R. Coote)*
9. Non-linear dynamics of long waves in the ocean *(H. Sandstrom)*
10. Stability problems in GFD flows (C. Quon)
11. Northwest Atlantic atlases *(R.F. Reiniger, R.A. Clarke, R.M. Hendry)*
12. Norwegian/Greenland sea experiment *(R.A. Clarke and others)*
13. Baseline hydrography and ocean heat flux *(R.M. Hendry)*
14. Polar front or North Atlantic current *(J.R.N. Lazier)*
15. Denmark Strait overflow (C.K. *Ross)*
16. Geochemical tracer studies *(G.T. Needier, D. Wright)*

C. CONTINENTAL SHELF AND PASSAGE DYNAMICS

1. Cape Sable experiment *(P.C. Smith, D. LeFaivre, K.-T. Tee, R.W. Trites)*
2. Shelf break experiment *(P.C. Smith, B.D. Petrie, J.P. Louis)*
3. Strait of Belle Isle *(B.D. Petrie, C. Garrett, B. Toulany, D.A. Greenberg)*
4. Shelf dynamics - Avalon Channel experiment *(B.D. Petrie, C. Anderson)*
5. Tidally induced mixing *(J.A. Elliott, H. Sandstrom)*
6. Batfish internal waves *(A.S. Bennett)*
7. Dynamics of tidal rectification over submarine topography *(D. Wright, J. Loder)*
8. Dynamics of residual circulation in the Gulf of Maine *(D.A. Greenberg, J. Loder, P.C. Smith, D. Wright)*
9. Mixing and circulation on Georges Bank *(J. Loder, D. Wright)*

D. CONTINENTAL SHELF AND PASSAGE WATER-MASS AND TRANSPORT STUDIES

1. Labrador shelf and slope studies *(J.R.N. Lazier)*
2. Flemish Cap experiment *(C.K. Ross)*
3. Impact of fresh water on the water masses of the coastal region of Atlantic Canada *(H.J.A. Neu)*
4. Long-term monitoring of the Labrador Current at Hamilton Bank *(J.R.N. Lazier)*
5. Data archiving *(D. Gregory)*
6. Development of remote sensing facilities at the Atlantic Oceanographic Laboratory (C.S. *Mason, A.S. Bennett, B. Topliss)*
7. Optical properties of Canadian waters *(B.J. Topliss)*
8. Satellite estimations of primary productivity *(B.J. Topliss, T.C. Platt)*
9. Oceanography of the Newfoundland continental shelf *(B.D. Petrie)*

E. OCEANOGRAPHY OF ESTUARIES AND EMBAYMENTS

1. Saguenay fjord study *(G.H. Seibert)*
2. Northwestern Gulf of St. Lawrence *(C.L. Tang, A.S. Bennett)*
3. Gaspe Current studies *(C.L. Tang)*
4. Gulf of St. Lawrence frontal study *(C.L. Tang, A.S. Bennett)*
5. Seasonal and interannual variability in the Gulf of St. Lawrence *(G.L. Bugden)*
6. Laurentian Channel current measurements *(G.L. Bugden)*
7. The Gulf of St. Lawrence - Numerical modelling studies *(K.-T. Tee)*
8. Tidal and residual currents - 3-D modelling studies *(K.-T. Tee)*
9. Bay of Fundy tidal power - studies in physical oceanography *(D.A. Greenberg)*
10. Forced flows in the Strait of Canso *(D.J. Lawrence, D.A. Greenberg)*
11. Physical behaviour of particulate matter and sediments in the natural environment *(K. Kranck)*
12. Laboratory studies of particulate matter *(K. Kranck)*
13. Particulate matter in the Bay of Fundy and Saint John Harbour *(K. Kranck)*
14. Bottom drifters *(D. Gregory)*
15. Residual barotropic circulation in the Bay of Fundy and Gulf of Maine *(D.A. Greenberg)*
16. Suspended sediment modelling *(D.A. Greenberg, C.L. Amos)*
17. Winter processes in the Gulf of St. Lawrence *(G.L. Bugden)*
18. Modelling historical tides *(D.A. Greenberg, D. Scott, D. Grant)*
19. Storm surge *(D.A. Greenberg, T.S. Murty)*

F. SENSOR DEVELOPMENT

1. Anemometers for drifting buoys *(J.-G. Dessureault)*

2. CTDs and associated sensors *(A S.Bennett)*
3. Thermistor chains on drifting buoys *(G.A. Fowler, J.A Elliot, A.J. Hartling)*
4. Towed biological sensors *(A. W. Herman and others)*
5 The dynamics of primary and secondary production on the Scotian Shelf *(A.W. Herman, D.D. Sameoto, T.C. Platt)*
6. Vertical profiling biological sensors (A.W. *Herman, M. Mitchell. S. Young, E. Phillips)*
7. Zooplankton grazing and phytoplankton production dynamics *(A.W. Herma,. A.R. Longhurst, D.D. Sameoto, T.C. Platt, W.G. Harrison)*
8. Measurement of zooplankton variability *(A.W. Herman, D.D. Sameoto)*
9. Real-time data acquisition *(A.S. Bennett)*
10. Optical instrumentation for suspended solids measurements *(A.S. Bennett)*
11. CTD sensor time constant measurements *(A.S. Bennett)*
12. Moored biological sensors *(A. Herman, M. Mitchell, S. Young, E. Phillips)*

G. SURVEY AND POSITIONING SYSTEM DEVELOPMENT

1. Acoustic current profiler *(D.L. McKeown, R.M. Hendry)*
2. Bottom referenced acoustic positioning systems *(D.L McKeown)*
3. Ship referenced acoustic positioning systems *(D.L. McKeown)*
4. Multifrequency acoustic scanning of water column *(N.A. Cochrane)*
5. Digital echo sounding *(N.A. Cochrane*
6. Doppler current profiler *(N.A. Cochrane)*

H. OCEANOGRAPHIC INSTRUMENT DEPLOYMENT

1. Engineering studies of stable platform *(S.D. Smith, R.J. Anderson, R.G. Mills)*
7. Mooring system development *(G.A. Fowler, R.F. Reiniger, A.J. Hartling)*
3. Handling and operational techniques for instrument cable systems *(J.-G. Dessureault, R.F. Reiniger)*
4. Drill system improvement *(G.A. Fowler, P.F. Kingston, P.J.C. Ryall)*
5. In-situ sampling of suspended particulate matter *(P.F. Kingston)*
6. Measurement of geotechnical properties *(G.A.* Fowler)

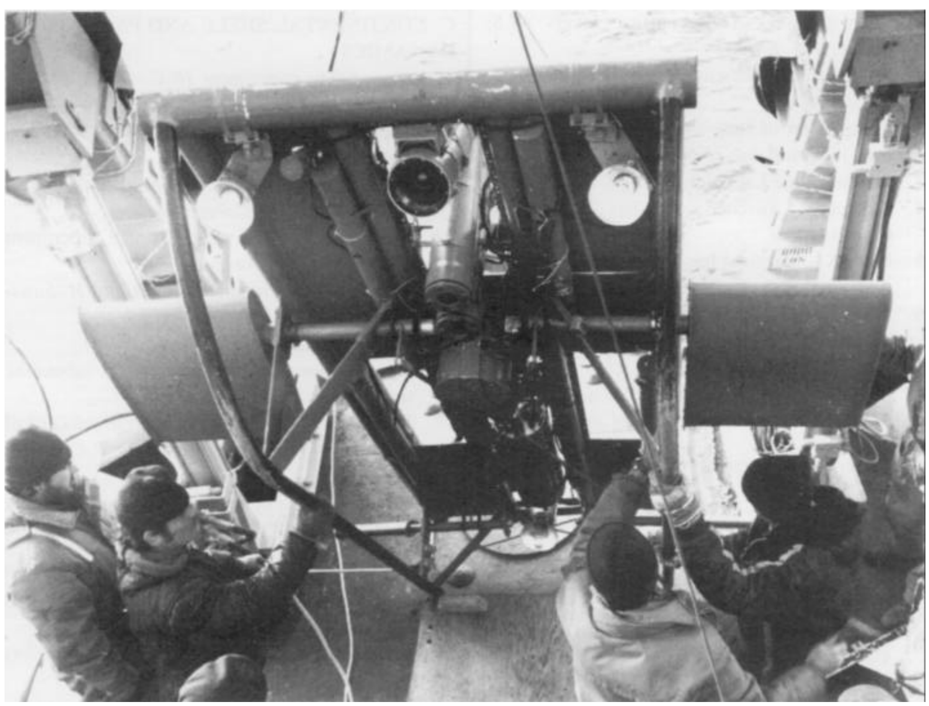
I. NEARSHORE AND ESTUARINE GEOCHEMISTRY

1. Nutrient distributions on the Grand Banks and their resupply *(A.R. Coote, E.P. Jones)*
2. Estuarine and coastal trace metal geochemistry *(P.A. Yeats, J.M. Bewers)*
3. Atmospheric input into the ocean *(P.A. Yeats, J. Dalziel)*
4. Sediment geocronology and geochemistry in the Saguenay Fjord *(J.N. Smith, K. Ellis)*
5. Sediment transport and bioturbation studies in the Bay of Fundy *(K. Ellis, J.N. Smith, D. Wildish)*
6. Comparison of organic matter in marginal seas *(R. Pocklington, C. Osterroht)*
7. Organic composition of the St. Lawrence River *(R. Pocklington, F.C. Tan, D. Cossa, E. Degens)*
8. Carbon isotope study on Scotian Shelf ecosystems *(F.C. Tan, E. Mills)*
9. Trace metals in suspended particulate matter in the Bay of Fundy *(D.H. Loring)*
10. Physical-chemical controls of particulate heavy metals in a turbid tidal estuary *(D.H. Loring, A Morris)*
12. CO_2 sinks in shelf and slope sediments *(R. Pocklington, E. Premuzic)*
12. Arctic and west coasf fjords *(J.N. Smith. K. Ellis, C.T. Schafer, J.P.M. Syvytski)*
13. Chemical pathways of environmental degradation of oil *(E.M. Levy)*
14. Climate variability in fjords *(J.N. Smith, K. Ellis, C.T. Sshafer)*
15. Plant degradation and coastal food web studies by stable isotope methods *(R. Stephenson, F. C. Tan, K.H. Mann)*

Tense moment in the computer room of C.S.S. *Hudson* - Dale Buckley, Mark Stoffyn, Ray Cranston.

J. DEEP OCEAN MARINE CHEMISTRY

1. Nutrient regeneration processes in Baffin Bay *(E.P. Jones A.R. Coote)*
2. The carbonate system and nutrients in Arctic regions *(E.P. Jones, A.R. Coote)*
3. Distribution of sea-ice meltwater in the Arctic *(F.C. Tan, P.M. Strain)*
4. Trace metal geochemistry in the North Atlantic *(P.A. Yeats, J.M. Bewers)*
5. Sediment transport, deposition, and bioturbation studies on the Newfoundland slope *(J.N. Smith, K. Ellis, C.T. Schafer)*
6. Upwelling and living resources *(R. Pocklington)*
7. Marine organic natural products *(R. Pocklington, J. Pempkowiak, J.D. Leonard)*
8. Particulate organic matter in the North Atlantic *(F.C. Tan, P.M. Strain)*
9. Paleoclimatic studies *(F.C. Tan, C.T. Schafer, D. Williams)*
10. Comparison of vertical distribution of trace metals in the North Atlantic and North Pacific oceans *(P.A. Yeats)*
11. Chemical budgets and tracers in the Arctic Ocean *(E.P. Jones, A.R. Coote)*
12. Particulate organic matter in the North Atlantic and western North Pacific *(R. Pocklington, N. Crewe)*
13. Carbon isotope fractionation studies in marine phytoplankton *(F.C. Tan, P. Wangersky)*
14. Extraction. identification. and analysis of dissolved organic matter *(R. Pocklington, F.C. Tan, T. Fu)*
15. Radionuclide measurements in the Arctic *(J.N. Smith, K. Ellis, E.P. Jones)*
16. Chemistry of sea ice *(E.P. Jones)*



The Brutiv vehicle about to be lowered from the stern of C.S.S. *Hudson* then towed at a constant distance from the seafloor. Brutiv carries TV cameras that selectively scan the bottom and deep-sea cameras that photograph sites at a preset number of frames per time interval. It was developed by the Biological Station at St. Andrews, N.B. and is now being used by the Atlantic Geoscience Centre at BIO.

MARINE ECOLOGY LABORATORY

Heinz Wiele prepares the deep-sea camera assembly for lowering over the ride of *C.S.S. Hudson.*

K. MARINE POLLUTION CHEMISTRY
1. Disolved low molecular weght hydrocarbons in Baffin Bay *(E.M. Levy)*
2. Petroleum hydrocarbon components *(E.M. Levy, P.M. Strain)*
2. Petroleum residues in the eastern Canadian Arctic *(E.M. Levv)*
4. Large-scale oil pollution of the oceans *(E.M. Levy)*
5. Point Lepreau environmental monitoring program *(J.N. Smith, K.Ellis, P.A. Yeats, G.L. Bugden, J.M. Bewers)*
6. Canadian marine chemical analytical standards program *(P.A. Yeats, J.M. Bewers, D.H. Loring)*
7. International activities *(J.M. Bewers, E.M. Levy, D.H. Loring)*
8. Joint Canada FRG caisson experiments on metal exchange between aqueous and sedimentary phases *(D.H. Loring, R. Rantala)*
9. Marine emergencies *(E.M. Levy)*
10. Heavy metal contamination in a Greenland fjord *(D.H. Loring)*
11. Baseline levels of petroleum residues and low molecular weight hydrocarbons in the Labrador and Hudson Strait regions *(E.M. Levy)*

L. TECHNOLOGY TRANSFER
1. Seabed mosaics *(J.-G. Dessureault)*
2. Ocean data systems *(J.A. Elliott)*
3. Papa *(J.A. Elliott)*

A. PRIMARY PRODUCTION PROCESSES
1. Mathematical representation and parameterization of photosynthetic response to change in light intensity *(T.C. Platt, W.G. Harrison)*
2. Dependence of photosynthesis-light parameters on environmental conditions *(T.C. Platt and others)*
3. Significance and nature of aggregation and dispersion in phytoplankton production processes *(T.C. Platt)*
4. Carboxylating enzymes and enzymes of the respiratory electron transport system in phytoplankton assemblages *(J.C. Swirl, T.C. Platt)*
5. Size fractionation of phytoplankton in photosynthesis-light experiments *(D.V. Subba Rao)*
6. Primary production rates of individual phytoplankton species *(T.C. Platt)*
7. Growth rate and protein synthesis by phytoplankton in relation to light intensity *(T.C. Platt and others)*
8. Respiration. nutrient uptake, and regeneration in natural phytoplankton populations *(W.G. Harrison, T.C. Platt)*
9. Physical oceanography of selected features in connection with marine ecological studies *(E.R.W. Horne)*
10. Physiology of marine bacteria *(W.K.W. Li)*
11. Patterns of phytoplankton photosynthesis assessed by radiocarbon distribution among cellular polymers and metabolites *(W.K.W. Li, T.C. Platt)*
12. Role f' picoplankton in the marine ecosystem *(T.C. Platt and others}*

B. SECONDARY PRODUCTION PROCESSES
1. Carbon and nitrogen utilization by zooplankton and factors controlling secondary production *(R.J. Conover)*
2. Ecology of microzooplankton in the Bedford Basin, Nova Scotia *(M.A. Paranjape)*
3. Development of profiling equipment for plankton and micronekton *(D.D. Sameoto)*
4. Use of acoustic techniques to measure distribution of plankton and ichthyoplankton *(D.D. Sameoto)*
5. Analysis of microdistribution of ichthyoplankton and zooplankton in upwelling ecosytems *(D.D. Sameoto)*
6. Nature and significance of vertical variability in zooplankton profiles *(A.R. Longhurst)*
7. Investigation of the biochemical composition of particulate organic matter in relation to digestion by zooplankton *(E. Head)*
8. Digestive enzymes in zooplankton *(E. Hcad)*
9. BIOSTAT program: zooplankton and ichthyoplankton *(D.D. Sameoto)*
10. Feeding studies on zooplankton grown in an algal chemostat *(E. Head, R.J. Conover)*

C. ATLANTIC CONSHELF ECOLOGY
1. Scotian Shelf Ichthyoplankton Program - SSIP *(R.J. Conover and others)*
2. Seasonal cycles of distribution and abundance of microzooplankton on the Scotian Shelf *(M.A. Paranjape)*
3. Comparison of methods of calculation of secondary production estimates from zooplankton population data *(R.J. Conover)*
4. Significance of Yarmouth upwelling plankton production to the general productivity of Scotian Shelf fish stocks *(D.D. Sameoto)*
5. Vertical flux of living and nonliving particles in the water column *(B.T. Hargrave, G.C.H. Harding)*
6. Comparative studies of functional structure of pelagic ecosystems *(A.R. Longhurst)*

D. EASTERN ARCTIC ECOLOGICAL STUDIES
1. Physiology. production. and distribution of marine phytoplankton *(T.C. Platt and others)*
2. Distribution, growth, production, and the role of diapause in Arctic zooplankton communities *(R.J. Conover and others)*
3. Zooplankton and micronekton of the eastern arctic *(D.D. Sameoto)*
4. Arctic surface water zooplankton *(D.D. Sameoto)*
5. Arctic microzooplankton *(D.D. Sameoto)*
6. Distribution and abundance of microzooplankton in the Arctic *(M.A. Paranjape)*
7. Ecophysiological aspects of marine bacterial processes *(W.K.W. Li)*

E. ECOLOGY OF FISHERIES PRODUCTION
1. Acoustic analysis of fish populations and development of survey methods *(L.M. Dickie and others)*
2. Genetic and environmental control of production parameters *(L.M. Dickie, K.R. Freeman)*
3. Geographic variations of production parameters *(L.M. Dickie, K.R. Freeman)*
4. Metabolism and growh of fishes *(S.R. Kerr)*
5. Mathematical analysis of fish production systems *(W.L. Silvert)*
6. Parameter estimation and the theory of prediction *(W.L. Silvert)*
7. Size-structure spectrum of fish production *(S.R. Kerr and others)*
8. Plankton growth rate in relation to size and temperature *(R. W. Sheldon)*
9. Bioenergetics: Marine mammals *(P.Brodie)*
10. Feeding strategies and ecological impact of bivalve larvae *(C. Abou Debs)*
11. Mathematical analysis of fish population interactions *(S.R. Kerr, L.M. Dickie)*
12. Marine mammal - fisheries interactions *(P. Brodie)*

F. ENVIRONMENTAL VARIABILITY EFFECTS: CLIMATIC AND ENVIRONMENTAL CONTROL OF FISH POPULATION ABUNDANCE
1. Residual current patterns on the Canadian Atlantic continental shelf as revealed by drift bottles and seabed drifters *(R.W. Trites)*
2. Water-type analyses for the NAFO areas *(R.W. Trites, K.F. Drinkwater)*
3. Mesoscale variability in current patterns in the southern Gulf of St. Lawrence *(R. W. Trites)*
4. Effect of Hudson Bay outflow on the Labrador Shelf *(K.F. Drinkwater)*

5. Effects of the St. Lawrence River outflow on the populations of fish and invertebrates in the Gulf of St. Lawrence and on the Scotian Shelf *(W.H. Sutcliffe, K.F. Drinkwater)*
6. Larval transport and diffusion studies *(R.W. Trites, D.M. Ware)*
7. Currents and transport in the George's Bank - SW Nova Scotia region in relation to the inshore/offshore lobster problem *(R.W. Trites)*
8. Oil distribution in relation to winds and currents following the break-up of the *Kurdistan (D.J. Lawrence and others)*
9. Halifax Section historical data *(K.F. Drinkwater)*
10. Environmental variability - correlations and response scales *(R.W. Trites)*
11. Climatic variability in the NAFO areas *(R.W. Trites, K.F. Drinkwater)*

G. FISHERIES RECRUITMENT VARIABILITY

1. Steady-state model and transient features of the circulation of St. George's Bay *(K.F. Drinkwarer)*
2. Lateral diffusion measurements in coastal areas *(R.W. Trites)*
3. The decline of lobster stocks off the Atlantic coast of Nova Scotia *(G.C.H. Harding and others)*
4. Seasonal variability of planktonic particle size spectrum *(G.C.H. Harding and others)*
5. Nutrition and growth of micro-, macro-, and ichthyoplankton *(R.W. Sheldon and others)*
6. Vertical movement of plankton, suspended matter, and dissolved nutrients in the water column of coastal embayments *(G.C.H. Harding and others)*
7. Early life history of mackerel *(D.M. Ware, T. Lambert)*
8. Spatial relationships between demersal fish and sediment parameters *(R.W. Sheldon)*
9. Characterization of water masses by particle spectra *(R.W. Sheldon, R.W. Trites)*
10. Langmuir circulation and small scale distribution of the plankton *(T. Lambert and others)*
11. Primary production dynamics *(K.F. Drinkwater and others)*
12. Vertical distribution and feeding behaviour of Atlantic mackerel *(B. Coté)*
13. Coupling of pelagic and benthic production systems *(P. Schwinghamer and others)*
14. Instrument development for surveys of particle size distribution *(R.W. Sheldon, J. deMestral)*
15. Trophic relationships in nearshore kelp communities *(K.H. Mann)*
16. Hydrography of the southern Gulf of St. Lawrence *(K.F. Drinkwater)*
17. Fish reproductive strategies *(T. Lambert)*
18. Recruitment of larval lobsters along SW Nova Scotia, Bay of Fundy, and Gulf of Maine *(G.C.H. Harding and others)*

H. SUBLETHAL CONTAMINATION EFFECTS

1 MFO induction by PCBs and PCB replacements *(R.F. Addison)*
2. Organochlorines in Arctic seals *(R.F. Addison)*
3. Fate, metabolism, and effects of petroleum hydrocarbons in the marine environment *(J.H. Vandermeulen)*
4. Uptake and clearance of organochlorines by zooplankton directly from sea water *(G.C.H. Harding and others)*
5. Transfer of metalloids through marine food chains *(J.H. Vandermeulen)*
6. Hazard assessment of "new" environmental contaminants *(R.F. Addison)*

I. BAY OF FUNDY ECOLOGICAL STUDIES

1. Ice dynamics in the upper reaches of the Bay of Fundy *(D.C. Gordon, Jr.)*
2. Water column chemistry and primary production in the Bay of Fundy (D.C. *Gordon, Jr., and others)*
3. Concentration, distribution, seasonal variation, and flux of inorganic nutrients and organic matter in shallow waters and intertidal sediments in the Bay of Fundy *(D.C. Gordon, Jr., and others)*
4. Intertidal primary production and respiration and the availability of sediment organic matter *(B.T. Hargrave and others)*
5. Microbial ecology of the Bay of Fundy *(L. Cammen, P. Schwinghamer)*
6. Subtidal ecology of the Bay of Fundy *(D.L. Peer, P. Schwinghamer)*
7. Intertidal benthic ecology of the upper reaches of the Bay of Fundy *(D.L. Peer and others)*
8. Zooplankton studies in the Bay of Fundy *(N.J. Prouse)*
9. Production and export of Cumberland Basin saltmarshes *(D.C. Gordon, Jr., P. Cranford)*
10. Stable carbon isotope studies of the Pecks Cove mudflat food chain *(P. Schwinghamer and others)*
11. Modelling Bay of Fundy ecosystems *(Entire group)*

J. DEEP OCEAN ECOLOGY

1. Deep ocean benthic community studies *(B.T. Hargrave and others)*
2. Kinetics of metals in sediments studied with a dialysis probe *(P.E. Kepkay)*
3. Activity of scavenging amphipods in transfer of materials in the deep ocean *(B.T. Hargrave)*
4. Vertical fluxes under the Arctic ice cap *(G.C.H. Harding and others)*

ATLANTIC GEOSCIENCE CENTRE

A. COASTAL PROGRAM

1. Consulting advice on conservation and restoration of coastal environments *(R.B. Taylor)*
2. Coastal morphology and sediment dynamics, southeast and east Cape Breton Island, N.S. *(R.B Taylor)*
3. Morphology, sedimentology, and dynamics of Newfoundland coast *(D.L. Forbes)*
4. Coastal environments and processes in the Canadian Arctic Archipelago *(R.B. Taylor)*
5. Sediment dynamics and depositional processes in the coastal zone *(D.L. Forbes)*
6. Beaufort Sea coast *(D.L. Forbes)*
7. Permafrost processes in Arctic beaches *(R.B. Taylor)*

B. COASTAL INLETS

1. The physical behaviour of suspended particulate matter in natural aqueous environments *(J.P.M. Syvitski)*
2. Sedimentology of fjord sills *(J.P.M. Syvitski)*
3. Landsat calibration for suspended sediment concentration in marine coastal environments *(C.L. Amos)*
4. Sediment dynamics - Head of the Bay of Fundy *(C.L. Amos)*
5. Geochemical transformations and reactions of organic compounds in Recent marine sediments *(M.A. Rashid)*
6. Ocean dumping consultation and study *(D.L. Forbes)*

C. CONTINENTAL SHELF

1. Ice scouring *(C.F.M. Lewis)*
2. Stability and transport of sediments on continental shelves *(C.L. Amos)*
3. Engineering geology of the Atlantic continental shelf *(C.F.M. Lewis)*

D. CONTINENTAL SLOPE

1. The Newfoundland continental slope at 49 to 50°N - Nature and magnitude of contemporary marine geologic processes *(C.T. Schafer)*
2. Quaternary geologic processes on continental slopes *(D.J.W. Piper)*

E, DEEP SEA

1. Environmental geology of the deep ocean *(D.E. Buckley)*
2. Surficial geology of the Lomonosov Ridge, Arctic Ocean *(S.M. Blasco)*

F. HOLOCENE

1. The Recent paleoclimatic and paleo-ecologic records in fjord sediments *(C.T. Schafer)*
2. Regional distribution of marine Mollusca in eastern Canada *(F.J.E. Wagner)*

G. PLEISTOCENE

1. Pleistocene-Holocene marine basin sedimentation *(G. Vilks)*
2. Quantitative Quaternary paleo-ecology, eastern Canada *(P. Mudie)*

H. SURFICIAL SEDIMENTS AND BEDROCK MAPPING

1. Bedrock and surficial geology, Grand Banks *(L.H. King)*
2. Eastern Baffin Island shelf bedrock and surficial geology mapping program *(B. MacLean)*
3. Surficial geology, geomorphology, and glaciology of the Labrador continental shelf *(H. Josenhans)*
4. Seabed II *(G.B. Fader)*

I. REGIONAL GEOPHYSICAL SURVEYS

1. East coast offshore surveys *(R.F. Macnab)*
2. Evaluation of KSS-30 gravimeter *(B.D. Loncarevic)*
3. An earth science atlas of the continental margins of eastern Canada *(S.P. Srivastava)*

J. DEEP STRUCTURAL INVESTIGATIONS

1. Geophysical investigations of the submarine extension of geological zonation of Newfoundland *(R.T. Haworth)*

2. Comparative studies of the continental margins of the Labrador Sea and of the North Atlantic *(S.P. Srivastava)*
3. Seismic studies of continental margins and ocean basins of the North Atlantic (C.E. *Keen)*
4. CESAR - the Canadian Expedition to Study the Alpha Ridge: Surficial geology of the Alpha Ridge Arctic Region *(H.R. Jackson)*
5. Geology of the Atlantic margin: Canada *(R.T. Haworth)*
6. The tectonics of the intersection of a mid-ocean ridge and a transform fault *(B.D. Loncarevic)*
7. Seismicity studies of the eastern low margins *(I. Reid)*

K. THEORETICAL MODELLING
1. Rift processes and the development of passive continental margins (C.E. *Keen)*

L. BASIN ANALYSIS AND PETROLEUM GEOLOGY
1. Regional subsurface geology of the Mesozoic and Cenozoic rocks of the Atlantic continental margin *(J.A. Wade)*
2. Geological interpretation of geophysical data as an aid to basin synthesis and hydrocarbon inventory *(A.C. Grant)*
3. Compilation of geoscientific data in the Upper Paleozoic basins of southeastern Canada *(R.D. Howie)*
4. Stratigraphy and sedimentology of the Mesozoic and Tertiary rocks of the Atlantic Continental margin *(L.F. Jansa)*
5. Reconnaissance field study of the Mesozoic sequences outcropping on the Ibcrian Peninsula *(L.F. Jansa)*
6. Microscopic study of pyrite in main seams of Sydney coalfield. Nova Scotia *(P.A. Hacquebard)*

M. RESOURCE APPRAISAL
1. Hydrocarbon inventory of the sedimentary basins of eastern Canada *(J.A. Wade)*
2. Geological assistance with provincial coal drilling project in Nova Scotia *(P.A. Hacquebard)*
3. To advise DEVCO on coal geology of its operations in the Sydney coalfield *(P.A. Hacquebard)*
4. Rank and petrographic studies of coal and organic matter dispersed in sediments *(P.A. Hacquebard)*
5. Maturation studies *(G.L. Williams)*

N. BIOSTRATIGRAPHY
1. Identification and biostratigraphic interpretation of referred fossils *(Various staff members)*
2. Palynological zonation of the Carboniferous and Permian rocks of the Atlantic provinces *(M.S. Barss)*
3. Biostratigraphy of the Atlantic and relevant areas *(E.H. Davies)*
4. Taxonomy, phytogeny, and ecology of palynomorphs *(E.H. Davies)*
5. DSDP dinoflagellates *(G.L. Williams)*
6. Biostratigraphic zonation (Foraminifera. Ostracoda) of the Mesozoic and Cenozoic rocks of the Atlantic shelf *(P. Ascoli)*
7. Biostratigraphic history of the Mesozoic-Cenozoic sediments of the Grand Banks, northeast Newfoundland. and Labrador shelves (based on Foraminifera and Ostracoda) *(F.M. Gradstein)*
8. Taxonomy, biostratigraphy, paleo-ecology, and paleobiogeography of Mesozoic-Ccnozoic agglutinated Foraminifera *(F.M. Gradstein)*

O. DATA BASES
1. Geological Survey of Canada representative on steering committee of the Kremp palynologic computer research project *(M.S. Barss)*
2. Information data base. offshore east coast wells *(G.L. Williams)*

P. TECHNOLOGY DEVELOPMENT
1. Systems develoment *(D.E. Heffler)*
2. Implementation and maintenance of data management system for geophysical data *(A.G. Sherin)*
3. Sediment dynamics monitor - RALPH *(D.E. Heffler)*
4. Vibracorer updating *(K.S. Manchester)*
5. Coastal information system development *(A. Fricker, D.L. Forbes)*

ATLANTIC REGION, CANADIAN HYDROGRAPHIC SERVICE

4. FIELD SURVEYS
1. Coastal and Harbour Surveys
   - Liscomb Island to Beaver Harbour. N.S. *(R.P. Haase)*
   - Sable Island *(V. Gaudet)*
   - Davis Inlet. Labrador Coast *(V. Gaudet)*
   - St. Mary's Bay, N.S. *(J. Ferguson)*
   - Strait of Belle Isle *(J. Ferguson)*
   - Miramichi River, N.B. *(J. Ferguson)*
   - Port Harmon. Nfld. *(J. Ferguson)*
   - Courtenay Bay, N.B. *(J. Ferguson)*
   - Eastern Arctic *(R. Cameron, S. Dunbrack)*
2. Revisory South Coast of Newfoundland *(J. Goodyear, R. Pietrzak)*
3. Offshore Scotian Shelf - Georges Bank to the Grand Banks *(M.G. Swim)*
4. Horizontal control Shoreline plots for Trinity Bay, Nfld. *(M.G. Swim, K. Malone)*
5. Upgrading survey launches *(T.B. Smith)*

B. TIDE AND CURRENT STUDIES
1. Inspection and servicing of the Permanent Tides and Water Levels Gauging Network *(C.P. McGinn)*
2. Inspection and servicing Arctic tide gauges *(C.P. McGinn)*
3. Completion of the tidal telemetry system *(Concordia University)*
4. Offshore deployment of three tide gauges *(C.P. McGinn)*
5. Deployment and recovery of one tide gauge in Koksoak River *(C.P. McGinn)*
6. Review and update of 1984 Tide Tables *(C. O'Reilly)*
7. Review and update of the tidal and current information in Labrador and Hudson Bay Pilot. Gulf and River St. Lawrence Pilot. and Arctic Pilot (C. *O'Reilly, S.T. Grant)*

C. NAVIGATION
1. Loran-C error predictions of Atlantic Canada *(N. Stuifbergen)*
2. Development of NAVSTAR (S.T. *Grant)*
3. Upgrading BIONAV *(S.T. Grant, M. Ruxton)*
4. Development of the electronic chart *(R.M. Eaton)*
5. Evaluation of UHF *(R.M. Eaton)*
6. Hi-Fix accuracy over sea ice *(N. Stuifbergen)*
7. New type of Loran-C receiver with video display *(R.M. Eaton)*
8. Contract development of the Canadian Fishcrmen's Charts *(R.M. Eaton)*

D. CHART PRODUCTION
1. Production of 11 New Charts. 5 New Editions. and 26 Chart Amendment Patches. and drafting of 50 Notices to Mariners *(B. McCorriston, W.S. Crowther, R. Chapeski)*

E. SAILING DIRECTIONS
1. Revisions to Sailing Directions on the south coast of Newfoundland *(R. Pietrzak)*
2. Revised Newfoundland Sailing Directions *(R. Lewis, R. Pietrzak)*

F. HYDROGRAPHIC DEVELOPMENT
1. Upgraded software documentation for HAAPS processing package *(K.T. White)*
2. Evaluation of depth digitizers and magnetic tape units *(R.G. Burke and S.R. Forbes)*
3. Evaluation of vertical acoustic sweep system *(R.G. Burke)*
4. Design and testing of sonar boom system *(R.G. Burke, R.N. Vine, T.S. Berkeley)*

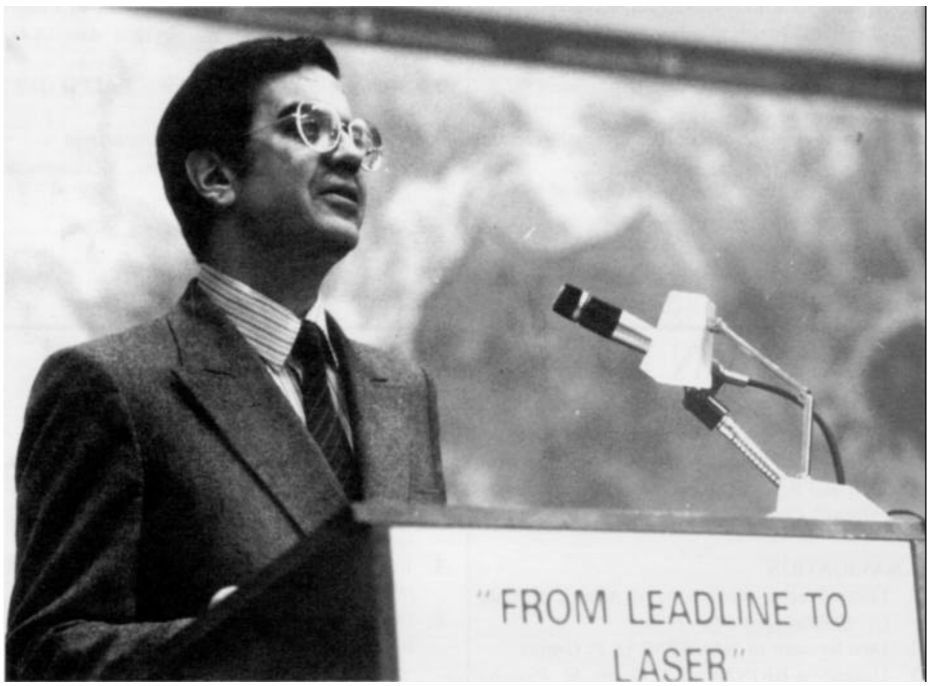
G. RESEARCH AND DEVELOPMENT
1. ARCS - Development of an Autonomous Remotely Controlled Submersible to use in the Arctic under ice cover *(under contract to International Submarine Engineering Ltd.)*
2. DOLPHIN - Development of a Remotely Controlled Survey Vehicle to run parallel sounding lines with a parent ship *(under contract to International Submarine Engineering Ltd.)*

Heiner Josenhans monitors Brutiv aboard C.S.S. *Hudson.*

CHAPTER 9

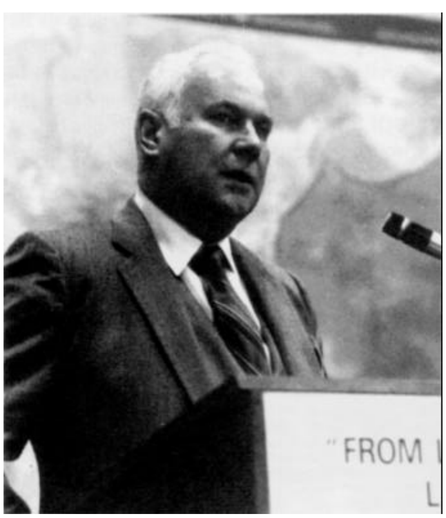
Excerpts from the BIO Log

To celebrate the first century of marine surveying by the Canadian Hydrographic Service, over 400 hydrographers and others met in Ottawa in April 1983. They were there to attend “From Leadline to Laser”, a four-day conference organized by the Canadian Hydrographic Service and the Canadian Hydrographers’ Association. Topics discussed ranged from 18th and 19th century British and French contributions to hydrography in Canada to hydrography in the early years following the 1883 founding of the Georgian Bay Survey by the Canadian government to hydrography today with its improved field-survey techniques, computer-assisted cartography. electronic positioning systems. and remote. sensing techniques.



The Hon. Pierre De Bane, Minister of Fisheries and Oceans.

Jean Bourgoin of the Service hvdrographique et océanographique de la marine, Paris.



Gerry N. Ewing, Assistant Deputy Minister of Ocean Science and Surveys, DFO.

Stephen MacPhee, Director General of the Canadian Hydrographic Service.

The very latest fashions for hydrographers - Neil Anderson and Adam Kerr.

Dr. Christopher Garrett received the 1982 A.G. Huntsman Award for Excellence in the Marine Sciences. The silver-medal award was presented to him at BIO by Dr. George Garland, President of the Academy of Sciences of the Royal Society of Canada. Dr. Garrett, a professor of oceanography at Dalhousie University in Halifax, was selected as the fifth recipient of the award for contributions to the understanding of mixing processes in the ocean and for his fundamental achievements in the field of internal wave dynamics.

Among BIO staff who received special honours recently, Eric Levy (at left) was given a Merit Award for his contributions to the Intergovernmental Oceanographic Commission's IGOSS Pilot Project on Marine Pollution (Petroleum) Monitoring - the MAPMOPP program. Eric was involved in this program since its inception following the 1972 Stockholm Conference on the Environment. He was instrumental in its execution and took the lead in many aspects of the program including the preparation of its final report published in 1981.

Norman Fenerty (at right) received the William Gordon Memorial Award for 1982 of the Biological Photographic Association for his outstanding achievements in scientific photography: his nomination was made by the Canadian chapter of this international association of biological and medical photographers. Norm has for many years been responsible for the organization of all photographic work at BIO and has specialized in the use of this medium in deep-sea and aerial work. His work has been applied to hydrographic surveys as well as to general oceanography and marine geology.

Trevor Platt received the 1981 APICS/Fraser Medal. The award is given for outstanding research conducted in Atlantic Canada by younger scientists and engineers. It is sponsored by the Atlantic Provinces Council on the Sciences and consists of a Gold Medal and $1,000. The distinguished panel from across Canada chose Trevor for his contributions to biological oceanography. A physicist by early training, he has helped unravel the relationship between biological productivity and the physical environment.

JOA 1982 registration desk, Dalhousie University.

Dr. E. Simpson, Dr. A. Ayala-Castanares, and the Hon. R. LeBlanc.

Drs. E. Seibold and W. Wooster.

Captain Fred Mauger, Mr. Gerry Ewing, and His Excellency Governor General E. Schreyer aboard C.S.S. *Hudson.*

JOA 1982 was hosted by Canada at the recommendation of the Canadian National Committee of SCOR, the Scientific Committee on Ocean Research. During the two weeks of the 5th Joint Oceanographic Assembly at Dalhousie University in Halifax, Canadian oceanography was exposed to a large international audience of peers. Apart from many DFO oceanographers being 'high profile' participants in the JOA, the facilities of BIO were put on display to such an audience for the first time.

The BIOMAIL Office

BIO's Marine Advisory and Industrial Liaison office, or BIOMAIL for short, is there to:

- assist in obtaining oceanographic information for you
- help you solve your problems with any aspect of oceanography
- smooth the transfer of our know-how to your company
- facilitate joint projects with BIO and industry
- bring the right people together for an expansion of oceanographic industry.

BIOMAIL's scope is not limited to local or Canadian aspects; we have access to global ocean information and expertise. The office is here to serve the interests of Canadian industry for the benefit of Canadian citizens.

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