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Introduction

The Bedford Institute of Oceanography (BIO) is a major oceanographic research facility, established in 1962 by the Federal Government of Canada and is located on the shores of the Bedford Basin in Dartmouth, Nova Scotia. The Institute will celebrate its 40th anniversary in 2002. Over the last four decades it has grown to become Canada's largest centre for ocean research. Scientists at BIO perform targeted research, mandated by the Canadian government, to provide advice and support to government decision making on a broad range of ocean issues including sovereignty, defence, environmental protection, health and safety, fisheries and natural resources, and also undertake environmental planning and oceans management.

DFO is represented by four divisions within its Science Branch, the Canadian Hydrographic Service (CHS), three divisions of the Oceans and Environment Branch, the Aquaculture Coordination office, and by technical and vessel support from the Canadian Coast Guard (CCG). Together they provide scientific knowledge and advice on issues related to climate, oceans, the environment, marine and diadromous fish, marine mammals, shell fish and marine plants, and carry out oceans and environmental management and planning.

NRCan is represented by the Geological Survey of Canada (Atlantic), Canada's principal marine geoscience facility. Its scientific research expertise focuses on marine and petroleum geology, geophysics, geochemistry, and geotechnology. GSC Atlantic is also the source of integrated knowledge and advice on Canada's coastal and offshore landmass.

DND's Route Survey Office of Maritime Forces Atlantic, located at BIO, supports ocean surveillance activities. Surveys are conducted in areas of the sea floor of specific interest to DND in cooperation with CHS and GSC Atlantic.

In support of the Canadian Shellfish Sanitation Program, the Shellfish Section of Environment Canada conducts sanitary and water quality surveys and analyzes the samples at the microbiology laboratory at BIO.

Altogether, approximately 650 scientists, engineers, technicians, managers, support staff, contractors and others from a variety of disciplines work at BIO.

This review highlights some of the ongoing research activities at the Institute as well as some of the activities dealing with the management of the oceans.

Four federal departments are located at BIO: Fisheries and Oceans Canada (DFO), Natural Resources Canada (NRCan), Environment Canada (EC), and the Department of National Defence (DND)

Jacob Verhoef, Director
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Natural Resources Canada

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Oceans and Environment
Fisheries and Oceans Canada

Big Motion Pictures of Chester, Nova Scotia filming a scene in the BIO auditorium for the four-hour mini series, Trudeau, *staring Colm Feore – photo by Chris Reardon.*

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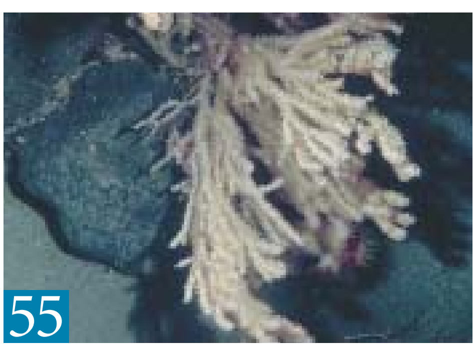

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In 2001, staff of the Bedford Institute of Oceanography continued to perform targeted oceanographic and biological research mandated by the Canadian government and engaged in management activities under the *Oceans Act* and the *Fisheries Act*. They provided advice on marine environments, especially those supporting fisheries, aquaculture, offshore hydrocarbon resources, provided navigational charts for waters from Georges Bank to the Canadian Arctic, undertook numerous reviews of development activities under the habitat protection provisions of the *Fisheries Act* and the *Canadian Environmental Assessment Act*, and led a number of oceans management activities. Some of the activities undertaken during 2001 to support emerging priorities are summarized below, or are featured in articles in this report.

NEW INITIATIVES

Late in 2000, the **Centre for Marine Biodiversity** (CMB) was established in partnership with scientists and students principally from Dalhousie University, Halifax, NS and the Huntsman Marine Science Centre, St. Andrews, NB. In the summer of 2001, Dr. Ellen Kenchington of BIO was elected as the first Executive Director, and the Centre's administrative office was located at BIO. Also in 2001, as part of a Memorandum of Understanding with Dalhousie University, a DFO Chair in Resource Conservation Genetics was created. Dr. Paul Bentzen presently holds this position (see the *Other Programs* section of this report for more information on the CMB).

The **Canadian Hydrographic Service** (CHS) obtained national ISO 9001-2000 certification in December 2001 from the International Organization for Standardization. This achievement is a result of more than two years of effort by CHS, at the national and regional levels, to meet the stringent ISO requirements. The ISO 9000 family of international quality management standards and guidelines has earned a global reputation as the basis for establishing quality management systems. For more details on ISO 9001-2000 at CHS refer to the *Science Activities* section of this report.

A Memorandum of Understanding (MOU) between **DFO** and the **Canada-Nova Scotia Offshore Petroleum Board** (CNSOPB) was signed on July 26, 2001. This MOU established a formal process through which DFO and CNSOPB can work together to facilitate and promote the sound management of petroleum activities while protecting the marine environment. Additional details are in the article in the *Resource Management Highlights* section of this report.

In 2001, BIO played a leadership role in the federal science and technology (S&T) community by initiating the **Hypatia Project**. This project was designed to identify and develop a strategy to reduce the factors limiting the recruitment, participation, and retention of women in its science and technology positions. The project was named Hypatia after an Egyptian mathematician, astronomer, natural philosopher, and teacher who lived in Alexandria in the fourth century. According to historical records, she was the first woman recognized as a scientist. This initiative is part of a provincial project to design and implement long-term strategies to improve the representation of women in S&T in Nova Scotia. Mandates of the Hypatia Project include improving organizational health, increasing awareness of the benefits that diversity brings to creativity in science and technology, and developing a workplace that actively supports diversity.

FIELD PROGRAMS AND ACTIVITIES

The **Canadian Hydrographic Service** conducted surveys in 2001 in Notre Dame Bay, St. Georges Bay, and St. Anthony, Newfoundland; in Red Bay, Labrador; and in the Bras d'Or Lakes, Nova Scotia. The Notre Dame Bay survey enabled the production of a new Canadian chart to replace a British chart that is over 100 years old. Two new 7.5m survey launches were ordered, the first new boats for CHS in 15 years. They will provide CHS with trailerable vessels for use on small high priority surveys. Additional activities included:

- Processing and publishing *Notices to Mariners* to update charts for major changes to the Coast Guard aids to navigation systems.

- Electronic chart coverage for all major harbours and routes on the East Coast has been completed. Production of traditional products continued with the publication of new paper charts and new editions of old charts.

Harbour and grey seals on a beach of Sable Island – photo by Jim McMillan.

- Progress has been made in updating older charts to modern standards. Critical computer hardware and software have been upgraded and the electronic data storage system at BIO has been improved.

Several **Ocean Sciences** programs made significant progress during 2001:

- An intensive current meter-mooring program across the Scotian Slope was initiated in partnership with the oil and gas industry.

- The recovery of the first year-round deployment of a sediment trap in the Labrador Sea showed higher than expected sedimentation rates in the fall and early winter.

- A winter field program on the water circulation patterns off Muggah Creek, Cape Breton was completed as part of an ongoing study of the fate of pollutants in Sydney Harbour.

- The Canadian contribution to the Atlantic part of the global array of Argo floats was initiated with the deployment of four profiling floats on the slope water region of the northwest Atlantic.

- The second year of a multi-disciplinary study of the Bras d'Or Lakes ecosystem was carried out. The primary focus has been on circulation patterns and detailed multibeam mapping of the bottom, with additional work on plankton blooms and fish distributions.

The **Marine Aquatic Species at Risk** office reported that surveys of right whale distribution in the Gulf of Maine area, conducted in collaboration with several United States groups, indicated the return of over 20 calves to the Bay of Fundy. This is a record compared to returns observed during the past decade.

The corpse of a leatherback turtle was found near the Bird Islands, off Cape Breton Island by a fisherman who brought it to the attention of the Nova Scotia Leatherback Turtle Working Group (NSLTWG). The NSLTWG, in collaboration with BIO, arranged for a public necropsy of the turtle and also conducted several education sessions for school children to increase awareness of the endangered leatherback turtle and current research pertaining to the species.

Progress was made on the following **Marine Fish Division** (MFD) initiatives in 2001:

- In collaboration with the fishing industry, scientists with MFD surgically implanted 200 inshore cod with acoustic transmitters and then deployed an array of acoustic receivers along 160 km of the seafloor off Cape Breton. The aim of the study was to evaluate the degree of mixing of inshore Cape Breton cod stocks with the Gulf of St. Lawrence cod that migrate off Cape Breton during the winter. Initial results indicated the receivers detected more than 50% of the cod during their annual migration, clearly showing where and when they moved.

- The Strategic Science Fund Project, Comparative Dynamics of Exploited Ecosystems in the Northwest Atlantic (CDEENA), has completed its third full year. The first two years were largely focussed on obtaining the data required for constructing models of ecosystem structure and function in Atlantic Canadian waters from the 1970s to the present. During the most recent year, many of these models approached completion, and the project is in the phase of comparing the various time periods and areas. The BIO contribution to this zonal project includes mass balance models of the eastern and western Scotian Shelf areas in two different time periods, models of multi-species dynamics, and reconstruction of cod-seal-fishery interactions on the eastern Scotian Shelf. The completion of the project is expected to include a special session at the American Fisheries Society meeting in Québec in 2004.

- The division has maintained an active grey seal population-monitoring program at Sable Island, Nova Scotia since 1977, and joint project research activities with Dalhousie University and the Smithsonian Institution have been in place since 1989. The research has focussed on generating new knowledge on grey seal foraging ecology and reproduction that has direct application to resource management issues. Distribution, foraging, reproduction, lactation, and behaviour projects were conducted.

- MFD is involved in the study of the threatened loggerhead and endangered leatherback turtle. The goal of the study is to identify when these animals arrive in Canadian waters, behaviour they exhibit while here, and the threats they face during their stay. A joint research project has been established with Dalhousie University and members of the Nova Scotia Leatherback Working Group whose researchers have successfully attached satellite-linked transmitters to 13 leatherback turtles in 2001. These turtles were tracked while in Canadian waters and beyond, providing exciting new knowledge on their movements. A subset of the turtles were fitted with dive-recorders that provided data about their foraging activities. This project will continue through 2002.

- MFD played an integral role in the groundfish pilot project sponsored under the DFO Objective-Based Fisheries Management Initiative. This national initiative introduces risk management, including the precautionary approach, to fishery management and requires that planning encompass general ecosystem considerations, socio-economic aspects of the fishery, and the conservation requirements of the stocks that support the fishery.

- Virtual Data Centre (VDC) presentations were made at a variety of national and international venues including: Canada-USA Fisheries Science bilateral meeting and the North Atlantic Fisheries Organization (NAFO) Scientific Council meeting. New data products such as online mapping continue to be produced on a regular basis. The Canadian Geospatial Data Infrastructure Initiative (GeoConnections) is creating a strong interest in VDC-based datasets as a source for marine geospatial data. For additional information on VDC, refer to the article in the *Science Activities* section of this report.

Cup coral (Flabellum alabastrum) *in an aquarium at BIO. The coral was collected from the Scotian Slope at around 400 meters. – photo by Pål Mortensen.*

The **Marine Environmental Sciences Division** has been involved in coral research since 1997. Deep-sea corals (200-1500 m) are abundant off Atlantic Canada, and concern has been raised about their vulnerability to human disturbance. In 2001, this program took a major step forward when the Environmental Studies Research Fund approved a two-year project to expand the current research effort. Two Norwegian deep-sea coral experts, Pål and Lene Mortensen, are working full time on coral studies. In addition to gathering information on coral distribution, new data are being collected on coral abundance, habitat association, and associated species from research cruises in 2001 to the Northeast Channel, the Verrill Canyon, the Gully, and along the continental slope. Some live coral specimens were transported to BIO and have been maintained in the Fish Laboratory for behavioural studies. Results to date indicate that corals are most diverse in the Gully (at least 10 species of soft, horny, and cup corals) but that their abundance is greatest in the Northeast Channel (two species of horny corals). The most common corals on the continental slope are cup corals.

In addition to the expanded coral research program, the Marine Environmental Science Division continued research on other habitat and contaminant issues. Some of the highlights for 2001 included:

- Major advances were made in communicating advice on environmental impacts of finfish culture to Habitat Management through the development of guidelines and a decision support system for evaluating site applications.

- A major research initiative to evaluate the factors affecting the sustainability of mussel culture was initiated.

- The compatibility and utility of a suite of acoustic equipment and software for sampling ocean sediments and associated marine organisms was evaluated. The favourable results of this evaluation have formed the basis for a new project to evaluate methodology for mapping essential fish habitat.

- A comprehensive survey of the contaminants in the marine environment of Sydney Harbour was completed.

Highlights of the **Diadromous Fish Division** included:

- The inner Bay of Fundy Atlantic salmon was listed as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). This gave added credence to an already active Recovery Planning Group comprised of more than three dozen clients/agencies.

- The first releases of juvenile salmon from the gene-banking program occurred at the division's three Biodiversity Facilities (formerly hatcheries).

- The first artificial spawning and rearing of the endangered Atlantic whitefish took place at the NS Biodiversity facilities (refer to the article in the *Science Activities* section).

- It was discovered that American eels can amass characteristic freshwater growth entirely in estuaries/saltwater of the Atlantic coast of Nova Scotia.

- Spawners of the declining alewife stock were transported around the fishways that had been blocked through legislation by the State of Maine on the international St. Croix River.

- DFO advised Nova Scotia Power on the construction of upstream and downstream fish passage facilities providing access to an additional 2.5 km of habitat on the inner Bay of Fundy's Gaspereau River. This work was completed in 2001.

The **Invertebrate Fisheries Division** conducted surveys to gather data for stock assessments that support major fisheries like lobster, offshore and inshore scallop, shrimp, and marine plants. Division staff also worked with the fishing industry that provided vessel time, equipment, staff, and funds under Joint Project Agreements to collect samples and data that became part of scientific evaluations and studies. Significant progress was made in 2001 on new survey approaches that reflect the integration of information from different disciplines, in particular, marine geomatics. Specific projects included:

- The offshore scallop group related scallop abundance and catch rate to bottom type through large-scale benthic habitat mapping projects funded in large part by the offshore scallop fishing industry. Industry benefits included reduced bottom disruption during fishing, large fuel saving, and increased catches (see *Cross-Cutting Issues* for more details).

- A remotely operated video system (designed by staff at the St. Andrews Biological Station in St. Andrews, NB) surveyed lobster distribution and the ecosystem in Lobster Bay, Yarmouth County. This versatile system can be mounted on inshore fishing vessels and provides an inventory of habitat type, lobster location, and behavioural observations using real-time location tracking.

- Staff designed a trapping survey for offshore Jonah Crab along the shelf edge between Western Bank and the Gully and worked with Clearwater Fine Foods, Donna Rae Fisheries, and Membertou First Nation to do the field work. The survey provided information on distribution, data on catch per unit of effort, and population size structure of the Jonah crab resource.

- Measurements of lobster larval production were taken in several locations around PEI. These data were correlated with fishery yields and used as input to a larval drift model that identified geographic sources of the larvae.

- Staff provided field guidance and assistance for lobster surveys conducted by the Eskasoni Fish and Wildlife Commission in the Bras d'Or Lakes.

- In a joint research project with R. Blok Martec Ltd., staff of the Marine Plants group collected plant biomass and environmental data to validate the application of the Venice Lagoon eutrophication model to Basin Head Lagoon, PEI.

- Bait worms were surveyed for density, size distribution, and size at maturity in the six principal harvest areas of western Nova Scotia. The results will be incorporated into the 2002 fisheries management plan.

Staff of **GSC Atlantic** were busy in 2001 with two major projects in the Canadian Arctic being added to the normal field program.

- In a joint project between the German and Canadian governments, the field support group mobilized a seismic refraction program in Nares Strait from the Canadian ice breaker CCGS *Louis S. St. Laurent*.

- In the Beaufort Sea, the first multibeam bathymetry and high resolution seismic survey of hazards to offshore pipeline routes was carried out from the Canadian Coast Guard vessel *Nahidik*. Research sponsored by Indian and Northern Affairs Canada involved re-surveying several of the artificial ice islands built during the 1970s and 1980s to assess their structural degradation.

Besides the above special cruises, **GSC Atlantic** conducted regular cruises on DFO vessels including:

- David Piper on the Grand Banks to study slope geological processes in support of industry research;

- Gary Sonnichsen on the Grand Banks to study ice scour occurrences in the area;

- David Mosher on the Scotian Slope to study slope geological processes;

- Gordon Fader on the Scotian Shelf to create habitat maps; and

- Russell Parrott in conjunction with Environment Canada to study dumping impacts over dredging sites in Northumberland Strait and Saint John Harbour.

For the third consecutive year, **Environment Canada** (EC) and the Eskasoni First Nation successfully completed the annual Bras d'Or Lakes shellfish water quality monitoring program. Since 1998, there has been a 12 % increase in approved shellfish growing areas within the Bras d'Or Lakes.

The Denys Basin Watershed Advisory Group was formed by EC to address local water quality problems. A pilot study is underway to define the pollution sources and to examine the feasibility of creating a conditionally-managed oyster harvesting plan within closed portions of the River Denys Basin.

Successful shellfish restoration activities in Atlantic Canada were initiated by Envrionment Canada. In Charlotte County, New Brunswick, along the Bay of Fundy coast, Atlantic Coastal Action Program (ACAP) groups have actively pursued the clean up of bacterial contamination in the area. A co-operative shellfish water quality monitoring program is in place and remediation efforts are continuing in several contaminated shellfish areas. To date, over 950 ha of clam flats, worth more than $100,000 annually to the local economy, have been reopened. An additional five productive clam harvesting areas are conditionally operated under formally established management plans.

WORKSHOPS AND SPECIAL MEETINGS

The **Marine Invertebrate Diversity Initiative** (MIDI) hosted a workshop at BIO for more than 60 participants on January 9. The focus of the workshop was the use of the MIDI website and a discussion on marine diversity. MIDI is a program developed by a group of scientists and educators to compile a comprehensive web-based standard reference database on marine invertebrates. The objective is to increase general awareness of marine invertebrates and engage community groups, educators, industry, government, academia, consultants, and the public to work together to conserve the oceans. MIDI operates as a registered society supported by DFO, the Ecology Action Centre, Environment Canada, National Fish and Wildlife Foundation, the Nova Scotia Museum of Natural History, private organizations, and individuals. For additional information, visit the website at (http://www.fundyforum.com/MIDI).

The second **Preserving the Environment of Halifax Harbour Workshop** was chaired by Brian Nicholls and held at BIO on March 14-15. The meeting brought together stakeholders from three levels of government, academia, industry, and public interest groups. The key objectives were to review the state of the environment for Halifax Harbour, to identify information gaps, and to recommend action for the preservation and restoration of habitat and aesthetic conditions of the harbour.

A **Coastal Climate Change Impacts and Adaptation (3CIA) Workshop** was held in March at BIO and brought together coastal resource users and scientists to explore the potential impacts of climate change on coastal areas in Canada. The workshop focussed on the information and research needs of coastal communities, including coastal responses to climate change and the formulation of appropriate strategies to cope with adaptation in the face of uncertainty. It is anticipated that the priorities identified for coastal climate change research will provide guidance for the evaluation of other coastal climate change-related research. The workshop Steering Committee was chaired by staff of Natural Resources Canada, and included individuals from DFO, EC, academia, and the private sector.

The **Gully Ecosystem Review** meeting was chaired by Don Gordon and held at BIO on May 2. The Gully, a deep canyon on the slope off eastern Nova Scotia, has been designated as an "area of interest" for a potential marine protected area. In 1999, special funding was provided for two years to increase our knowledge of the oceanography of this unique ecosystem. The aim of the meeting was to bring together the results of the diverse studies and to provide an integrated view of the area. A roundtable discussion addressed the degree to which recent research has increased our understanding of the physical and ecological boundaries and the connections between ecosystem elements.

The **Maritimes Regional Advisory Process** (RAP) held 11 stock assessment meetings in 2001 to review the status of finfish and invertebrate resources in the Maritime Provinces. The Stock Status Reports, Habitat Status Reports, and Proceedings generated from these meetings are listed in the Publications section of this report and are available on the web at (www.mar.dfo-mpo.gc.ca/science/rap/internet/index.htm).

In addition, two special **RAP** meetings were convened in 2001:

- The meeting on **Maintenance of the Diversity of Ecosystem Types: A Framework for the Conservation of Benthic Communities of the Scotia-Fundy Area of the Maritimes Region** was chaired by Joe Arbour and brought together experts in benthic ecology, physical oceanography, and habitat classification. This meeting was held at BIO on June 26-28 and reviewed the geographic patterns of benthic ecosystem types (or seascapes) of the Scotian Shelf and Canadian part of the Gulf of Maine. The longer-term aims of generating a benthos classification scheme for this area, and guidelines on the proportion of each seascape type that need special protection were considered.

- The second RAP reviewed **The Possible Environmental Impacts of Petroleum Exploration Activities in the Southern Gulf of St. Lawrence and Sydney Bight Ecosystems** and was chaired by Paul Keizer. This meeting was held at St. Francis Xavier University in Antigonish on November 21-23. The objectives of the meeting were twofold. First, to characterize ecosystem features of the southern Gulf of St. Lawrence and Sydney Bight area that deserve special attention in the context of oil and gas exploration and the potential impact of this activity on the ecosystem. Second, to identify what issues are insufficiently understood and require further research before an assessment can be made of the potential impacts of oil and gas exploration in these areas.

Don Forbes of Natural Resources Canada and Martha McCulloch of Environment Canada, gave an invited presentation to the Deputy Ministers' Committee of the Government of PEI to review impacts of climate change and sea-level rise in the coastal zone of PEI.

GSC Atlantic/Natural Resources Canada scientists participated in the Offshore Technology Association of Nova Scotia Conference and Trade Show in Halifax in October. A resurgence of activity in the east coast offshore has resulted in heightened interest in research and data for the area.

Paul Kennedy, host of **CBC Radio's *Ideas*** program, visited BIO in May to talk with staff about ideas for a radio program titled ***Oceans Exploration 2001: Learning from our Oceans.*** This national discussion series was broadcast in November and December of 2001 and was designed to encourage dialogue among Canadians about the oceans and the coastal zone.

INTERNATIONAL MEETINGS

Delegates from five continents gathered at Saint Mary's University in Halifax in June for **CoastGIS 2001**, the fourth international symposium on computer mapping and GIS for coastal zone mapping. GSC Atlantic/Natural Resources Canada played a leading role in the scientific program and logistical organization of the meeting in collaboration with staff from the Department of Fisheries and Oceans, local universities, and the private sector. GSC Atlantic will be involved in the scientific content of future CoastGIS symposia through staff participation on the Program Committees and the newly formed Executive Committee. 2001 was the first time this important meeting of geomatic researchers involved in coastal zone management had been held outside of Europe.

An international *ad hoc* working group meeting on **The Northwest Atlantic Ecosystem - A Basin Scale Approach** was chaired by Erica Head and held in Halifax, NS between June 21-23. The meeting focussed on the ecosystem of the northwest Atlantic and the role of the zooplankton species, *Calanus finmarchicus*, within it. The Canadian GLOBEC studies had indicated the key role of this organism in the flux of energy from ocean basins to the continental shelf and from primary producers to higher food chain members such as commercial fish species and baleen whales. Progress has been made in modelling the population dynamics of *C. finmarchicus* and transport processes in the Northeast Atlantic. The aim of the meeting was to develop a research plan for the study of the space-time dynamics of *Calanus finmarchicus* in the Northwest Atlantic and how they are affected by climatic changes in environmental conditions and circulation. Such effects may have implications in food chain dynamics and carbon flux both in the deep ocean and on the continental shelf. The report of the meeting is available on the web (www.dfo-mpo.gc.ca/csas/CSAS/English/Proceedings%20_Years /2001e.htm).

The second meeting of the international joint **Scientific Steering Group for the Arctic Climate System Study** (ACSYS) and the **Climate and Cryosphere** (CliC) projects was held at BIO on October 15-19. These are the high latitude climate science programs of the World Climate Research Programme (WCRP). ACSYS is nearing its completion, whereas CliC is developing its implementation plan. Peter Jones was the local organizer.

Paul Kepkay chaired a **Workshop on Carbon Storage in the Coastal Zone** in Halifax, NS on October 16-17. National and international experts developed new research initiatives to describe the export and storage of carbon in the Atlantic Canada Coastal Zone (ACCZ). Given the global importance of the ACCZ in the storage of carbon exported by rivers, the new initiatives were incorporated into a research plan highlighting the importance of Canada's coastal regions in the global carbon cycle. The workshop report is available on the web at (www.dfo-mpo.gc.ca/csas/CSAS/English/ Proceedings %20_Years/2001e.htm).

The third meeting of the **Partnership of the Observation of the Global Oceans** (POGO) was held at White Point Beach Lodge, Hunts Point, NS on November 27-29. POGO members hold the position of directors at the major oceanographic institutes and organizations around the world. The major themes of the meeting were enhancing biological monitoring in the deep oceans and support for fixed deep-ocean monitoring stations. Shubha Sathyendranath, the Executive Director of POGO, organized the meeting and Dan Wright gave a presentation on BIO programs of relevance to the activities being promoted by POGO.

Steve Blasco receiving the Order of Canada from her Excellency, Adrienne Clarkson, Governor General.

AWARDS AND HONOURS

Steve Blasco was appointed a Member of the **Order of Canada** by the Governor General. The official citation reads: "He played a pivotal role in promoting the transfer of technology from government and industry researchers to the exploration industry. A renowned geophysicist with the federal Department of Natural Resources, he has designed innovative equipment for the harvesting of ocean resources. Relating his experience as a member of the production team for the IMAX film *Titanica*, he uses his excellent communications skills to educate Canadians and share with them his passion for science." The award was announced in December 2000 and presented in the fall of 2001.

The **A.G. Huntsman Award** is an annual award established by the Canadian marine science community to recognize excellence in

2001 Huntsman Award winner Dr. David Karl (left) and Dr. Howard Alper, President Academy of Science, Royal Society of Canada.

research and outstanding contribution to marine sciences. It is presented annually in one of three categories: marine geosciences, physical/chemical oceanography, or biological oceanography. The award is named in honour of Archibald Gowanlock Huntsman (1883-1972), a pioneer Canadian oceanographer and fishery biologist.

Dr. David M. Karl, Department of Oceanography, University of Hawaii, was awarded the 2001 **A.G. Huntsman Award**. Dr. Karl is a biological oceanographer who brings a deep understanding of biochemistry, microbiology, and genomics to the study of ocean ecosystems and global processes. He has played a leading role in the development of innovative methods for marine microbiology and nutrient chemistry and has examined microbially-mediated transformations and physical supply mechanisms of major plant nutrients in the ocean. His work has revealed the existence and importance of new classes of organisms in the sea, notably the marine archaea found in the mesopelagic region. He has worked in a wide variety of marine environments including the central Pacific Ocean, the Antarctic, the Black Sea, and deep-sea hydrothermal vents.

At the second annual **Nova Scotia Federal Council Awards Ceremony** in June, nine awards were presented in five different categories. The interdepartmental SeaMap team received an award in Category II - *to individuals or teams who have successfully coordinated the implementation of a high priority federal initiative*. Team members are: **Dick Pickrill (NRCan), Les Burke** and **Dick McDougall (DFO), Jim Bradford (DND)** and **Kate Moran (contract manager of the SeaMap office)**. They were recommended for this award because of their work in implementing the SeaMap initiative and enhancing interdepartmental relationships.

In 2001, **Donald Gordon** was presented the **5NR Science Award to Leaders in Sustainable Development** which pays tribute to outstanding contributions by federal scientists in their field. This award recognizes the contributions made by Dr. Gordon over his career to understanding marine ecosystems and applying this information to sound management decisions that have affected the sustainability of marine resources. It also provides encouragement to young scientists by providing graduate student scholarships to pursue research projects that propose innovative ways to preserve Canada's environment and its biodiversity. The 5NR federal departments are Agriculture and Agri-Food Canada, Environment Canada, Fisheries and Oceans, Health Canada, and Natural Resources Canada.

The BIO-Oceans Association established the **Beluga Award** to pay tribute to those who have contributed their talents and effort to make BIO a successful and well-recognized oceanographic institute. **Roger Belanger**, a member of the photographic unit from 1966 to 1991, was the first recipient of this award (see *Other Programs* for more details).

Charlie Dennis, of the Eskasoni Band in Cape Breton, was the second recipient of the **DFO Deputy Minister's Award for Partners**. He was recognized for his cooperative work with the old Halifax Fisheries Research Laboratory and BIO over several decades on research of importance to the First Nations in the Bras d'Or Lakes. The award was presented during a Talking Circle involving elders from the Cape Breton bands and scientists from BIO (more details in *Cross Cutting Issues*).

The **DM's Prix d'Excellence** was awarded to the "Sea Ice Field Research" team composed of **Brian Beanlands, Ingrid Peterson, George Fowler,** and **Simon Prinsenberg** for their excellent work on the development of instruments for sea ice research. This team also won a regional DFO merit award for this work.

The Field Ice Research Team receiving the DM's Prix d'Excellence (left to right – Wayne Wouters, Simon Prinsenberg, Ruth Dantzer, Brian Beanlands, and George Fowler) – photo by Wolf.

Natural Resources Canada presented Sector and Division merit awards to eleven staff members and two volunteers during 2001.

- **John Shimeld** was awarded a Sector Merit Award for his successful negotiations with a marine seismic acquisition company which resulted in GSC researchers having access to 35,000 km of seismic data along the continental slope off Nova Scotia.

- **Graham Williams, Rob Fensome,** and **Jennifer Bates** were awarded a team Sector Merit Award for having assembled, inspired and guided a group of dozens of contributors from 26 organizations through the final publication of *The Last Billion Years: A Geological History of the Maritime Provinces of Canada.* The book explains in everyday language the geology of the Maritime Provinces, both onshore and offshore.

- **Phil Moir** was awarded a team Sector Merit Award for exceptional work in developing consensus and demonstrating leadership in the development of the Sector's Geoscience IM/IT Roadmap. The team developed a framework that was endorsed by the GSC Program Committee, and which will position the Sector to better respond to GOL/NOL.

- **Gary Grant** and **John Shaw** were awarded a team Sector Merit Award for coordinating the development and production of a series of seven regional posters, web site and teachers' resource kit on the science and impacts of climate change.

- **Terry Hayes** was awarded a team Sector Merit Award for demonstrating exceptional achievement by reconciling the Earth Sciences Sector assets management database for upload to the departmental GFS Assets Management Module.

- **Susan Merchant** was awarded a Division Merit Award for her continuing effort in data coordination and input to the Physical Archives Data system, which will result in a major improvement in the security and accessibility of data collections.

- **Andre Rochon** was awarded a Division Merit Award in recognition of his efforts in editing the French translation of a major scientific document.

- **John Shimeld** was awarded a Division Merit Award for his successful negotiation which resulted in access to a major seismic data set on the Scotian Margin.

- **Don Forbes** was awarded a Division Merit Award for the leadership shown in the PEI Climate Change Action Fund project and also his participation on the Intergovernmental Panel on Climate Change.

- **Rob Fensome** was awarded a Division Merit Award for his coordination efforts of *The Last Billion Years: A Geological History of the Maritime Provinces of Canada.*

- **Barbe Szlavko** was awarded a Division Merit Award in recognition of her efforts in providing access to data, and for her participation in the Canadian Geoscience Knowledge Network project.

- **Calvin Campbell** was awarded a Division Merit Award in recognition of work done on the Ocean Alert survey, and for his ongoing work on the Scotian Slope.

- **Bille-Jo Gauley** and **Ernest Douglas**, two volunteers at GSC Atlantic, were awarded Division Merit Awards for their work as a highly efficient team on a series of coring cruises.

DFO National and Regional Merit Awards, and other honours were presented in 2001 to:

- **Sherry Niven** was awarded the **DFO ADM's Commendation** for her outstanding contribution to the development and implementation of the National Universal Classification System (UCS) strategy for the Science Sector.

- A team Regional Merit Award to **Trevor Goff and staff of the Mactaquac Biodiversity Facility**, for the innovative manner the program has been run in partnership with community groups and First Nations.

- A team Regional Merit Award to **Phil Hubley** and **Henry Caracristi**, of the Diadromous Fish Division, for their outstanding contribution to the design and implementation of physical modifications to the Mactaquac facility.

- An individual Regional Merit Award to **Shane O'Neil** for his leadership in a number of initiatives including the transition of the Mersey and Coldbrook fish hatcheries to biodiversity facilities with emphasis on gene banking of endangered populations of Atlantic salmon.

- An individual Regional Merit Award to **Brian Jessop** for his research on eel, smelt, striped bass, gaspereau, and other diadromous species.

- An individual regional merit award to **Murray Scotney** for his key role in ensuring that the physical oceanographic cruises are successfully completed.

- **Reg Sweeney, André Ducharme, Jim Leadbetter,** and **Joey Crocker** were part of a larger team receiving a Regional Merit Award for evaluating the impacts of a 500 km long natural gas pipeline from Country Harbour, NS to the United States boarder.

- **P. Jones**, Ocean Science Division - City of Trail Champion.

- **J. Lazier**, Ocean Science Division - International Council for the Exploration of the Sea Guest of Honour.

- Several high school students were given awards for their artwork in celebration of Oceans Day. The theme was *Sea Odyssey 2001*. **Kimberly Piccott** of Prince Andrew High in Dartmouth was the first place winner. Second place went to **Carmen Gill**, Cornwallis Junior High, and the third place winner was **Lauren MacDormand** of Eric Graves Junior High. Kaitlyn Hemphill, Tim Bouter, Max Schnutgen, Kit McManus, Brittany Edgett, Nicole McNeil, and Tessa Boucher all received honourable mention for their artwork.

Science Activities

Geological Survey of Canada (Atlantic)

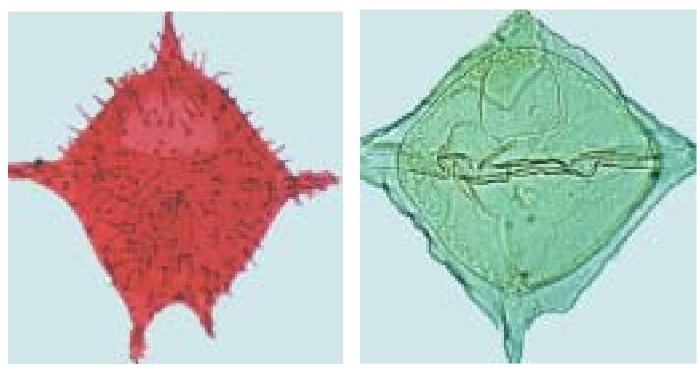
Fossil Dinoflagellates Make a Difference to the Dating Game

- Rob Fensome and Graham Williams

A popular educational website poses the question, “How do we determine the age of a rock?” The answer according to the website is: “By its minerals!” It continues: “Geologists first used fossils to determine the relative ages of rocks. Thanks to the discovery of radioactivity and advances in technology, it is now possible to assign an absolute age to a rock.” Although this answer is not strictly incorrect, it is misleading. The statement implies that the use of fossils is old-fashioned and no longer important for determining the ages of rocks and that number-crunching radiometric dating techniques are the modern way to go. Yet in reality, radiometric-dating techniques are expensive, time-consuming, and only applicable for certain rock types. Fossils are still the primary tool for dating rocks less than half a billion years old. Moreover, fossils, especially microscopic fossils, are vital tools in understanding the geology of oil-and-natural-gas-prone sedimentary sequences such as those in offshore eastern Canada.

The study of the nature, origin and relationships of rock sequences is known as stratigraphy, and the dating of rocks through their fossil content is called biostratigraphy. Geological periods (such as the Jurassic) are defined by their biostratigraphy, not by their absolute age in millions of years. The best-known biostratigraphic event is the Cretaceous-Tertiary (K-T) boundary - the extinction of the dinosaurs. If a rock contains *Tyrannosaurus rex*, it is Cretaceous, not Tertiary. No Tertiary rock contains fossils of *T. rex*. On the basis of radiometric dating, the K-T boundary is believed to be 65 million years old. But if new radiometric analyses were to revise the age to 60 million years, this would be only a numerical re-adjustment. The K-T would not change physically since it would still be defined by fossil occurrences. Numerical readjustments of important stratigraphic boundaries occur more commonly than might be suspected. For example, the Devonian-Carboniferous boundary was changed recently from 354 to 362 million years ago.

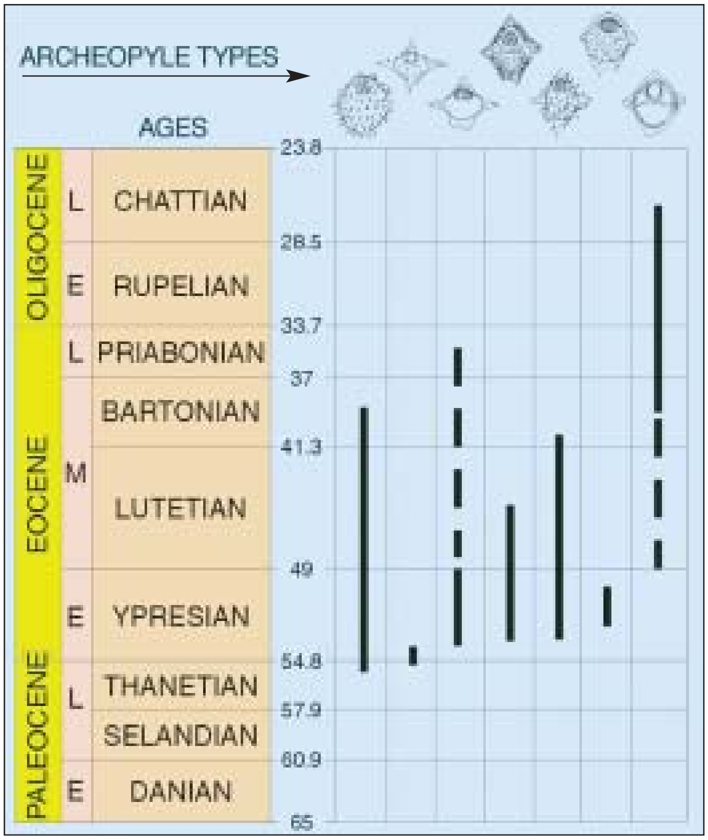
No dinosaurs have been found in the rock cores and cuttings (small rock fragments) from the oil and gas wells of offshore eastern Canada. However, other “dinos”, fossil dinoflagellates that occur in the millions,



Wetzelielloid specimens – photos by Lew Stover and Dan Beju.

now constitute the principal biostratigraphic tool in the region for determining the age of marine rocks less than 200 million years old. Dinoflagellates are among the most common plankton found in today’s oceans. They are single-celled organisms ranging from 10-200 μm in size, and have both plant-like characteristics (many contain chloroplasts) and animal-like features (most have an active, motile stage in their life cycle). Some dinoflagellates cause red tides and some produce potent toxins. Fossilizable dinoflagellate cysts (dinocysts) are about the same size as their motile counterparts, and always have a characteristic excystment opening, or archeopyle, through which the next generation’s motile cell can escape.

Rock samples analyzed for fossilized dinocysts must be treated with hydrochloric and hydrofluoric acids, plus other chemical and fractionation techniques to release the organic-walled dinocysts. When extracted from their stony tombs, dinocysts have been found to be abundant. This profusion, plus their variable morphology and often rapid evolution, make dinocysts ideal for biostratigraphy. Just as the extinction of the dinosaurs represents an event that marks the end of the Cretaceous Period, so the origination and extinction of individual dinocyst species define particular stratigraphic events. As the definition of dinocyst species and the timing of their first and last occurrences become more refined, so does our understanding of the



Ages of the different archeopyle types in wetzelielloid dinocysts.

stratigraphy, geology, and oil and gas occurrence in the sedimentary basins of offshore eastern Canada.

To illustrate the developing refinement of dinocyst biostratigraphy, we focus here on a group known as the wetzelielloids, named after two unrelated German pioneer biostratigraphers, Otto and Walter Wetzel. Wetzelielloids are found in 25-65 million-year-old marine rocks and have proven useful in both biostratigraphy and paleoecology. Typically, they have an ovoidal to rhomboidal shape with 4-5 protrusions or horns: 1 anterior (apical), 1-2 posterior (antapical), and 2 lateral (a right and a left). There are also two wall layers with a space between and commonly spines on the outer wall; the spines are sometimes connected by rods (trabecula) or a thin membrane.

Over the years, wetzelielloid species have been separated from one another on such nebulous variations as: the length, shape, and symmetry of the horns; the nature of surface ornamentation including spines; and the development of walls and membranes. The fact that these features were so distinctive and variable was both a blessing and a curse: a blessing because the variation was easy to recognize and describe; but a curse because each feature seemed to develop largely independently of the others. No particular morphological feature provided a consistent focus for the classification of the group or reflected a consistent stratigraphic pattern. Hence, many wetzelielloid species have been named and used inconsistently and this has hampered the biostratigraphic usefulness of the group, despite the use of statistical techniques such as multivariate analysis.

Based on observations primarily from offshore eastern Canada, a more effective and practical way of subdividing the wetzelielloids seems to be emerging. This subdivision involves giving priority in classification to variations in the development of one morphological feature, the archeopyle. The archeopyle in wetzelielloids is a more or less four-sided opening on the dorsal surface of the cyst, towards the apex. As shown in the accompanying table, different configurations of the archeopyle and its operculum are related to age, reflecting what were apparently general evolutionary trends in the group.

The authors in collaboration with Sarah Damassa of Massachusetts, USA, and Raquel Guerstein of Argentina, are currently revising the taxonomy of the wetzelielloids and re-evaluating the stratigraphic occurrence of species in the group. Upon completion, the work will provide enhanced biostratigraphic control, helping to refine the ages of the strata, and hence our understanding of the sedimentary basins and petroleum systems of offshore eastern Canada.

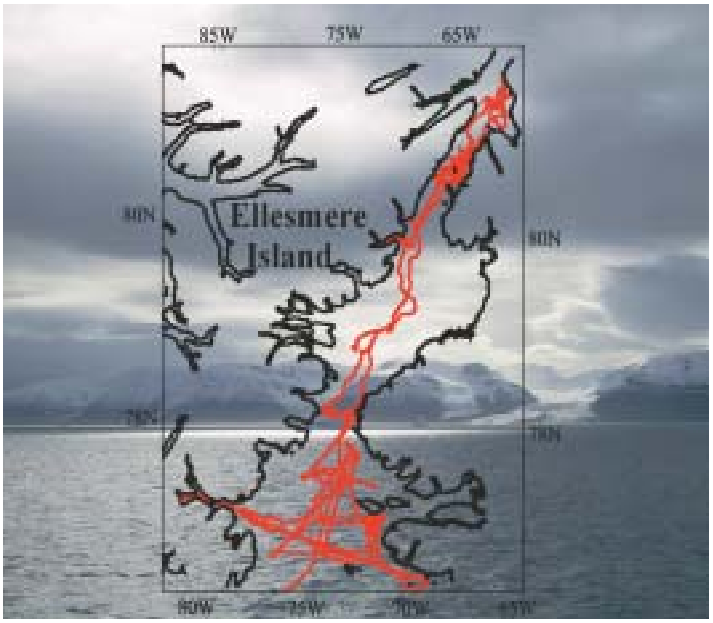
Nares Strait: Collaborative Research to Solve a Geological Controversy

- H. Ruth Jackson, Gordon N. Oakey and Sonya A. Dehler

A multi-disciplinary experiment in Nares Strait, the waterway between North Greenland and Ellesmere Island, was organized under the auspices of the Canadian-German Bilateral Agreement in Science and Technology and run in August and early September of 2001. The German Federal Institute for Geosciences and Natural Resources and the Geological Survey of Canada (GSC) were the principal participants, with support from Danish and other Canadian agencies. Heavy ice conditions in Nares Strait necessitated the use of Canada's most powerful ice breaker, the CCGS *Louis S. St-Laurent*.

The primary objective for the experiment was to collect information to solve a long-standing controversy on the origins of Nares Strait. This controversy has resulted from an apparent incompatibility between the onshore geology surrounding Nares Strait and plate tectonic models describing the opening of the North Atlantic and resulting motions of Greenland. The major strength of this expedition was the ability to integrate targeted onshore geological field work with regional geophysical measurements to extend interpretations offshore.

Additional scientific objectives of the program included studying geodetic, hydrographic, oceanographic, climatological, and biological issues. Four students from the community of Grise Fiord and the Free University of Amsterdam participated in many of these programs. The geodetic study was a combined effort coordinated between Geomatics Canada (GC) and the Danish Geodetic Department. The international boundary between Canada and Greenland (Denmark) lies along Nares Strait and modern positioning methods are required to establish its location more accurately. Also, by re-occupying previously measured stations, modern motions of the tectonic plates can be established. Fisheries and Oceans Canada (DFO) participated with a project to study water flow and mixing through the Canadian Arctic Islands, and the influence of the Pacific Ocean as a nutrient source on



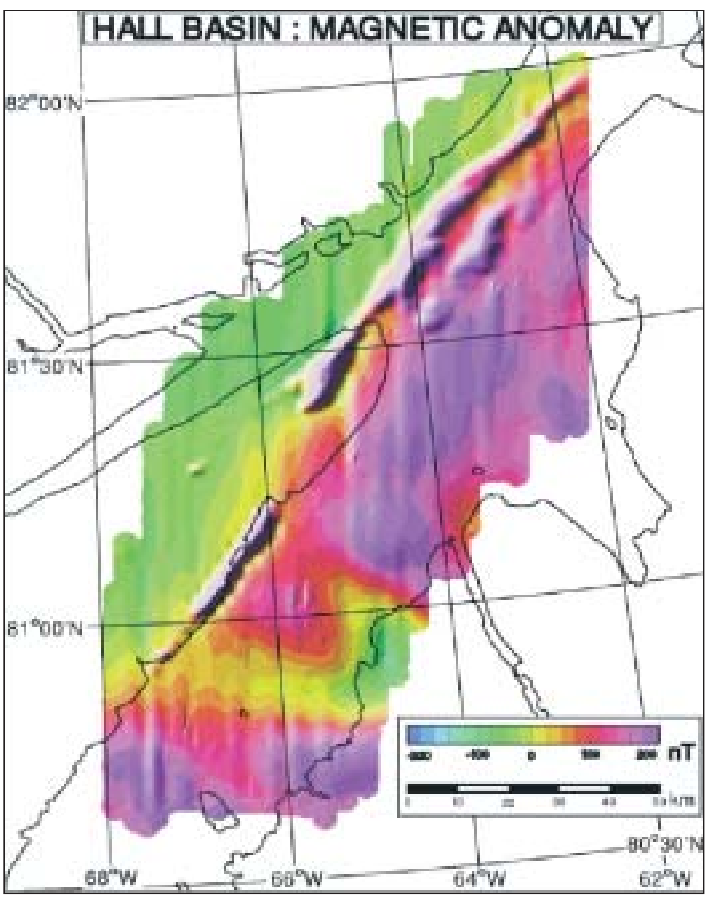
The red line is the cruise track, totaling 6400 km, between Ellesmere Island in the west and Greenland to the east. Seismic data, bathymetric measurements, water samples, and temperature profiles were collected along these lines. In the background is the coast of Greenland south of 78°N.

the Arctic ecosystem. The water samples and temperature profiles collected are also useful for monitoring short-term climate change. Sediment cores and grab samples were collected by GSC to study the post-ice age evolution of the region. These data are required for understanding long-term variability in the Earth's climate. Because of the sensitivity of Arctic habitats, a marine mammal scientist was included in the expedition to observe ice and weather conditions, distribution of wildlife, and provide a critical evaluation of the environmental impact posed by the scientific activities.

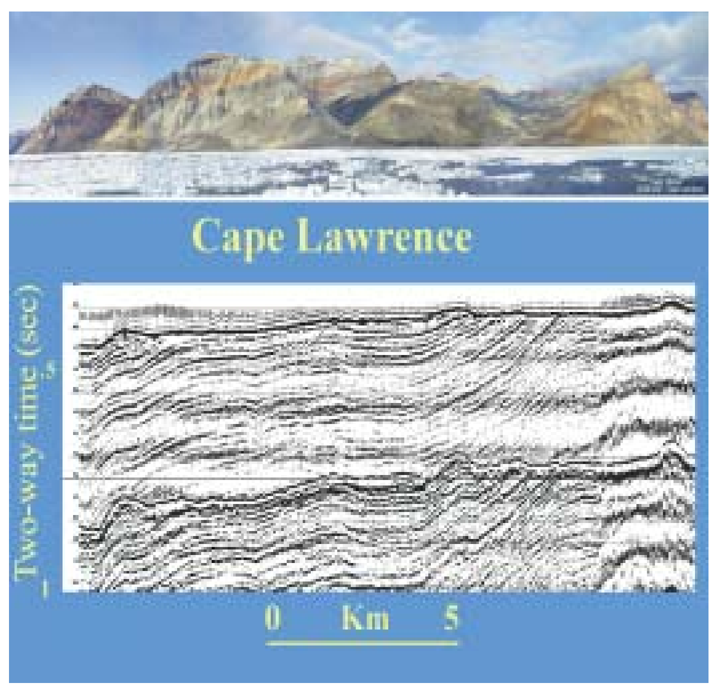
Aeromagnetic data were acquired by towing a sensor from a helicopter. This style of surveying allows for direct correlation between onshore and offshore magnetic anomalies. A total of 9000 km of aeromagnetic data were collected. In the northern part of Nares Strait, the magnetic anomaly map shows prominent northeast trending linear features. Based on the onshore geological studies, these anomalies are coincident with sedimentary rocks having unusually high concentration of magnetic particles. Without the onshore mapping, these anomalies might have been interpreted as caused by igneous rocks. The existence of offshore sedimentary basins is also interesting because the regional geology indicates that there are both source and reservoir rocks for hydrocarbons. The fission track studies, to be performed in 2002 and beyond, as part of this program, will indicate if the thermal maturity of the basins is appropriate for oil and gas generation.

The major geophysical component of the cruise was the acquisition of three types of seismic data: 1) high resolution reflection for imaging 100 m below the seafloor, 2) multichannel reflection for penetration to 5 km, and 3) refraction to map large-scale structures from 0-40 km in depth. The ship's bubbler system, used for assisting with difficult ice conditions, proved an asset for towing seismic equipment behind the ship in ice infested waters. The bubbles moved the ice away from the stern, providing an ice-free zone behind the ship.

The cliffs at Cape Lawrence (shown below), on Ellesmere Island are formed by thrusting. The narrow bands of red rocks are about 600 million years old. In contrast, the cliff face on the right, with the ice-free water in front of it, is 60 million years old. The seismic profile shows strata that are gently warped toward the surface. The interpreted seismic section reveals a basin formed in the space before the frontal thrust along the coast. This is equivalent to the structures you



The aeromagnetic survey covering a portion of northern Nares Strait and onshore Ellesmere Island.



The upper section is a photo of a thrust on the coast of Ellesmere Island near 80°N. It also illustrates the ice conditions encountered in Nares Strait. The open water area was enlarged by the ship before the seismic gear was streamed. The lower half is a portion of the seismic reflection profile collected perpendicular to the photo.

would encounter driving from Calgary toward Banff. The less deformed rocks of the foot hills would be crossed before the abrupt face of the McConnell thrust is reached. The crustal shortening observed here is consistent with the second stage of deformation motion predicted from the plate reconstructions.

Nares Strait is a unique natural laboratory for studying continental translation and compression because the amount and timing of it are quantitatively constrained by plate reconstructions. The preliminary analyses of the data are consistent with the hypothesis that strike-slip motion was followed by compression.

Postglacial Coastlines in Atlantic Canada: A New Perspective

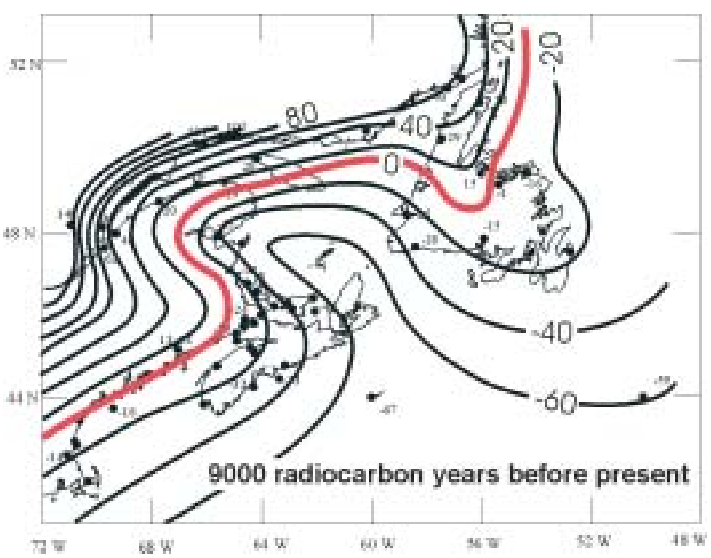
- John Shaw and Robert Courtney

Relative sea levels in Atlantic Canada have varied greatly since the end of the last ice age, primarily because of: 1) glacial isostasy (motions of the earth's crust in response to the removal of glacier ice); and 2) eustasy (addition of meltwater to the oceans). The glacial isostatic effect has varied regionally, so that in northern Newfoundland sea level has been falling continually since the glaciers retreated. On the other hand, sea level at Halifax, Nova Scotia, has been rising for more than 11,000 years.

Although sea level histories have been compiled for locations throughout eastern Canada, the resulting regional variations in coastline position have rarely been demonstrated. Advances in Geographic Information Systems (GIS) allow us to visualise coastline changes as never before. A 1 km-grid digital elevation model (DEM) of Atlantic Canada has been constructed using relief and bathymetry data from various sources. Relative sea-level values were extracted from radiocarbon-dated sea-level curves and contoured to produce isobase maps. These were used to generate gridded surfaces that were subtracted from the modern DEM to produce DEMs for 1000 year time slices for 13,000 radiocarbon years before present (BP) onwards.

Geography of Atlantic Canada 9000 radiocarbon years before present; modern coastline shown as a white line.

On the isobase map relative sea level for 9000 BP was the same as today along the zero line. Relative sea level was higher to the north and lower to the south. As shown on the palaeogeography map for 9000 BP, large islands existed on the outer continental shelves. They had been much larger at 13,000 BP, and had been slowly submerging since that time.



Isobase map, showing relative sea levels (in metres relative to modern sea level) 9000 radiocarbon years before present. Dots represent locations where relative sea level is known.

Compared with today, the most significant change in geography 9000 years ago was in the southern Gulf of St. Lawrence. A wide emergent zone surrounded the Magdalen Islands, and Prince Edward Island was connected to the mainland. The fact that Northumberland Strait was dry land at this time has been confirmed by a multibeam survey that shows a submerged landscape under Confederation Bridge, replete with river valleys and lake basins. In northern areas, where relative sea level was higher than today, many coasts were still submerged 9000 years ago. Thus, the northern tip of Newfoundland's Great Northern Peninsula was partly submerged, and a large island existed at the north side of modern Hare Bay.

The reconstruction of ancient coastlines has many significant and perhaps surprising ramifications. For example, they indicate to archaeologists where to search for the remains of early cultures who were adapted to coastal living. In northern Newfoundland, the remains lie far inland on raised beaches, whereas in Northumberland Strait they are submerged. Also, the reconstructions demonstrate that tidal regimes had to be much different in the past. One possibility remaining to be explored is the running of tidal models using the ancient DEMs. This would allow us to reconstruct ancient tidal regimes across the region.

Canadian Hydrographic Service

The Canadian Hydrographic Service in the International Forum

– Gerard Costello and Tom Rowsell

Hydrography is truly an international discipline. Whether it is trade, ocean science, resource exploration, coastal zone management, or any of the other myriad issues surrounding the marine environment, hydrographic information is a key ingredient. To maximize the benefits of hydrographic data, it is essential that hydrographic offices adhere to international standards and that advances are shared globally. In order to promote this international view, CHS remains an active member of the International Hydrographic Organization (IHO).

Many advances in hydrography in Canada have been achieved in partnership with private industry. By leveraging development resources domestically, Canadian industry can build and provide products and services for the international community. Canadian-led progress in multibeam technology, electronic charting, and data management all attest to the benefits of a partnership approach. CHS interrelationships with hydrographic offices around the world provide the opportunity to promote Canadian solutions.

CHS Atlantic participated in two major international exchanges in 2001. In January, Hydrographic Project Leader, Tom Rowsell, travelled to Wellington, New Zealand to be Hydrographer-In-Charge of a six-week survey centered in the Western Ross Sea and the Balleny Islands of the Antarctic. One purpose of the exchange was to provide the Canadian private sector company contracted to complete the project with a Hydrographer-In-Charge who had completed an International Hydrographic Organization accredited hydrography program and who had expertise in multibeam data collection and processing. The second purpose was to transfer expertise to the private sector and ultimately make Canadian industry more competitive internationally. Through the exchange, New Zealand acquired hydrographic data for chart production and multibeam data that supports their United Nations Convention on the Law of the Sea (UNCLOS) initiative and CHS gained experience in using a deep-water multibeam system. In order to create the products required by the primary client, Land Information New Zealand (LINZ), Tom Rowsell participated in a month of data processing following the field portion of the project. This survey was successful and further established Canadian industry in the international arena.

New Zealand Research Vessel Tangaroa *in the Ross Sea, Antarctica.*

In 1999, The Irish government announced 20 million pounds funding over 7 years to map the seabed of the continental shelf surrounding Ireland. The Geological Survey of Ireland (GSI), the lead agency, requested proposals from scientific consultants to help plan, design, and execute the Irish Seabed Mapping Project. The Marine Institute of Ireland is also participating in the project. The Canada Centre for Marine Communications, located in St. John's Newfoundland, partnered with the CHS, the University of New Brunswick, and Natural Resources Canada, under a Joint Project Agreement for this purpose and was awarded this contract.

The survey team on the Celtic Voyager*, Galway Bay hydrographic survey, August 2001 (Gerard Costello is on the left).*

The Canadian team was involved in writing the specifications for the project, evaluating the proposals, and training of GSI contract authority in quality assurance. Data collection parameters include multibeam, gravity, magnetics, sub-bottom characteristics, seismics, and ancillary data. Gerard Costello and John Cunningham, CHS hydrographers, participated in this effort on several occasions. The focus of this exchange was a seabed survey, creating baseline products, and developing hydrographic capability in Ireland. Gerard Costello spent September and October 2001 in Ireland providing advice and organizing a seminar where Canadian experts exchanged technical information on multibeam sounding, geological mapping, and habitat interpretation. Two Canadian private sector companies have recently been awarded contracts as a result of this project.

These projects exemplify the role CHS plays in the international arena in support of Canadian industry and also in support of hydrographic offices. These continuing efforts in the international hydrographic community will have long-term benefits for CHS, Canadian industry, and ultimately the users of hydrographic products and services.

The Sea Road to ISO 9001:2000 Registration

- Nicholas J. Palmer

The Canadian Hydrographic Service (CHS) has successfully implemented a Quality Management System. There is one Quality Policy and one Quality Manual with identical national procedures that have regional flavours for region-specific processes. The Quality Management System (QMS) forms the basis for continuous improvement of processes within CHS, including the adoption of best practices. As part of this system, CHS is now registered as compliant with the International Organization for Standardization (IOS) ISO 9001:2000 standard.

The IOS coordinates the development and adoption of a number of international standards. In December 2000, a revised standard that applies to service-oriented organizations was adopted. Previously, ISO 9000 standards focused primarily on design and manufacturing industries. The basic premise of ISO is, "Say what you do – do what you say – and be able to prove you did what you said you were going to do". This means that procedures must be documented and followed, and records of the process maintained. ISO registration does not guarantee quality in a product or service. It does, however, certify that you have a Quality Management System relative to one of the ISO standards. Being ISO registered is a requirement for many businesses to compete internationally. As of December 2000, 158 countries had businesses registered under ISO. In Canada, 11,435 businesses have been awarded certificates of registration, however, few government agencies are registered.

The new ISO 9001:2000 standard combines several of the ISO 9000:1994 suite of standards and focuses on registration and compliance, as well as on living the Quality Management System (QMS). Continuous improvement is monitored and recorded in all aspects of business including administration, finance, training, and production processes. There is an emphasis on management commitment to the Quality Management System. The QMS empowers all employees to propose changes to the system. It sets out procedures for process owners to evaluate proposals for change, and establishes management accountability to act on proposed changes. It provides a structured process for reviewing changes, for addressing complaints and feedback, and for conducting internal and external audits of the QMS; thus making it a key responsibility of management.

Why would CHS, a government agency, seek ISO registration? CHS provides both a public service and produces products such as charts and nautical publications. In the production process, the division is similar to a factory. Raw materials are turned into products, checked, released, and distributed. Unlike a factory, CHS's motives are public good and service to clients rather than profit. CHS has always focused on quality. We had quality processes for products but lacked quantitative performance measures to define their effectiveness or measure client satisfaction. Documented procedures of all supporting processes did not exist and 50% of the staff and their corporate memory can retire in the next ten years. The benefits of ISO registration include: documented procedures for new staff, the adoption of standards of best practices and process review, and establishment of a culture where quality is everyone's business and is instilled at each step of the process, not just at the end.

The ISO journey for CHS started in 1998 with a pilot project in Laurentian Region when the new electronic chart production processes were registered as compliant to the ISO 9002 Standard. An evaluation of the benefits identified included: improved consistency of the quality of products, the identification and resolution of root causes of nonconformities, and the establishment of a structure to measure and improve performance.

In June 1999, the CHS Management Committee set a goal for all of CHS to become ISO registered within two years. A national ISO coordination team was assembled with a fulltime chair. Training of the coordination team and CHS senior management was initiated and a consultant was selected. The consulting firm provided an expert to guide each CHS office and document-writing teams were assembled, trained, and tasked. The next step was working with the documentation and refining it as more people used it. This was followed by the establishment and training of internal audit teams who audited the fit of the processes in use with those in the Quality Management System, and identified nonconformities and opportunities for improvement. After using the QMS system for eight months and addressing improvements, the system was audited externally.

The external audits consisted of audits of the Quality Manual to ensure the documentation conformed to the ISO 9001:2000 standard. The consultant's auditors audited the use of the system and, after their recommendations were addressed, a registration audit was performed on each CHS region by the Registrar. The firm selected as Registrar was Deloitte and Touche who performed the initial registration audits and will do maintenance audits on a six-month basis for a three-year period. The role of the Registrar is to ensure that CHS's QMS conforms to the standard, that the system is being used, and to work with CHS to improve the QMS by identifying nonconformities and opportunities for improvement.

In a two-year period, all CHS employees learned about the ISO 9001:2000 standard and terminology and documented procedures to the appropriate level of detail. We have learned a lot about ourselves and our processes have instilled a sense of pride in staff as they use the Quality Management System, and we have raised its accountability to CHS senior management. Performance measurement teams, internal audit teams, and internal communications working groups have been established along with a Quality Policy that mirrors the CHS Mission, Vision, and Values. We understand how the processes support the QMS and Quality Policy. The links between departmental objectives and QMS are understood. These include responsiveness to client needs, maintenance of a challenging and rewarding workplace, cultivation of a spirit of partnering and team work, production of quality products, and the use of innovative business practices to be both efficient and effective.

The QMS is our system – we control it – we can change it. Having processes documented and controlled and the change processes in place is the starting point for a QMS that continuously improves.

Ocean Sciences

Tales of the Unexpected from the Scotian Shelf

- Erica Head and Leslie Harris

Since 1998, the Ocean Sciences Division has been collecting hydrographic data and chemical and biological samples at selected sites on the Scotian Shelf. The collections are made each spring and fall as part of the Atlantic Zone Monitoring Program (AZMP). This program was set up to observe climate-related changes in environmental and biological conditions of the lowest levels of the food chain (plankton) that might affect the status of higher trophic levels including commercial fish species. Zooplankton, the principal vectors for the transfer of energy from the primary producers (phytoplankton) to the higher trophic levels, are collected using plankton nets fitted with a 0.2mm mesh. This article describes several recent unusual zooplankton observations.

Occurrence of a bloom of an exotic phytoplankton species

Over the last few decades the introduction and geographic spread of exotic, or non-indigenous, species has increased dramatically. The chief mechanism is thought to be the ballast water exchanges carried out by cargo ships. One well-known example is the introduction of zebra mussels into the Great Lakes. Introductions of non-indigenous phytoplankton are often unnoticed until they reach "nuisance" status. Here, we are reporting the occurrence of a bloom of a species of non-indigenous diatom on the Scotian Shelf, described as a nuisance species elsewhere, which has had no recorded effects here.

In the spring 2000, plankton tows from most of the central and western Scotian Shelf sampling sites contained high levels of phytoplankton. This is not in itself unusual, since many phytoplankton species, especially diatoms, form long chains of cells that can get caught up in the 0.2mm mesh. When looking at our samples under the microscope, however, we found that this was not the type of phytoplankton usually seen (Fig. 1). Instead, it was in the form of large individual diatom cells, shaped like petrie dishes, which had both diameter and height of approximately 0.25mm.

The diatoms were identified as *Coscinodiscus wailseii* (J. Martin, DFO, St. Andrews). This species was originally reported in only two areas: the Pacific coast of North America and Japanese coastal waters. Since the late 1970s, however, *C.wailseii* has established itself as an immigrant in the waters around the United Kingdom and in the North Sea. *C. wailseii* cells may be too big for many zooplankton, such as the copepods in Fig. 1, to eat so that blooms may cause disruptions in the food chain at its lowest level. Also, it has been reported that *C. wailseii* can clog fishing nets, by producing large amounts of mucilage, and that it is noxious to *Nori*, a seaweed harvested in Japan. As yet, however no complaints have been reported of either of these potential nuisance effects from around our coast.

The history of occurrence of *C. wailseii* on the Scotian Shelf is partially documented through Continuous Plankton Recorder (CPR) records. The CPR is a towed body, deployed from commercial ships, that collects, preserves, and saves plankton samples. *C. wailseii* did not occur on the Scotian Shelf in the 1970s, but it had arrived by the early 1990s. It is an interesting thought that the commercial vessels that conduct long-term monitoring of exotic species invasions, such as this one, may also contribute to their occurrence.

Figure 1. Plankton net sample collected on Browns Bank in April 2000. Contents of the diatoms appear shrivelled due to chemical preservation. Preservation also destroys the colours of the phytoplankton and zooplankton (copepods) – photo by Dan Jackson.

Strange copepod mating behaviour on the Scotian Shelf

One species of copepod, *Calanus finmarchicus*, dominates the zooplankton in spring and early summer. Individuals spend the winter as pre-adults in the deep waters surrounding the shelf or in the shelf basins, but as spring arrives they swim up to the surface to moult and develop into sexually mature males and females. Dr. Charles Miller (Oregon State Univ.) has described the mating process. Newly-moulted females perform a "hop and sink" swimming routine, while releasing a trail of pheromones that attracts the males. The males swim in broad horizontal loops until they get near a female at which point their loops become smaller and three-dimensional. Some encounters do not result in successful mating, but in those that do, the male clasps the females and transfers a sac of sperm, called a spermatophore, to the genital segment of the female's tail. This is the normal routine, but samples collected from sites on the northeastern shelf (off Louisbourg) in April 2000, contained products of some apparently sexually deviant behaviour.

Firstly, we saw juveniles of another related copepod species *(Calanus hyperboreus)* with spermatophores attached to one of their tail segments (Fig. 2). These juveniles were approximately the same size as female *C. finmarchicus*. Male *C. finmarchicus* were the only

Figure 2. A female Calanus finmarchicus *with a spermatophore attached to her genital segment (below) and a juvenile* Calanus hyperboreus *with one attached to a tail segment (above). Both copepods are approximately 2mm in body length – photo by Dan Jackson.*

males in the samples of a size appropriate to produce such spermatophores. This looks like a case of mistaken identity. A male *C. finmarchicus*, perhaps in pursuit of a pheromone-releasing female, has his path interrupted by a copepod of the right size, mistakes it for a female of his own species and passes over his sac of sperm. We have never heard of such an observation being made before. In one sample, approximately 18% of this stage of juvenile *C. hyperboreus* had spermatophores attached when it was first examined. This proportion had dropped dramatically when the sample was re-examined sometime later. Perhaps it is not surprising that the attachment of the spermatophore is weak, but it opens the possibility that such strange events may not be unusual. Possibly we had a sample that had received especially gentle treatment during capture and handling. This is something to consider as we collect samples in future.

A second observation of unusual mating behaviour was that of a female *C. finmarchicus* with multiple spermatophores attached (Fig. 3). Although unusual, we occasionally see such females at sites all over the Scotian Shelf during the mating season. Females need to mate only once and most are observed with only one spermatophore attached. In this case, however, not only had the female mated several times, but since several of the sperm-sacs were empty, she had apparently absorbed the sperm from several males into her body. Why such a multiple mating should occur is not known. We can only conjecture that perhaps she laid down a particularly strong pheromone trail, attracting multiple mates.

Figure 3. A female Calanus finmarchicus *with ten spermatophores attached to her genital segment: seven empty, three full – photo by Dan Jackson.*

An unusual jellyfish outbreak on Sable Island Bank

Plankton tows collected with a net fitted with a 0.2mm mesh generally contain mainly zooplankton, and zooplankton communities on the Scotian Shelf are generally dominated by copepods. Sometimes, however, we encounter sites where a copepod predator has proliferated to such an extent that it has come close to eliminating its prey. We encountered such a site on Sable Island Bank in May 2001. At this site, small hydroid jellyfish of approximately 2mm in length, of the Family Tubulariidae, were found in very large numbers (>10,000 m^{-2} or >150 m^{-3}) (Fig. 4). These jellyfish do not have tentacles all around the edge of the bell, but instead at only one point (hence their common name "one-armed" jellyfish). Roughly 17% had copepods in their guts in various stages of digestion. We noticed that jellyfish having the least digested copepods in their guts often had their bells inverted. Inversion may be how these jellyfish ingest large prey items; ingested copepods were often as big as they were. As the copepod becomes more and more digested, presumably the jellyfish draws its manubrium (mouth and stomach) back into the bell.

At this site, none of the common copepod species were too large for these jellyfish to envelop. The concentration of *Calanus finmarchicus*, one of the prey items commonly seen within jellyfish guts, was approximately 2,000 m^{-2} (approximately 30 m^{-3}), five times lower than that of the jellyfish. At sites 10-15 miles away, concentrations of *C. finmarchicus* were 2-7 times higher and none of these jellyfish were present. This is fortunate, not only for the survival of *C. finmarchicus* in the region, but also for the survival of the copepod predators. Among these predators are larval and juvenile fish, which are often concentrated on Sable Island Bank, since it is an important spawning area for many species including haddock, cod, and sand lance.

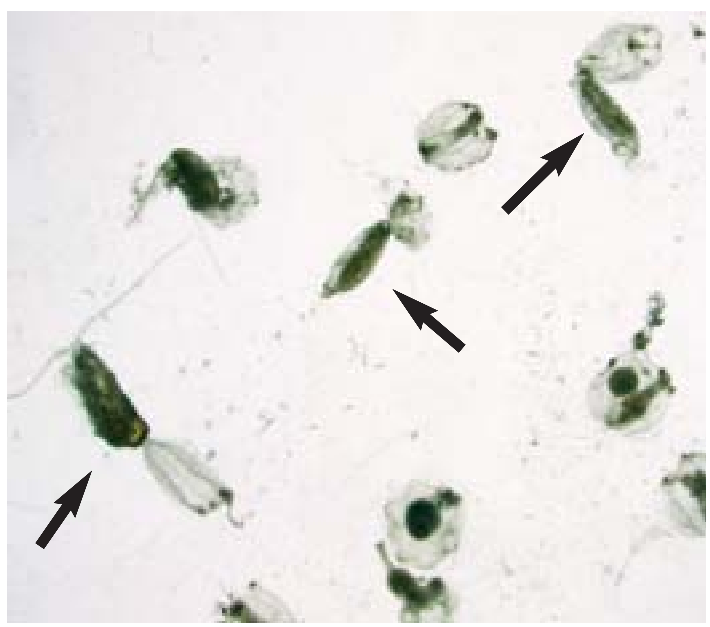


Figure 4. Tubulariid jellyfish from Sable Island Bank. Arrows indicate jellyfish with inverted bells and stomachs containing barely digested copepods – photo by Dan Jackson.

Pacific Water in the North Atlantic Ocean

- E. P. Jones

The earth's water cycle shapes our climate and sustains life on earth. Water evaporates from the oceans into the atmosphere, is transported over wide regions, falls as rain, and snow and returns to the oceans either directly or via rivers. The oceans are not, however, merely a passive provider of water vapor to the atmosphere. Ocean dynamics are controlled by seawater density, which in turn depends on the salt content and temperature of seawater. Through density, the oceans are greatly affected by how, when, and where freshwater enters and leaves the ocean through evaporation, precipitation, and run-off.

In arctic regions, freshwater figures strongly in the formation of dense water that sinks into the deep ocean as part of thermohaline circulation or the Global Conveyor Belt (Figure 1). As ice is formed, freshwater is extracted from seawater, and the excluded salt drains from the ice as brine to form dense water. This denser water forms thick mixed layers in the surface ocean or over shallow shelves triggering dense plumes that flow down the continental slopes into deeper water. In some regions, these waters are dense enough to penetrate to the lowest depths of the ocean; however, too much freshwater in the surface layers might interfere with this process. The Greenland Sea is presently the source of much of the northern hemisphere's deep waters feeding the Global Conveyor Belt. Both freshwater from rivers entering the Arctic Ocean, and ice produced within it, are exported to the Greenland Sea and can affect its deep convection processes. The freshwater budgets in arctic regions are of direct relevance to the understanding and prediction of changes in thermohaline circulation and hence to global climate.

The North Atlantic is the saltiest of the world's oceans while the North Pacific is the freshest. The Arctic Ocean provides a pathway that moves freshwater from the Pacific Ocean to the North Atlantic Ocean as low salinity surface water. This source of freshwater is comparable in volume to river runoff.

Pacific water enters the Arctic Ocean through the shallow (50 m deep) Bering Strait. Atlantic water flows along the northern coast of Norway, entering the Arctic Ocean through the much deeper Fram Strait. Pacific and Atlantic waters partially mix within the Arctic Ocean, but with the Pacific water being less dense (less saline) than the Atlantic water, it remains confined in the Arctic surface layers within the basins adjacent to North America. In addition to their different salinities, the two source waters have other properties that distinguish one from the other. In particular, they have different relationships

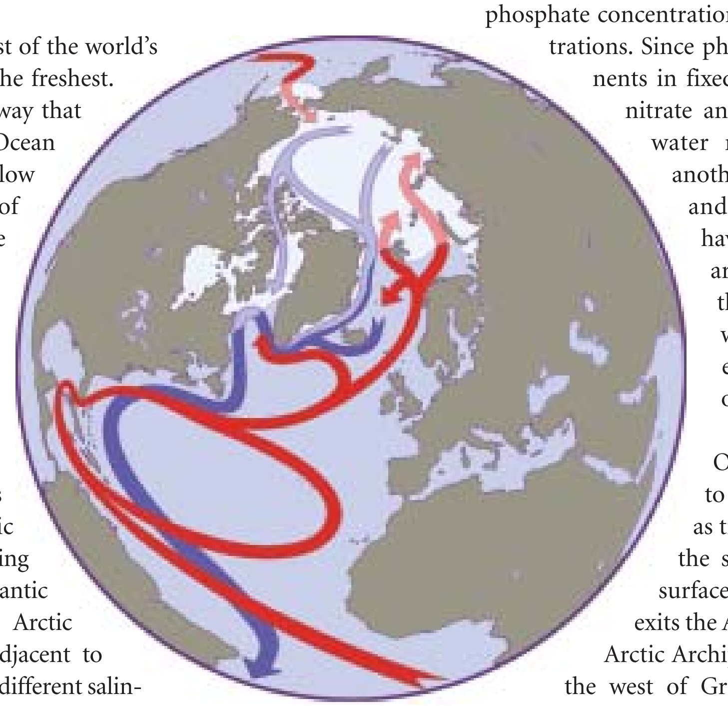


Figure 1. The Global Conveyor Belt representing global thermohaline circulation in the Arctic and Atlantic oceans (thanks to Greg Holloway). Warm water flows to polar regions, transporting heat and eventually becoming cooled and made dense enough to sink to deep waters and flow south. Upwelling in equatorial regions closes the loop.

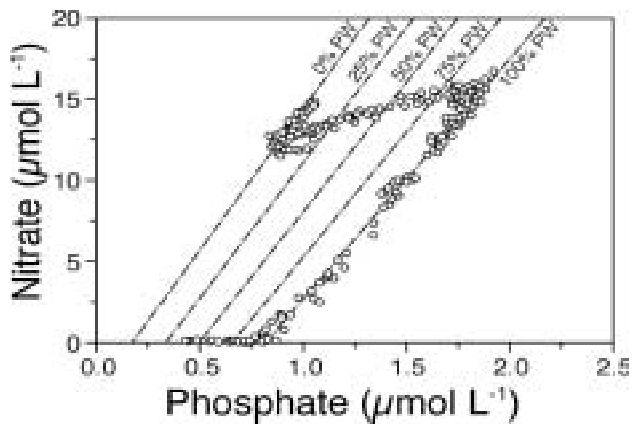


Figure 2. Nitrate-phosphate relationships showing the distinction between waters of Atlantic and Pacific origins. Pacific water has less nitrate relative to phosphate than does Atlantic water.

between their dissolved nitrate and phosphate concentrations that have enabled us to trace the pathway of Pacific water through the Arctic Ocean into the North Atlantic Ocean (Figure 2).

Two processes affect nutrient concentrations in the oceans. Photosynthesis reduces carbon, nitrate, and phosphate concentrations in the ocean and increases oxygen concentrations. Decay reverses this process, increasing carbon (carbon dioxide), nitrate, and phosphate concentrations, and decreasing oxygen concentrations. Since photosynthesis utilizes these components in fixed ratios, the relationships between nitrate and phosphate are maintained in a water mass that has not mixed with another one. By observing the nitrate and phosphate concentrations, we have been able to delineate boundaries and mixing regions between the source waters in the near surface waters of the Arctic Ocean. This has enabled us to infer the circulation of near-surface water (Figure 3).

Once having entered the Arctic Ocean, Pacific water is not confined to it. Using nutrient concentrations as tracers, we find Pacific water well to the south in the Atlantic sector. Near surface water (typically the top 200 m) exits the Arctic Ocean through the Canadian Arctic Archipelago and through Fram Strait to the west of Greenland. Our analyses show that much of the water flowing through the Canadian Archipelago is of Pacific origin. In Barrow Strait and Jones Sound almost all is of Pacific

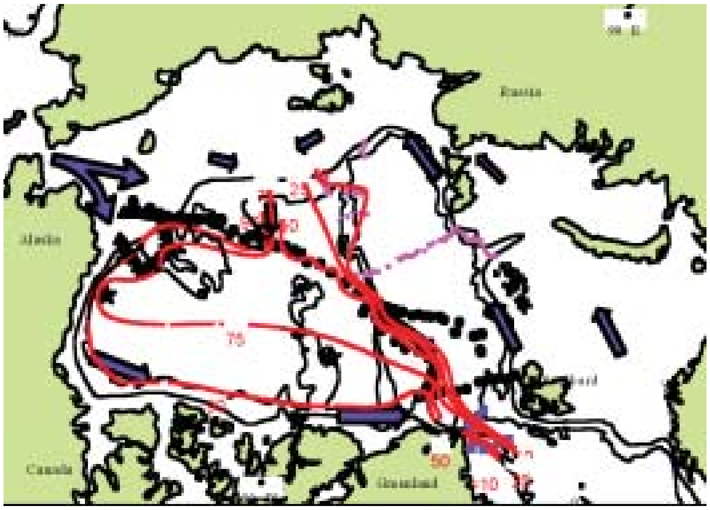


Figure 3. Contours of the percentage of Pacific source water in the surface layer (upper 30 m) of the Arctic Ocean. Arrows show the flow pattern in the surface layer suggested by the relative distribution of Pacific and Atlantic source waters.

Figure 4. Map showing locations of oceanographic sections where Pacific water is found.

origin. Atlantic water is only seen exiting through Smith Sound between Ellesmere Island and Greenland at depths greater than 100 metres (Figure 4).

An unexpected, but with hindsight not surprising, finding was that the seawater (that is, excluding contributions from rivers and sea ice meltwater) in Hudson Bay appears to have come from the Pacific Ocean. Since water flowing through Barrow Strait is of Pacific origin, water flowing south from Barrow Strait through Fury and Hecla straits into Hudson Bay could also be expected to be of Pacific origin.

Pacific water flowing through the Canadian Archipelago joins the Baffin and Labrador currents and can be distinguished as far south as the Grand Banks, and perhaps Flemish Cap, before it becomes too well mixed with Atlantic water to be discernible.

Pacific water also exits the Arctic Ocean through Fram Strait and along the east coast of Greenland. As it travels south, it mixes with Atlantic water, but is still identifiable in Denmark Strait between Greenland and Iceland. Near the south of Greenland, available data show no signs of Pacific water.

Changes in the freshwater flow from the Arctic Ocean may have significant consequences for the climate and life on earth. At the least, it could result in a cooling in northern regions if the thermohaline circulation in the North Atlantic Ocean is weakened. More drastically, it has been postulated that past changes in the thermohaline circulation, a shutdown of the Global Conveyor Belt, may have been the cause of ice ages. We must become able to predict, with far greater certainty, the magnitude of such effects and the probability of their occurrence within a given time scale. Identifying where source waters originate and tracing their circulation is necessary so that ocean currents can be appropriately represented in models that describe ocean circulation and its interactions with the atmosphere. Such models are vital to describing climate and predicting climate change.

Recent Advances in Modelling the Organic Carbon Cycle in the Central Labrador Sea and Perspectives for Climate Research

- Alain Vézina

The oceans absorb roughly a quarter of the carbon dioxide (CO_2) created by anthropogenic emissions. This alleviates the rise in atmospheric CO_2 and its potential climate impact. The evolution of this ocean carbon sink under an altered climate has enormous implications for climate change scenarios. Relative to its size, the Labrador Sea has a disproportionately large importance in the oceanic uptake of CO_2. Over the past decades, DFO has put considerable effort into making observations on the physical, chemical, and biological processes that regulate the transfer of carbon from the atmosphere to the Labrador Sea. More recently, these observations have been synthesized into state of the art ocean ecosystem models. The Labrador Sea is important for the global oceans' carbon cycle because it is one of the few regions where there is a direct connection between the atmosphere and the deep ocean through deep winter convection. Deep winter convection occurs when winter cooling makes the surface water heavy enough to sink to depths of two kilometers and deeper. It plays a critical role in the uptake and long-term sequestration of anthropogenic CO_2.

Less well known is the role of deep convective areas such as the Labrador Sea in the sequestration of CO_2 through the biological pump. The biological pump is the transfer of carbon from the surface to the deep ocean through biological processes. It begins with the production of organic carbon from dissolved CO_2 through photosynthesis. A fraction of that organic material escapes the ocean's surface, effectively removing CO_2 from the atmosphere-ocean system. In most of the world's oceans, this export of organic carbon is due mostly to the settling of detritus (sinking flux) and, to a lesser extent, to the vertical motions of marine biota (vertical migration flux). Thus, in most of the world's oceans, organic carbon moves through the water column to reach the depths. In convective areas, however, such as the Labrador Sea, dissolved organic carbon (DOC) can be transported with the water to the depths where it can be sequestered. A collaborative project with Memorial University in Newfoundland was formed to explore the strength of this DOC flux relative to other export fluxes and its sensitivity to climate using ecosystem models and physical information on the climate of the Labrador Sea.

The project uses an ecosystem model that simulates the flows of nitrogen among various ecosystem compartments and tracks the vertical motions of organic nitrogen. Nitrogen is used because it is assumed to limit biological activity in the ocean. The associated carbon flows are calculated using mostly fixed ratios. In some cases, we introduce simple rules that essentially say that organisms prefer to retain nitrogen in their bodies, because it is in short supply, and expel carbon. This model has been tested extensively in the Gulf of St. Lawrence. When applied to the Labrador Sea, the model suggests that the DOC flux is as large as the sinking flux and is substantially larger than the vertical migration flux (Figure 1). The model also suggests that the DOC flux is particularly efficient in moving organic carbon to depth, while retaining nitrogen in the surface ocean. This decoupling of carbon and nitrogen fluxes enhances the biological pump when nutrients are limiting.

We also examined the impact of variations in the strength of winter convection on carbon export (Figure 2). To study this effect, the ecosystem model was forced with data on the physical structure and climate of the Labrador Sea from periods when convection was weak (the late 1960s and early 1970s) and when it was strong (early to mid-1990s). The results indicate that the sinking flux is relatively insensitive to the variations in ocean climate. In contrast, the DOC flux is very sensitive and is the main contributor to climate-related variations in total export. This goes against prevailing views that the sinking flux is the main driver behind export variability. More to the point, this gives clues as to the potential impact of climate change on organic carbon cycling in the Labrador Sea if climate warming does result in a reduction of winter convection. Lower organic carbon export would leave more CO_2 in surface waters and lower the ocean's uptake of CO_2.

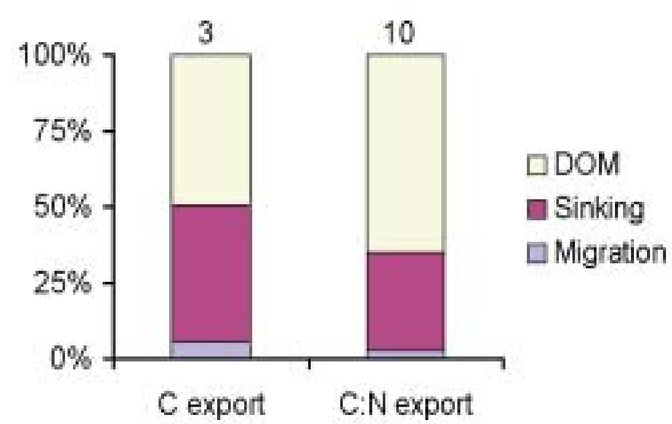


Figure 1. Relative importance of export fluxes in the Labrador Sea simulated by a physical-ecosystem model. C export is the total downward organic carbon flux across the 200 m isobath (moles C/yr). C:N export is the carbon-to-nitrogen ratio of the exported organic matter (moles C/moles N); a C:N higher than 6.6, the average C:N of organic matter, indicates that C is preferentially exported. C export and C:N export averaged across a number of simulations are given at the top of each bar and are broken down into contributions from dissolved organic matter (DOM), particle sinking, and vertical migration.

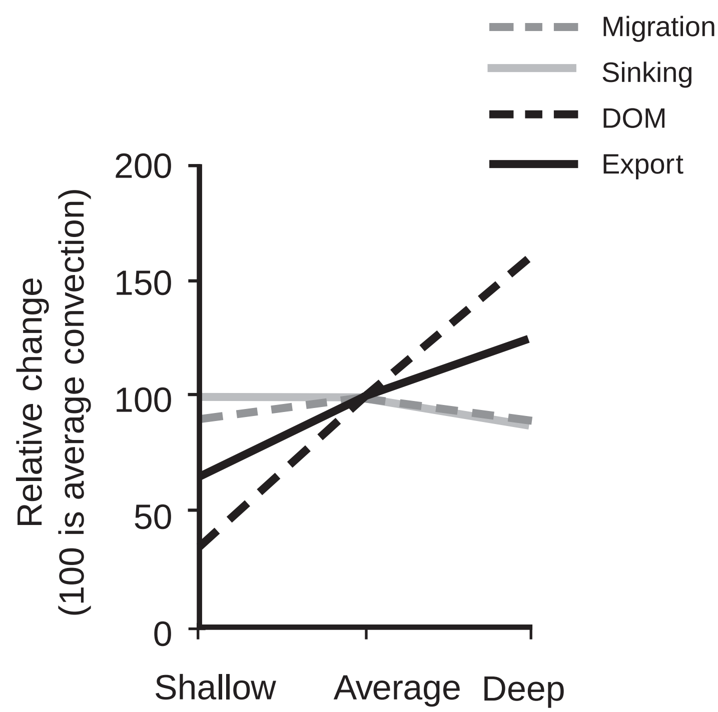


Figure 2. Relative changes in export fluxes simulated by the physical-ecosystem model under shallow (< 200 m), average (300-1000 m) and deep (> 1500 m) maximum depth of winter convection in the central Labrador Sea.

These results are preliminary and subject to change as the work evolves. Nevertheless, they are stimulating further research. One ongoing effort is to develop and refine an ecosystem model that couples carbon and nitrogen flows across all compartments, as opposed to only some of the compartments in this model. A related effort is to investigate the implications of the DOC flux for climate variations at a global scale by coupling the improved ecosystem model to an atmosphere-ocean climate model. This work will be part of a new international research initiative (SOLAS or Surface Ocean Lower Atmosphere Study) that DFO has joined along with a network of Canadian universities and other government laboratories. As part of a team working to understand the future of the ocean's carbon sink, our goal is to learn more about potential interactions between DOC flux and climate.

Marine Storms and Extreme Waves

- William Perrie

Severe Atlantic storms, such as hurricanes, begin in the tropics between 10°-14°N and 20°-70°W. They then propagate westward and some move northward towards Atlantic Canada where they affect offshore activities and cause wave and flood damage ashore. The 1990s saw several very powerful storms when maximum waves achieved heights of around 30 metres. These include the Perfect Storm in 1991, the Storm of the Century in 1993 and Hurricane Luis in 1995. The winds and waves associated with the Perfect Storm are shown in Figure 1, as observed at a buoy at the edge of the Scotian Shelf.

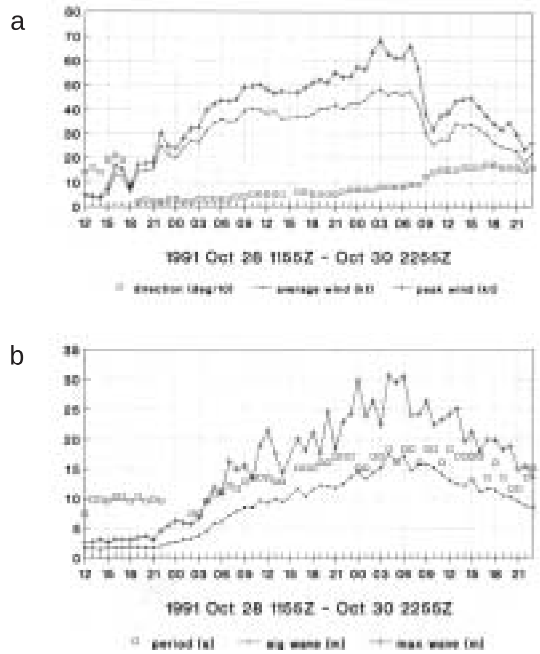


Figure 1. Buoy (a) wind and (b) wave measurements for the Perfect Storm as measured at buoy 44137 at 44.83N, 60.94W off Scotian Shelf. Sig wave, or H_S , is the mean of the highest third waves in the distribution (from Cameron and Parkes, 1992, 3rd International Workshop on Wave Hindcasting and Forecasting).

The tracks for hurricanes for the 2000 season are shown in Figure 2. While there is a large scatter in the tracks, six of these fifteen hurricanes impacted Canadian waters. Other severe marine storms begin over the mid-west and strengthen significantly as they move along the eastern seaboard of North America. Ocean Sciences Division has been studying the air-sea processes related to the development of the winds and the waves associated with the most severe of these storms.

To predict the development of winds and waves with such storms, we need to consider the processes that couple these two phenomena. The wind, blowing over the sea surface, generates waves. The longer the winds blow and the stronger the winds, the larger the waves grow. Computer wave models, developed and tested by the Ocean Sciences Division, in collaboration with other researchers in the US and abroad, simulate wave growth and development. As waves grow and develop, they increase the roughness of the sea surface as experienced by the atmospheric boundary layer. This affects the atmospheric dynamics and changes both the winds and the momentum transfers

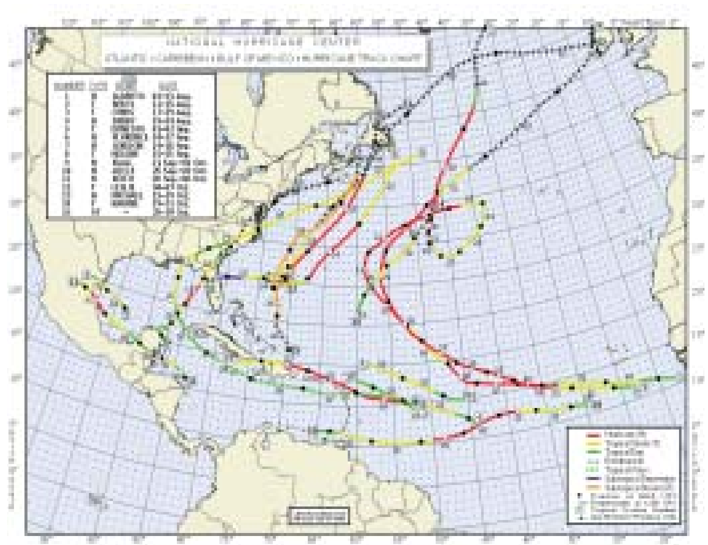


Figure 2. Hurricane and cyclonic storm tracks from 2000. As presented on the US National Hurricane Center website.

that feed the wave growth. Thus, the coupling of waves and winds has impact not only on winds, but also on the waves that we try to simulate. Figure 3 is an example taken from a 1997 storm. When the wave model is driven by winds that are not coupled, it under-predicts the waves measured at buoy 44138 on Scotian Shelf. When the wave model is coupled to the atmospheric model, the simulation is improved, particularly at the peak of the storm.

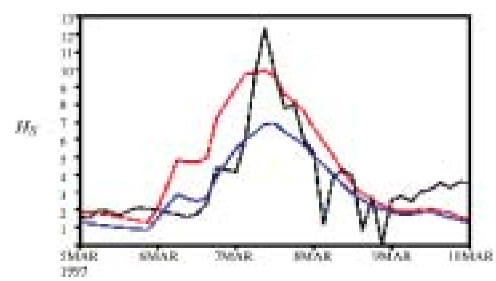


Figure 3. Observed significant wave height H_S at buoy 44138 in comparison with estimates from the coupled and uncoupled models at 0800 UTC on March 8, 1997 at the peak of a storm crossing the NW Atlantic. Coupled model is red, uncoupled model is blue and measured data is black. Units are in meters.

Understanding the interactions of waves on waves is heavily dependent on numerical methods and computational work. As a wave field develops, wave-wave interactions re-distribute energy within the wave spectrum. These interactions are computationally intensive. We were able to establish an efficient and accurate algorithm to compute the energy and momentum re-distribution caused by these interactions and to show the conditions when it would become inaccurate. Unfortunately this algorithm is still not efficient enough for implementation in the operational wave forecast models run by weather forecast centres. Our objective continues to be the achievement of a better optimization that can be implemented.

The improved-coupled model allows us to investigate other processes associated with winds and waves. Wave dissipation takes energy from the spectrum and puts it into surface currents. During a rapidly developing storm, surface currents may be enhanced as much as 30-40% by wave dissipation. During quiescent periods when waves are small or are not rapidly developing, this surface current enhancement effect is small.

Thus, waves interact with the atmospheric boundary layer that forms and drives them. Through wave-induced roughness, sea spray and other processes, the ocean exchanges mass, momentum, and heat with the atmosphere. These effects are caused by the marine winds, and also have impact on the processes that create and determine these winds. The waves are also coupled to surface currents. These, in turn, affect the wave growth. Wave growth leads to wave breaking which adds new momentum to these currents. It is only by working with a coupled upper ocean and atmospheric boundary layer that one can hope to arrive at an improved understanding of marine storms and their impacts on human activities in Atlantic Canada.

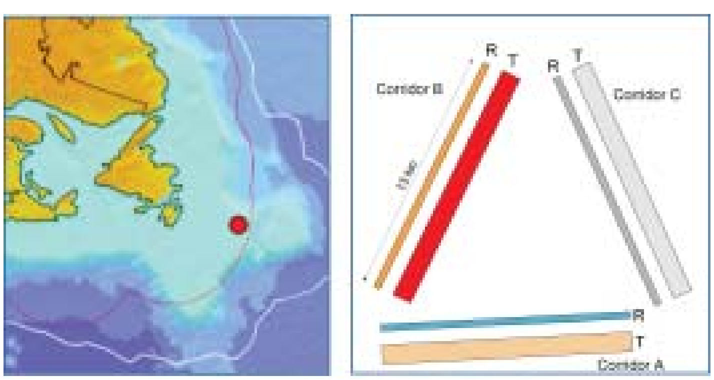
Marine Environmental Sciences

The Grand Banks Otter Trawling Experiment

– Donald C. Gordon Jr., Kent D. Gilkinson, Ellen L.R. Kenchington, Cynthia Bourbonnais, Kevin MacIsaac, David L. McKeown, and W. Peter Vass

Mobile fishing gear such as beam trawls, otter trawls, scallop rakes, and clam dredges is widely used around the world to harvest fishery resources. Concerns have been raised about their environmental effects. Understanding the impacts on benthic habitats and communities is difficult and expensive, especially for offshore fishing banks. Benthic habitats and communities display considerable natural variability, both spatially and temporally, which must be factored into the design of research programs.

Over the past 50 years, otter trawls have been widely used in Atlantic Canada to capture bottom dwelling species such as cod, haddock, plaice, flounder, and shrimp. From 1993-1995, we conducted an experiment to examine the effects of intensive otter trawling on a sandy bottom ecosystem at a depth of 120-146 m on the Grand Banks off Newfoundland. Analysis of historical effort data indicated that the study site had not been trawled for at least 13 years and was therefore undisturbed. Three, 13 km long experimental corridors were trawled twelve times each year, with an Engel 145 otter trawl equipped with rockhopper footgear. A broad array of imaging and sampling instrumentation was used to survey trawled and nearby reference corridors both before and after experimental trawling over different spatial scales. This instrumentation included sidescan sonar, an epibenthic sled, and a video-equipped grab.



Location of study site on the Grand Banks and orientation of trawled (T) and reference (R) corridors (300 meters apart). All three corridors were trawled while the epibenthic sled and videograb samples were only collected in corridors A and B.

The most pronounced impacts were the immediate physical effects on habitat. Sediment was resuspended by all parts of the otter trawl, furrows and berms were formed by the doors, biological sediment structures were either modified or destroyed, and organic detritus was dispersed. However, these physical effects appeared to be relatively short-lived. The available evidence suggested that the habitat recovered in about a year or less.

The most immediate biological effect was the removal of large epibenthic organisms from the seabed by the otter trawl. Except for snow crabs and basket stars, removal appears to have an insignificant effect at the population level. This is because of the low efficiency of the otter trawl in catching epibenthic organisms.

Less obvious, but more significant, was the immediate damage done to epibenthic organisms that were left behind on the seabed. Some were killed outright, while others were damaged or exposed. Most susceptible were the larger epibenthic organisms that live on the sediment surface such as snow crabs, basket stars, sand dollars, brittle stars, sea urchins, and soft corals. The net effect was a 24% reduction in mean biomass, within a few days after trawling. This reduction in biomass was due to removal by the otter trawl, predation by scavenging organisms, displacement outside the disturbed area, and perhaps burial by resuspended sediment.

Both the immediate and long-term impacts of otter trawling on benthic infauna, which live within the sandy seabed, appeared to be minor. For the most part, significant effects were seen in a limited number of polychaetes and were restricted to one year of the experiment (1994). All available evidence suggested that the biological community recovered from the trawling disturbance in less than a year. Most of the affected epibenthic species have some power of locomotion, and migration into the disturbed area from the surrounding undisturbed area was highly probable. Effects were observed on only 25 species out of over 250 taxa, so the majority of species present (including all the molluscs) were not affected by otter trawling. No significant effects could be seen on the benthic community after three years of trawling. The habitat and biological community at the experimental site were naturally dynamic and exhibited marked changes irrespective of trawling activity. The effects of

Typical epibenthic sled sample showing dominant species.

natural variability on the infaunal benthic community at the study site appeared to over-shadow the effects of trawling.

The results of this unique experiment are in agreement with the scientific literature. This literature indicates that the effects of otter trawling are quite variable and depend upon numerous factors such as previous fishing history, how the otter trawl is deployed, the intensity and frequency of use, the type of habitat, and the kind of organisms present. In some instances, effects are negligible and short lived, while in other cases they may be profound and long lasting. Sandy bottom ecosystems, such as the one studied in this experiment, tend to be the most resilient to trawling effects.

Further research is needed to improve our knowledge of mobile gear impacts and to develop the information needed to adopt a more ecosystem-oriented approach to fisheries, habitat, and oceans management. Information requirements include further gear impact experiments to improve our understanding of the role that benthic habitat and communities play in marine ecosystems, mapping benthic habitat and communities, and mapping the fine-scale spatial distribution of fishing effort. Additional experiments are currently being conducted by DFO to study the effects of otter trawling on a cobble bottom on Western Bank and hydraulic clam dredging on Banquereau.

Biological Sciences

Aquaculture Research at BIO

- Dan Jackson, Bénédikte Vercaemer, Barry MacDonald, Koren Spence, Rajashree Gouda, and Ellen Kenchington

Invertebrate aquaculture research is a focus of research at BIO, with most of this activity occurring in the facilities of the Fish Laboratory building. Scientists from the Invertebrate Fisheries Division of DFO conduct research projects designed to advance the shellfish aquaculture industry in Atlantic Canada. A strong emphasis is placed on applying the latest developments in biotechnology to current problems in aquaculture.

Most of our studies are carried out on bivalves currently under commercial production in Atlantic Canada which include sea scallops, bay scallops, oysters, and mussels. However, we also have a mandate to conduct research into other species in which there is growing interest from the aquaculture industry, such as, abalone. Many of our activities are directed towards refining husbandry techniques and dealing with specific biological problems in cultivation, as well as dealing with general questions related to the life history processes of shellfish. This information is used to help develop superior performing strains for aquaculture, and to address related ecological and genetic questions. The knowledge gained by our efforts is shared with commercial aquaculture ventures to assist in the development of this growing industry.

Ongoing research in our labs includes studies on improving the quality and quantity of phytoplankton diets for cultured bivalves, and on better larval culture methods to improve the efficiency and quality of bivalve production. Some of our work with mussels is intended to provide Nova Scotian growers with guidance as to how the deploy-

Bénédikte Vercaemer measuring oysters in the Fish Laboratory – photo by Barry MacDonald.

Shawn Roach and Barry MacDonald assess pedigree mussels in the BIO bivalve culture lab – photo by Dan Jackson.

ment of spat collectors can affect farm yield on sites where two similar species of mussels, *Mytilus edulis* and *Mytilus trossulus*, exist. Other investigations include species identification using genetic markers, assessment of inbreeding levels in local European oyster broodstock using genetic sequence data, and studies of the sex determination mechanisms in the blue mussel. We are also developing genetic techniques geared towards identifying disease resistant genes in oyster broodstock.

BIO's scallop triploid project, supported by the federal Canadian Biotechnology Strategy, is designed to produce scallops that grow faster and have larger, higher quality meats. Our technology involves manipulation of the fertilization process to produce scallops that have three complete sets of chromosomes instead of the usual two. These triploid animals are sterile, and as a result they redirect energy otherwise allocated to reproduction into increasing overall growth. Recent efforts in our lab have focussed on the optimum methods of inducing triploidy in sea scallops, and assessment of the physiological performance (growth and feeding rates) of triploids and diploids.

A juvenile scallop, approximately two months old – photo by Dan Jackson.

Our Canadian Biotechnology Strategy-funded genetic biotechnology projects examine genetic variability in wild haddock and integrate molecular techniques in attempts to enhance the efficiency of genetic improvement programs for haddock aquaculture. This work is conducted in collaboration with scientists in the Centre for Marine Biodiversity, Diadromous Fish Division of DFO at BIO, and the St. Andrew's Biological Station (DFO) in New Brunswick.

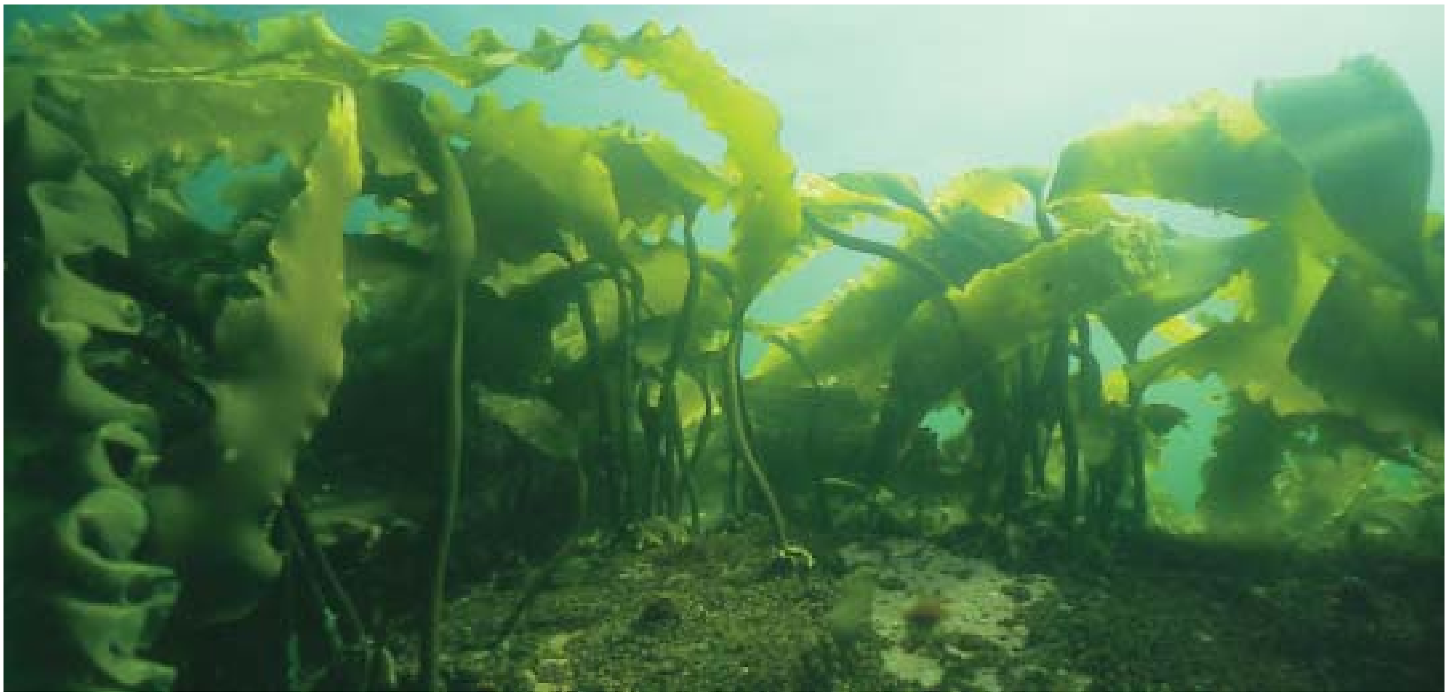
The BIO facilities (including a phytoplankton production room, shellfish hatchery, nursery, and broodstock rooms, and supporting labs) are well suited to support our research into the hatchery production of molluscan species. We currently have 13 species of phytoplankton under production that are used as feed for larval, juvenile, and adult bivalves. Our phytoplankton production lab includes 13 large culture tubes for producing up to 600 litres of algae daily (at a density of approximately 6 to 7 million cells/ml) for feeding both juveniles and adults. We also culture algae in 10 litre carboys, which are used to supply bacteria-free food to the larval stages. We can produce approximately 50 litres of this higher density food (10 to 12 million cells/ml) daily, which is enough to feed up to 85 million newly hatched bivalve larvae.

Bivalve larvae are usually reared in insulated tanks; we currently have four 1000-litre tanks and fifteen 250-litre tanks, as well as a number of smaller non-insulated culture vessels. Juvenile and adult animals are held in a variety of fibreglass and plastic tanks, which range in size from six-foot diameter circular tanks to 60-litre plastic containers. Larval tanks are changed and cleaned every two days and the larvae are fed daily, while the adult tanks are supplied with a constant flow of seawater and the juvenile tanks are set up on a semi-recirculating system. These allow for replicated experiments at all life history stages. In addition, BIO has a quarantine facility, with three lab modules, that is used to support research on diseased animals and non-domestic species. These labs offer flexibility with respect to the size and number of tanks, and have independent lighting and water options. The wastewater is monitored and treated to ensure that the discharge water will not affect the local environment.

As an essential part of our aquaculture research, we have developed advanced laboratory facilities, including the BIO Flow Cytometry and Scientific Imaging Laboratory. In this lab we have top-grade research microscopes and digital camera equipment that is used to take high-resolution images of our experimental animals. Using this technology we can measure the sizes and other features of the animals, or perform more sophisticated image analysis routines such as fluorescent probe studies or motion analysis. A flow cytometer is used to measure the ploidy level of scallops and mussels in support of our triploid research programme. Detailed bivalve feeding studies that measure the type and amount of phytoplankton cells, which are ingested by the animals, are also performed using the capabilities of the flow cytometer. The affiliated Centre for Marine Biodiversity Laboratory has a new state-of-the-art molecular level biology facility, which features an MJ BaseStation slab gel automated platform and supporting equipment for performing genotyping and sequencing. In this lab, genetic markers are used and developed to address questions related to population genetics or species identification and pedigree analysis of broodstock, providing a wide range of molecular biological information to biologists and researchers at BIO.

The Challenge of Developing New Fisheries

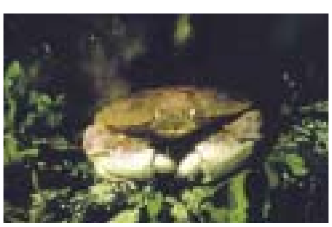
– Bob Miller



Kelp bed – photo by Bob Semple.

The inception of a new fishery is generally accompanied by regulatory challenges. The newer fisheries such as sea cucumber, periwinkle, Jonah crab, toad crab, ocean quahog, and whelk have all experienced a sporadic history of exploitation. This highlights the importance of an amicable working relationship between fisher and fishery scientist because even the most rudimentary assessment requires catch data.

Fishery science questions that biologists usually address throughout the course of a fishery relate to growth, mortality, fecundity, size at maturity, sustainable yield, stock size, and stock boundaries. Most of this information is not needed at the outset. Early in the fishery, accurate data are needed on fish removals which include catches sold through conventional channels, discard mortalities of the target species, bycatch by other fishing fleets, the recreational catch, and poaching. At the beginning of a new fishery, fishing gear needs to be evaluated and possibly modified to minimize waste of non-target species, discards of undersized individuals of the target species, and habitat damage. Because many fishery management measures relate to gear (size, number of units, bycatch, and gear conflicts) the fewer the gear types the easier the fishery is to manage. Fishing location is also important because most parameters of interest are area specific. Even if a new fishery fails, a report on what was learned is produced for potential future use.



Jonah crab – photo by Bob Semple.

Sea cucumber – photo by Bob Semple.

The following are some species under new regulations. Although blood worm is an old fishery it has only recently become regulated.

SPECIES	FISHERY MANAGEMENT MEASURES
Blood worms	Minimum worm size in grams, spawning season closed, and temporary closure of overexploited areas.
Kelp	Limits on the largest patch that can be cut (15 m by 15 m), the fraction of a bed that can be harvested in one year (one-third), and minimum plant size (1 m long).
Jonah crab and rock crab	Minimum size to maintain reproductive potential, season to reduce gear conflicts with other fisheries, and trap modifications to allow sublegal crabs to escape and to reduce lobster bycatch.
Sea cucumber	Seasons to avoid gear conflicts with the lobster fishery.

Marine Fish Division/Invertebrate Fisheries Division Virtual Data Centre

– R. Branton (MFD), G. Black (IFD), and J. McRuer (MFD)

What is VDC

Marine Fish (MFD) and Invertebrate Fisheries (IFD) divisions at BIO and Saint Andrews Biological Station (SABS) provide the scientific foundation for the DFO Maritimes Region's finfish and shellfish harvest fisheries management activities. The primary inputs are a complex array of data from various sources including government research vessel surveys, industry surveys, fishers' logbooks, commercial catch statistics, port samples, and at-sea observers.

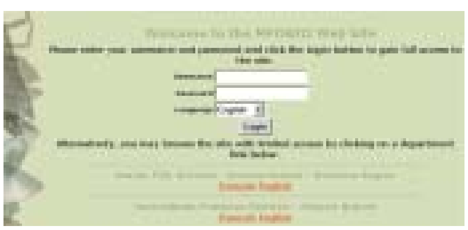
Recent changes to DFO's computing culture (adopting software standards and declaring a Science Data Management Policy) have prompted MFD and IFD to jointly develop an intranet website to facilitate access to these data. This integrated science user-oriented facility, otherwise referred to as the 'Virtual Data Centre' or VDC, is a completely new data retrieval and analysis tool. This tool greatly enhances research productivity by enabling diverse and disparate data sets to appear in common/familiar forms at a central location.

The VDC offers a product-oriented approach to data analysis activities. Data products are produced on demand directly from the database, including a wide range of maps, graphs, reports, spreadsheets, images, and movies.

Using VDC

The VDC is accessed using Internet Explorer. Entry is controlled via a central username/password login page.

http://mfdvdc.bio.dfo.ca

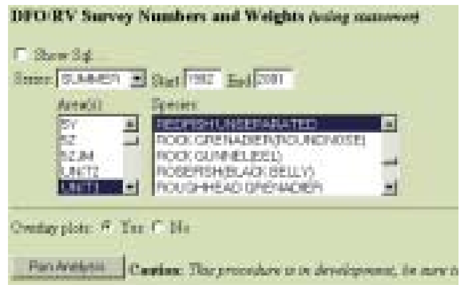


New users automatically receive guest status to view pre-formed public material. Before viewing private or restricted material or querying the underlying data, the guest must apply to site or group administrators for a username and password. Each group contributing to the site controls its own mini VDC consisting of staff lists, project pages, and data pages.

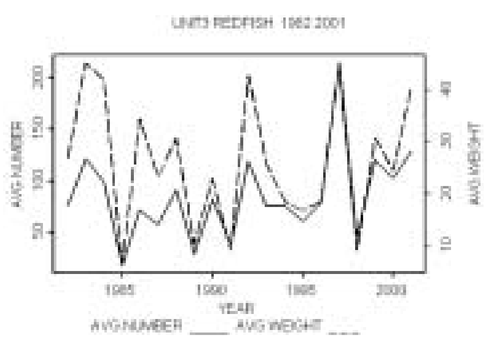
Project leaders and data managers administer their project and data pages while individual staff can create links to frequently used project and data pages, as well as create and maintain their own personal content.

VDC products

Data products appear as pre-formed reports or as drop down menus and push buttons, which give the user the option of creating their own report. These menus provide the ability to specify species names, stock area, survey series, and ranges of years, all appearing in a common natural language form.

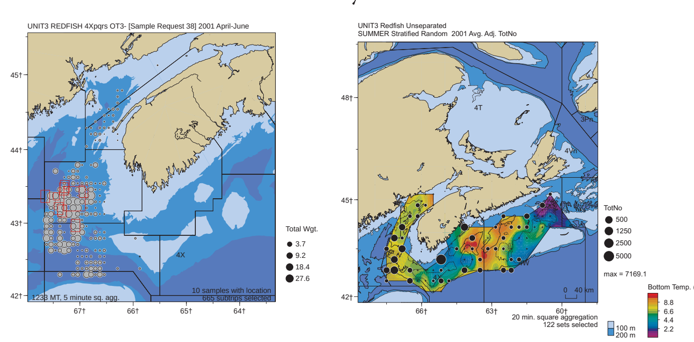


Data tables, graphs and maps can be used in presentations or pasted directly into scientific documents.

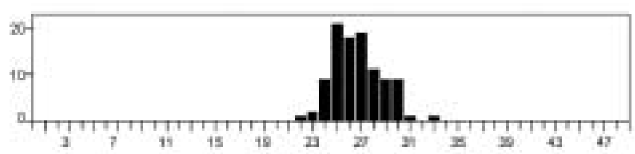


Sample line graph - research vessel survey information for Scotian Shelf redfish.

Maps can be produced as data movies to facilitate exploration of spatial and temporal trends within the data or as interactive graphics where the area of interest can be enlarged and triggered to provide spreadsheets and/or detailed statistical analysis of the selected observations.



Sample maps – (Right) research vessel survey information for Scotian Shelf redfish. (Left) commercial landings and port samples (otter trawlers <65') for western Scotian Shelf redfish.



Sample histogram - redfish port samples selected from map shown above.

Data sources accessed via the VDC are documented with a full-featured data dictionary describing all data tables, columns, and codes.

GROUNDFISH PORT SAMPLES
Data Dictionary - CODE Tables

Column	NotNull	Indexed	Coded	Type	Size	Description
[illegible]	*			VARCHAR2	1	[illegible]
DESCRIPTION	*			VARCHAR2	13	[illegible]

[illegible]	DESCRIPTION
[illegible]	[illegible]
1	MALE
2	FEMALE
3	[illegible]
4	[illegible]
9	NOT [illegible]

GROUNDFISH PORT SAMPLES
Data Dictionary - DATA Tables

Select	Column	NotNull	Indexed	Coded	Type	Size	Description
	SAMPLE	*	*		NUMBER	6	Sample Number
	MARKET	*	*	[illegible]	VARCHAR2	1	Market Category
	SEX	*	*	[illegible]	VARCHAR2	1	Sex Code
	GROUPING				NUMBER	1	CR Length Grouping
	LENGROUP	*	*		NUMBER	7,1	Length Interval
	NUMATLEN	*			NUMBER	3	Number of Fish at Length Interval

Ready to use Structured Query Language (SQL) queries are also provided for ad hoc access to the data.

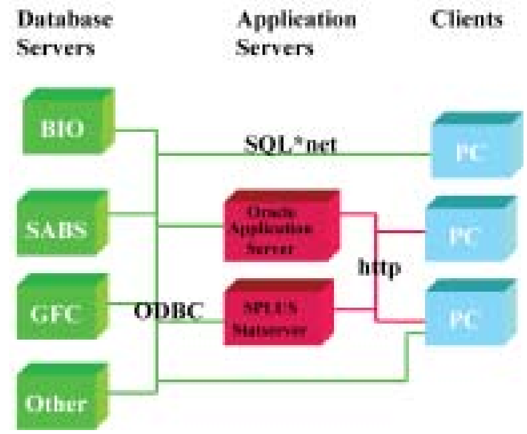
In addition to data, the VDC stores and retrieves digital images of research activities, individual specimens, and sampled materials such as the otoliths used to determine fish age.

Redfish otolith – photo by Steven Campana.

VDC details

The VDC was created as part of the computing revitalization initiatives arising from the government-wide Year 2000 project. External funds from the Census of Marine Life Project and Fisheries Information Management Project are now being used to make further improvements.

The VDC is the interplay of several technologies. Key hardware components are the DFO intranet, Oracle Databases & Web Application Servers, ACON data visualization system and Splus Statserver. Primary programming languages are: HTM, SQL, PL/SQL, C++, and Splus.



User and Administrator manuals are available directly from the website.

VDC benefits

Standardized data management methods have allowed MFD and IFD to improve data collection activities. For example, survey data are now routinely available for analysis within a day or two of the completion of a research vessel cruise. The VDC, coupled with improved data collection, has increased data accessibility, thus increasing overall analytical capability and facilitating the resource status evaluation process. The VDC provides a focus for liaison with resource managers and external clients, as it allows research managers to quickly develop and review stock indicators to determine when significant changes in stock status have occurred.

New analytical modules are continually being added, with a new release of the VDC core expected in early 2002. DFO Maritimes Informatics Branch is in the process of adopting the new VDC into the realm of supported systems and will use it to form the basis of a system of regional and potentially national virtual data centres.

Redfish or ocean perch.

VDC contacts

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The Scotian Shelf and Southern Grand Banks Atlantic Halibut *(Hippoglossus hippoglossus)* Survey

– Collaboration Between the Fishing and Fisheries Science Communities

- K.C.T. Zwanenburg and S. Wilson

Since 1970, Canada has conducted standardized otter trawl surveys to derive estimates of fish population abundance on the Scotian Shelf. These surveys give highly variable abundance estimates for Atlantic halibut *(Hippoglossus hippoglossus)*, a very valuable, commercially exploited species. The groundfish surveys were not designed to estimate abundance of this non-schooling species and do not cover the entire geographic range of the population.

In 1998, a longline survey for Atlantic halibut was implemented to improve these estimates by using fishing gear that captures halibut more effectively and by covering more of the geographic range of the population (Figure 1). The survey is a collaboration between DFO and the community of expert halibut fishermen who exploit this species on the Scotian Shelf and southern Grand Banks. A self-funding, long-term (10 year plus), two-stage design consisting of stratified random and commercial index phases was adopted. The stratified random phase picked 220 sampling locations which are now fixed positions sampled each year, while the commercial index phase allows the commercial fishermen to pick varying sampling locations based on their experience. The stratified random phase provides unbiased estimates of population abundance while the commercial index phase provides estimates of commercial catch per unit effort and allows fishermen to contribute their knowledge and expertise to improving our understanding of this species.

The ongoing survey has already provided a wealth of information on halibut distribution, population size structure, and diet composition, and has also collected large numbers of halibut otoliths (ear bones) to be used in determining the age structure of the population. The halibut survey has provided more information on the distribution, abundance and biology of halibut than was collected by the previous 30 years of trawl surveys.

The fourth year of this important survey, conducted by 10–15 commercial fishing vessels each year, was completed in July of 2001. Although it is still too early to draw firm conclusions based on only four years of data, we do see that halibut population numbers have been relatively stable over the course of the survey (Figure 2) as judged by both the stratified random and the commercial index portions of the survey. The missing piece of the puzzle is whether the population is stable at high or low numbers relative to its history.

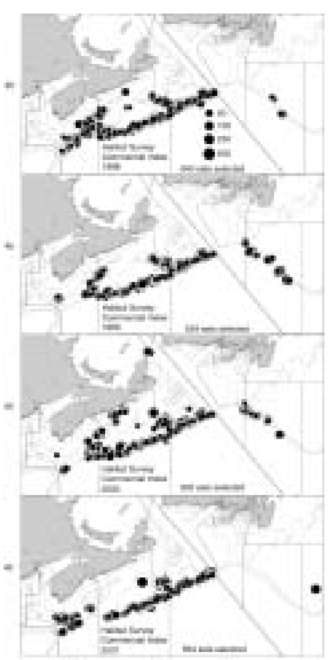


Figure 1A. Geographic distribution of halibut survey commercial index catch rates (kg per 1000 hooks adjusted for soak time).

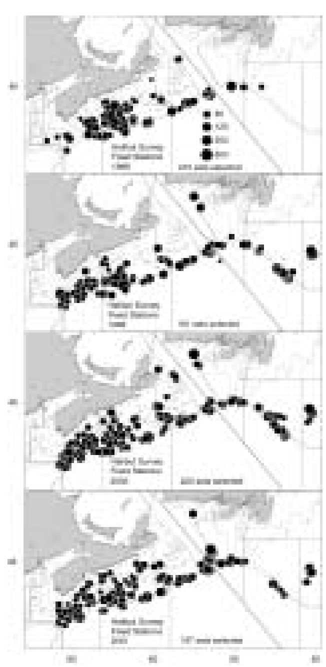


Figure 1B. Geographic distribution of halibut survey fixed station catch rates (kg per 1000 hooks adjusted for soak time).

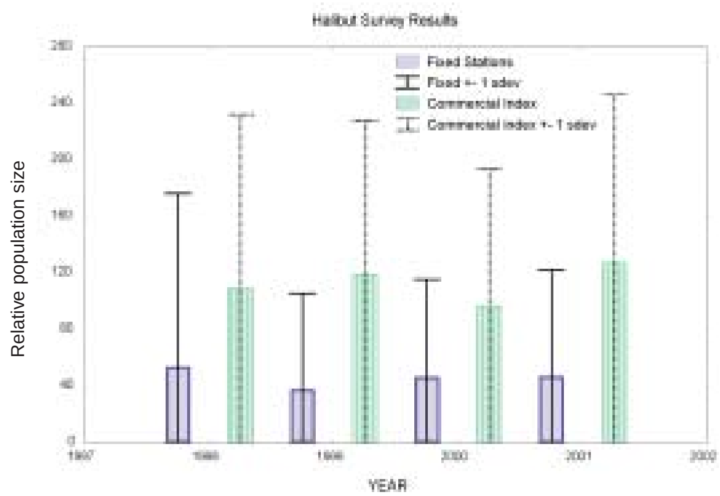


Figure 2. Results of the Scotian Shelf and Grand Banks longline halibut survey showing catch rates for both the stratified random and commercial index phases.

We are also in the process of verifying the ages of halibut as determined by counting the growth rings in the otoliths. This study uses the detectable fall-out from nuclear testing, started in the 1950s, as a marker in the otoliths to judge whether each observed ring is equivalent to a single year's growth. Preliminary results indicate that this is the case and we are now in position to determine the ages of all the fish sampled. Knowing the age structure of any fish population is important because it tells us the probability of surviving from one age to the next, and what impact fisheries have on that probability. The large numbers of otoliths collected will allow us to develop detailed estimates of population age structure and survival rates.

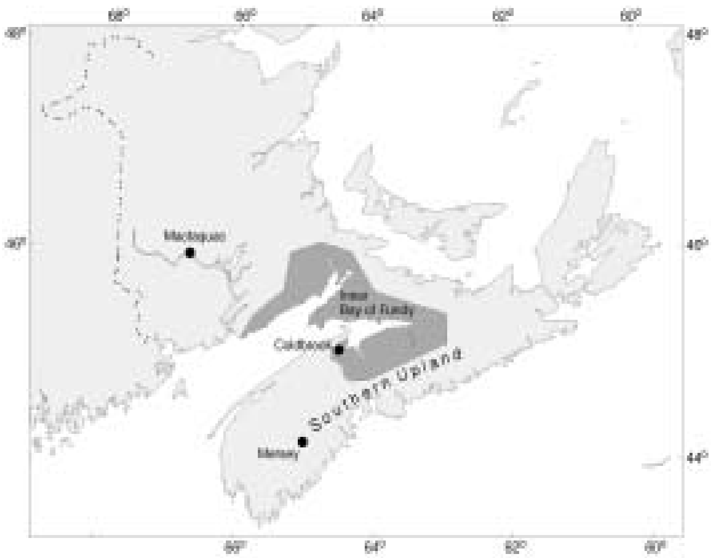
This survey has provided important information on the halibut of the Scotian Shelf and southern Grand Banks and has fostered cooperation between scientists and fishermen.

Freshwater Biodiversity Facilities

- T. R. Goff, S. F. O'Neil, and T. L. Marshall

Declines in abundance of Atlantic salmon, closures of many fisheries, and the recognition that many stocks are either endangered or threatened, dictated a new focus for DFO Maritimes Region's three hatcheries. That focus is the development and maintenance of living gene banks. This is done through captive production of broodstock, DNA-based selected matings to maximize genetic variability, early stocking of their progeny to maximize natural selection in freshwater, and later collection of older parr for renewed production of broodstock. This circumvents the current harsh marine conditions affecting the salmon's normal life history, and maximizes their potential for recovery once conditions for survival improve. The new focus essentially eliminates smolt and juvenile stocking for "enhancement of fisheries". This has prompted DFO Science Branch to rename facilities at Mactaquac near Fredericton, NB, Coldbrook, NS, and Mersey, near Liverpool NS as "Biodiversity Facilities".

Aerial view of the Mactaquac Biodiversity Facility (bottom), Mactaquac Dam (top center) and Early Rearing Facility (complex downstream and right of the dam).



Location of Freshwater Biodiversity Facilities, inner Bay of Fundy watersheds and NS Southern Upland.

Mactaquac Biodiversity Facility

The Mactaquac Fish Culture Station was opened in 1968 to mitigate losses of salmon to hydroelectric development on the Saint John River. Mitigation relied on releases of smolts. Smolt quality was improved over time by the deepening of ponds, reductions in fish densities, and construction of an Early Rearing Facility that reduced age-at-smoltification from two to one year. By the 1990s, juvenile production, principally for the Saint John River and tributaries, was about 300,000 age-1 sea-going smolts and an equal or greater number of age-0 parr for river stocking.

In 1998, a few of the facility's many ponds were dedicated to the first phase of live gene banking of New Brunswick's "endangered" inner Bay of Fundy salmon. This involved rearing captured wild juvenile salmon from the Big Salmon River through to the adult stage, and their subsequent mating. All fish were subjected to DNA analysis for stock origin and family grouping so that mating of siblings was minimized and family representation was optimized.

This program is expected to yield about 2.5 million eggs per year for re-population of inner Bay of Fundy rivers and production of next generation parr, and ultimately broodstock. Plans are to continue this process until such time as marine survival improves.

In 2000, a similar but smaller scale program was initiated for the near-extirpated Magaguadavic River stock of the outer Bay of Fundy.

Further, the Mactaquac program is now shifting from using wild brood fish captured at Mactaquac Dam for production and release of smolts, to using wild juvenile salmon captured upstream of the dam for the production of broodstock and release of adult spawners. This departure from past practices is due to:

- a 20-year and 10-fold decline in the number of adult returns originating both at and upstream of Mactaquac, and
- emerging confidence in the ability to produce adult fish in freshwater from juveniles.

Recovery to previous stock numbers is unlikely to occur until marine survival improves. Recovery will be impossible however without a stable freshwater population of wild juveniles. Adult releases from the captive rearing program will have the potential to deposit 12 million eggs or about 40% of the conservation requirement for the river upstream of Mactaquac. This will eliminate the need to retain broodstock from valuable wild adults returning to the dam.

Stock assessments, research, and outreach

In addition to rearing fish, the Mactaquac Biodiversity Facility yields biological information. In particular, its trapping facility at the Mactaquac Dam yields important information for the assessment of salmon, alewife, blueback herring, American eel, striped bass, and Atlantic and shortnose sturgeon. Research is also conducted in cooperation with universities, private industry, and fish and wildlife organizations. Investigations have included the viability of triploid salmonids for aquaculture, vaccine development, and growth and condition of fish reared at various temperature regimes. Cooperative programs with local First Nations contribute to the facility's operations, including a Visitor Interpretation Center. The Visitor Center exhibits the operations of the facilities and the life cycle of the Atlantic salmon.

Coldbrook and Mersey Biodiversity facilities

The Coldbrook and Mersey Biodiversity facilities engage in live gene banking of Atlantic salmon, stocking of salmon in rivers negatively impacted by acid precipitation, and research on a variety of salmon and endangered Atlantic whitefish initiatives. These activities replace previous enhancement programs.

Mersey Biodiversity Facility upper ponds and culture and research buildings.

The Mersey and Coldbrook Biodiversity facilities are operated jointly to meet program objectives. The brood fish for all salmon programs are held at Coldbrook, where surface and well water provide temperature control and flexibility. Rearing of young takes place at Mersey where the greater water supply permits the production of up to 300,000 age-1 sea-going smolts, and an equal or greater number of age-0 parr for river stocking.

Living gene banks

As was the case at Mactaquac in 1998, a few of the many ponds at Coldbrook were dedicated to the first phase of live gene banking the endangered Nova Scotia inner Bay of Fundy salmon. In this case, wild juvenile salmon from the Stewiacke River are being reared through to maturity at Coldbrook. Between 0.5 and 1.0 million eggs will be hatched and grown at Mersey for release into the Stewiacke and other inner Bay of Fundy rivers, from which salmon have been extirpated. Implicit in our direction for the living gene banks is a DNA-based prescriptive mating strategy like that described for Mactaquac.

Additionally, progeny of adult salmon of the inner Bay of Fundy's unique Gaspereau River are reared and returned to the river. Juveniles from several other Nova Scotia inner Bay of Fundy rivers have been collected for possible inclusion in the inner Bay gene bank program.

Intervention in acid-impacted rivers

Acid precipitation has contributed to serious declines, and in some cases, extirpation, of salmon in over 50 rivers of the Nova Scotia Southern Upland. Adult salmon are being collected from several rivers to supplement smolt production due to losses caused by acid precipitation. Genetic analysis of many other river stocks is ongoing and in the short term, supplementation with cultured fish and or live gene banking should avoid complete loss of the unique stocks.

Research, First Nations support, and outreach

Breeding, rearing, and stocking fish in support of fisheries was the previous principal activity of federal fish hatcheries in Nova Scotia. Few fisheries now remain and the preservation of stocks and their genetic diversity is becoming the goal.

Confined to a single watershed in Nova Scotia, the endangered Atlantic whitefish *(Coregonus huntsmani)* is being cultured at Mersey to ascertain the influence of environmental variables on its survival and growth. Ultimately, the goal is to develop technical capability to repatriate the species to its former range.

Endangered Atlantic whitefish, Coregonus huntsmani.

The facilities also support salmon conservation initiatives identified by First Nations, welcome tour groups, and offer training for community college students.

Research Voyages

– D. L. McKeown

CCGS *Alfred Needler*

Redfish catch – summer 2001 groundfish survey of the CCGS Alfred Needler *on the eastern Scotian Shelf – photo by J.G. Reid.*

CCGS *Alfred Needler* is a 50m offshore fisheries research trawler. In January 2001, the vessel was engaged in fish behaviour studies off Cape Breton and during February and March, carried out shellfish and winter groundfish surveys on the Scotian Shelf. From May to November, DFO scientists from the Bedford Institute of Oceanography, Gulf Fisheries Centre, and the Maurice Lamontagne Institute used the vessel to conduct offshore finfish and shellfish ecosystem surveys and related research programs on the Scotian Shelf from Georges Bank to Cabot Strait and into the Gulf of St. Lawrence. In December, the ship undertook groundfish surveys for the Newfoundland Region in place of the *Teleost* that had mechanical equipment problems.

CCGS *Hudson*

Towcam being deployed on the CCGS Hudson *by Peter Vass and Dwight Reimer.*

CCGS *Hudson* is a 90m offshore oceanographic research and survey vessel. During the winter of 2000/2001, the vessel completed the second phase of an extensive refit to prolong its working life another seven to ten years. On May 1, it departed on the annual spring cruise to collect physical and biological oceanographic data for the Atlantic Zone Monitoring Program (AZMP). This cruise encompassed a series of survey lines across the Scotian Shelf ranging from southern Nova Scotia to Cabot Strait. In early June, the ship journeyed to the Labrador Sea to service oceanographic moorings and conduct hydrographic (conductivity/temperature/depth) survey operations as part of Canada's contribution to global climate studies. After returning to BIO to change staff and re-configure equipment, the ship served as a platform for Natural Resources Canada and Dalhousie University staff who conducted a major seismic refraction survey on the Scotian Shelf.

After another stop at BIO to reconfigure scientific equipment, the vessel carried out a series of geoscience studies on the Grand Bank, Scotian Slope, and Scotian Shelf from mid-July to mid-September. A team of BIO and Northwest Atlantic Fisheries Centre scientists then boarded the ship to conduct benthic and fisheries habitat studies on several of the offshore banks from Banquereau to Georges and to survey and sample deep sea corals in the Gully and along the continental slope. From mid-October to mid-December, staff from BIO, the Northwest Atlantic Fisheries Centre and the Maurice Lamontange Institute conducted three consecutive cruises to obtain the autumn AZMP physical and biological oceanographic data set. The scientific season concluded on December 9 when the ship was laid up at BIO for the winter season.

CCGS *Matthew*

CCGS *Matthew* is a 50m coastal research and survey vessel. Its season began in May when a group of BIO physical and chemical oceanographers took the vessel to Sydney Harbour to collect sediment samples and water column data for toxicological studies. At the beginning of June, the ship proceeded to the south coast of Newfoundland to commence its annual hydrographic charting program. After a brief geoscience survey in Notre Dame Bay, the vessel moved to the Labrador Coast to continue hydrographic surveys until early October. After being reconfigured with geophysical equipment at BIO, it carried out a geoscience survey near Rustico, Prince Edward Island. Its operational season ended at BIO on November 2.

The launch Pipit *approaching the CCGS* Matthew *– Isle aux Morts, south shore of Newfoundland.*

CCGS *J.L.Hart*, CCGS *Navicula*, CCGS *Opilio* and CCGS *Pandalus III*

The DFO Maritimes Region also operates several smaller inshore fisheries research trawlers. These vessels are used by a large number of scientists to pursue a wide range of scientific program including stock assessment, fisheries and habitat research and geophysical surveys. CCGS *J.L.Hart* (20m), operating out of the St. Andrews Biological Station, spent most of the 2001 season supporting research programs in the Bay of Fundy area. The CCGS *Opilio* (18m), based in Shipigan, New Brunswick, enabled staff of the Gulf Fisheries Centre to carry out research programs in the Northumberland Strait and in the Bay of Chaleur area. The CCGS *Navicula* (20m) served as a platform for a cooperative DFO/First Nations fisheries research program in the Bras d'Or Lakes as well as supporting a number of other fisheries and habitat research programs in the Bay of Fundy and Cape Breton coastal areas of Nova Scotia. The CCGS *Pandalus III* (13m) operating out of the St. Andrews Biological Station conducted numerous daily trips in the local area throughout the year.

Cross Cutting Issues

Partnering between First Nations and DFO Science and Oceans and Environment Branches

- K. Paul, R. Lavoie, and T. L. Marshall

The Marshall decision of 1999 brought significant changes to the Atlantic fishery and to DFO's relationship with First Nations. DFO Science has a long history of working with First Nations; in 2001 there was an enhancement of cooperative activities, particularly on Cape Breton Island.

The Eskasoni Fish and Wildlife Commission (EF&WC) is located in the Mi'kmaw community of Eskasoni, Nova Scotia, on the shores of the Bras d'Or Lakes. The EF&WC is a Native-run, non-profit organization that deals with environmental and scientific issues that affect the entire Bras d'Or Lakes watershed. Over the past decade, EF&WC has developed a good working relationship with DFO Science at BIO and has collaborated on issues concerning the health of the Bras d'Or Lakes ecosystem. Earlier projects in this area include water testing, and fisheries studies.

In the early 1960s, the Gillis Cove Oyster Culture Station was set up to study the reproduction of the American oyster and to develop techniques to grow high quality oysters from seed to market size. Since the mid-1990s, a joint project run by an Aboriginal biologist has used the station to experiment with new techniques and to train young Natives in the production of seed oysters.

With the Union of Nova Scotia Indians, the EF&WC recently incorporated the Unama'ki Institute of Natural Resources (UINR) to deal with the environmental issues and scientific opportunities for the Native communities in Nova Scotia. Memoranda of Understanding (MOUs) were signed between DFO and the UINR for the use of the CCG research vessel *Navicula* for data collection, collaboration on scientific research, cross training for DFO and EF&WC staff, sharing of lab facilities, staff exchanges, and information sharing on the Bras d'Or Lakes ecosystem. A second MOU is ready for signing in 2002.

DFO Science launched an initiative called SIMBOL (Science for Integrated Management of the Bras d'Or Lakes) to address stakeholder concerns identified at a Bras d'Or Lakes Ecosystem Workshop held at the Canadian Coast Guard College in October 1999. A more detailed article on SIMBOL is contained later in this section of the report. Now in its second year, SIMBOL has enabled:

Charlie Joe Dennis being presented with the DFO Deputy Minister's Certificate of Recognition for his extensive work with DFO on preserving and developing the renewable natural resources of the Bras d'Or Lakes. (left to right) Kenneth Paul, Diana Denny, René Lavoie, Charlie Joe Dennis, Shelley Denny and Mike Sinclair – photo by George Paul.

- historical data rescue,
- benthic habitat mapping,
- deployment of moorings to monitor winter processes,
- satellite data extraction,
- DFO and Environment Canada water quality monitoring,
- surveys of green crab distribution, and
- data collection using CASI (Compact Airborne Spectrographic Imager).

During the winter and spring of 2001, the regional DFO Science and

A Talking Circle meeting between First Nations Elders, DFO scientists and managers, staff of the Eskasoni Fish and Wildlife Commissions, and Environment Canada at the Wagmatcook Cultural Center, Cape Breton Island, May 23, 2001 - photo by George Paul.

Oceans and Environment branches and the Eskasoni First Nation jointly organized a number of meetings including Mi'kmaw cultural awareness sessions for BIO staff. A meeting at Wagmatcook Cultural Center in May 2001 culminated in a large Talking Circle with DFO and Environment Canada staff, and Mi'kmaw Elders. This gathering of peace and friendship is intended as a first step towards integrating Mi'kmaw traditional knowledge with DFO Science.

Each of the Chapel Island, Membertou, Waycobah, Eskasoni and Wagmatcook First Nations of Cape Breton also have a special interest in the plight of Atlantic salmon and each has partnered in past salmon assessment activities. In 2001, Wagmatcook First Nation continued its involvement in surveys of juvenile salmon in the Middle and Baddeck rivers. However, in 2001, their usual assistance in the fall swim-through surveys of adult salmon in the same rivers was precluded by low water.

At the Mactaquac Biodiversity Facility in New Brunswick, an apprenticeship program continued for three Kingsclear First Nation graduates of the aquaculture program at the St. Andrews Community College. St. Mary's First Nation also continued to share in the training of an assistant fish culture technician and Oromocto First Nation assisted in important juvenile salmon marking activities. Kingsclear and Oromocto First Nations assisted in the deployment and operation of the Nashwaak River adult salmon counting fence.

In the summer of 2001, the following communities of the Saint John River basin were involved in the electrofishing surveys of juvenile salmon:

- Oromocto First Nation on the Nashwaak and areas south,
- Woodstock First Nation on tributaries in the Woodstock and Big Salmon River areas, and
- Maliseet First Nation on the Tobique River and areas north.

Also in 2001, Woodstock and Kingsclear First Nations assisted in salmon research/monitoring activities on the "endangered" Big Salmon River population of Atlantic salmon. Oromocto First Nation assisted in the monitoring of salmon smolts on the Nashwaak River and Fort Folly First Nation on the Petitcodiac River, made significant commitments for 2002 to monitor and conduct research on Atlantic salmon in several nearby inner Bay of Fundy rivers.

Other initiatives at BIO in 2001 included:

- Two interns (one from Membertou working for the Eskasoni Fish and Wildlife Commission, and one from Acadia now working for the Band as a Fisheries Coordinator) received training in aquaculture, sea sampling techniques, and conference organization.
- A summer student from the Gwitchin First Nation in the Yukon was employed on aquaculture projects.
- With the scientific guidance of a DFO scientist, a biologist from Eskasoni conducted an oyster predation project in the Fish Lab facilities.
- Provision of scientific advice both at BIO and Eskasoni on several projects involving shellfish resources and aquaculture.
- In July and August, a summer student from the Oromocto First Nation worked at BIO on projects focussing on lobster and juvenile fish.

Cooperative research and integrating traditional knowledge with science in the spirit of peace and friendship will continue to be a priority at BIO and Mactaquac.

Fisheries staff of Oromocto First Nation pause during installation of a portable "fence" to capture adult Atlantic salmon – photo by Ross Jones.

Interactions between Offshore Oil and Gas Operations and the Marine Environment

- Peter Cranford, Shelley Armsworthy, Kenneth Lee, Tim Milligan, Kee Muschenheim (Marine Environmental Sciences Division [DFO]), Charles Hannah, John Loder (Ocean Sciences Division [DFO]), Michael Li, Gary Sonnichsen, and Edward King (Geological Survey of Canada – Atlantic [NRCan])

Offshore oil and gas operations off the east coast of Canada have increased dramatically within the last decade, and are expanding to include shallow coastal and deep slope waters (Fig. 1). Environmental factors such as ice, waves, currents, and seabed structure and stability can greatly affect these activities. Conversely, there is also the potential that some oil and gas activities may impact the environment. DFO and NRCan have an ongoing research program, largely supported by the federal Program for Energy Research and Development, to study the potential impacts of discharges into the environment and environmental factors that affect oil and gas activities.

Potential environmental impacts associated with the exposure of marine organisms to low-level operational waste discharges are an ongoing concern. Drilling wastes (spent drilling mud and well cuttings) are the primary concern during exploration and development operations, while produced water recovered from the hydrocarbon bearing strata is the highest volume waste generated during production. Produced water may contain elevated concentrations of metals, nutrients, radionuclides, hydrocarbons, and trace amounts of chemical agents. A multidisciplinary research program has been initiated by DFO to study the environmental pathways, transport rate, and ultimate fate and effects of drilling and production wastes.

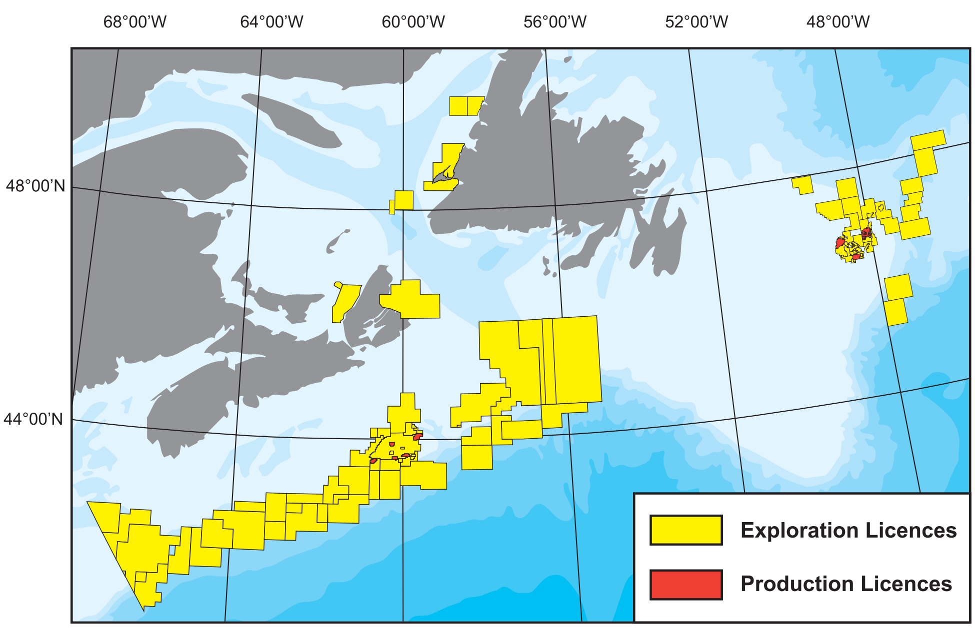


Figure 1. Map of the eastern Canadian shelf showing areas where licences have been issued for oil and gas exploration and production.

Flocculation (the adhesion of smaller particles to form large particles) and surface adsorption (the adhesion of small particles to larger particles and/or droplets) are important processes in the transport of material in the ocean. Laboratory studies of the behaviour of fine drilling waste particles in seawater suggest that flocculation could result in the rapid transport of this material to the seafloor. This is in contrast to the previous view that these particles settle too slowly to accumulate to levels that can impact benthic organisms. While dissolved contaminants are expected to rapidly dilute with seawater to harmless levels, potential toxic metals in produced water were observed to transform from dissolved to particulate forms that settled rapidly. Studies also showed that buoyant oil droplets in produced water could sequester particles on their surface. These studies demonstrate the importance of aggregation processes that mediate the rapid transport of contaminants to both the surface microlayer and the seabed (Fig. 2). New sampling methods have been developed at BIO to study waste dispersion around drilling platforms. Application of these technologies has revealed that elevated concentrations of drilling wastes occasionally exist on and above the seafloor around drilling platforms. However, elevated concentrations appear to be transient (days to months) as the wastes are eventually dispersed by currents and waves.

Given these new insights into the fate of waste discharges, laboratory studies are being conducted to assess the potential impact on selected marine organisms. Scallops feed on particles in an area immediately above the seafloor, the benthic boundary layer, where wastes can accumulate. Exposure to different drilling wastes showed that important biological effects can result at waste levels that are lower than previously reported for other species tested. Observed impacts on growth and reproduction were not caused by waste toxicity, but resulted from fine waste particles interfering with the animals' ability to feed. Research is currently in progress to assess the utility of deploying caged scallops around drilling platforms to verify laboratory observations and to monitor impacts at offshore drilling sites. Laboratory biotests with produced water from the Scotian Shelf showed that the tox-

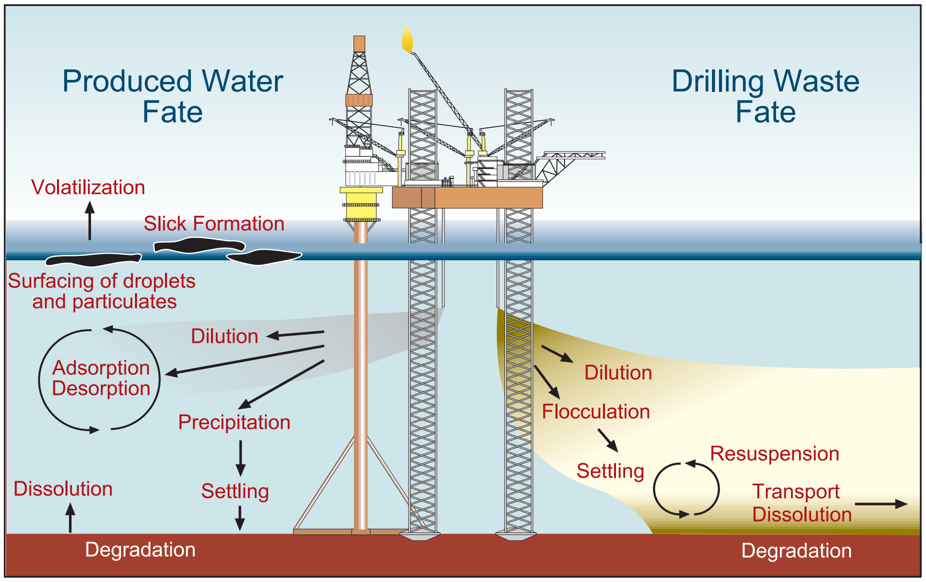


Figure 2. Major processes controlling the environmental fate of wastes from offshore oil and gas drilling and production activities.

icity of produced water was altered as a result of chemical changes that occur following its discharge. Toxicity was associated with both dissolved and particulate fractions. Preliminary studies suggest that chemical components within produced water, such as inorganic nutrients and hydrocarbons, may stimulate the rates of primary production and/or induce changes in microbial communities in offshore waters.

To determine the potential trajectories and dispersion of operational wastes at drilling sites, the research program has included a quantitative description of the physical environment. Data from current moorings have been used to develop comprehensive three-dimensional circulation models of the eastern Canadian continental shelf. A benthic boundary layer transport model was developed to use information on the currents, the bottom stress, and the settling velocity of the drilling mud to calculate the fate of waste discharges. Model predictions have been integrated with results of biological and chemical studies to assess the risk of environmental impacts resulting from offshore oil and gas developments. The model has recently been modified to include an improved representation of the combined effects of currents and waves on the fate of drilling wastes. We have also included a simple model of flocculation and break-up processes to allow the settling rate of wastes to adjust to local environmental conditions. Evaluations of the reliability of models are ongoing, including comparisons with industry observations of waste distributions.

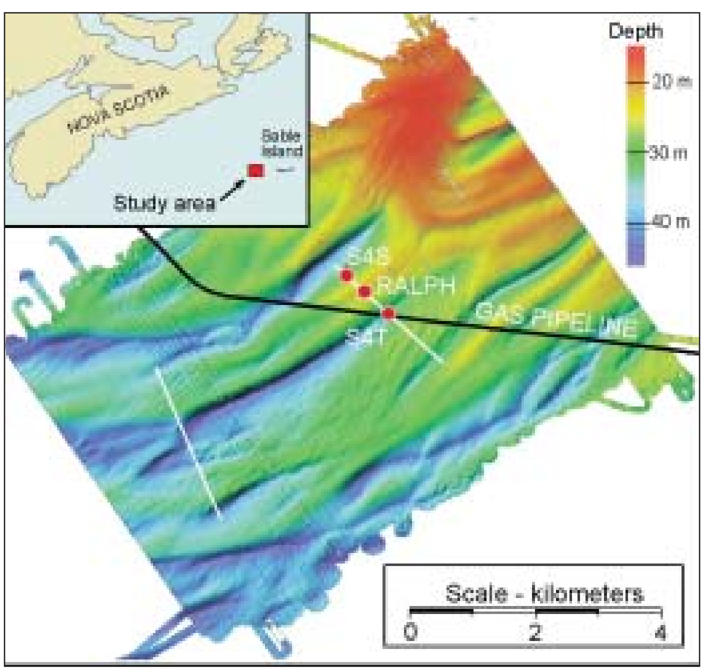


Figure 3. Multibeam image showing sand ridges and instrument deployment transects (white lines) on Sable Island Bank. The black line is a section of gas pipeline running through the area.

Another important environmental concern for offshore oil and gas developments is the presence of seabed geohazards. These include difficult foundation conditions (for example, weak sediment strata, mass failures, shallow gas, faults, and bouldery till), and geologic processes that may alter seabed stability (e.g. sediment transport and erosion, and seabed iceberg scouring). Detailed knowledge of these seabed stability issues and processes is critical to pipeline routing, drilling site selection, safe and cost-effective engineering designs, and the protection of offshore structures and the environment. Geological coring and sampling, geophysical and multibeam surveys, sediment transport measurements, and modeling are all used to identify and assess the nature of seabed instabilities and geologic processes which pose constraints to offshore hydrocarbon developments.

Cutting-edge instruments (http://agcwww.bio.ns.ca/support/equipment) have been deployed on Sable Island Bank to measure flow intensity, seabed scouring, sediment transport, and mobility of small to medium scale bedforms during storms. Instrument deployments have been combined with repetitive sidescan and multibeam surveys to understand the morphology, sediment transport processes, and migration of sand ridges (Fig. 3). Geological studies have compiled a detailed database of surface and subsurface sediment features on Sable Island Bank. Past glacial events and related changes in sea-level have given rise to a complex suite of shallow marine sand and clay bodies. Shallow gas manifests as small pockets or widespread zones, and tends to be concentrated in specific geologic settings. Mass sediment failure events were found to be rare, except on the outer slope.

Iceberg scour research has focused on the northeastern sector of Grand Banks. A database of almost 6000 scour features (distribution, dimensions, and occurrence frequency) has been compiled. A study was conducted to document the seabed effects of scouring icebergs and to provide insights into the processes and rates of scour decay. Nine grounding sites were surveyed using sidescan sonar, sub-bottom profiler, a remotely operated vehicle, and towed cameras. These surveys provide case histories for iceberg impacts and form a unique and comprehensive data set.

Research conducted at BIO on these topics and other environmental factors, such as sea ice and waves, enhances our ability to address environmental issues expressed by clients related to offshore oil and gas operations. The knowledge obtained forms the basis for codes, standards, regulations, and advice. This knowledge is designed to reduce costs to industry while protecting the public, workers, and the environment from the effects of energy related activities.

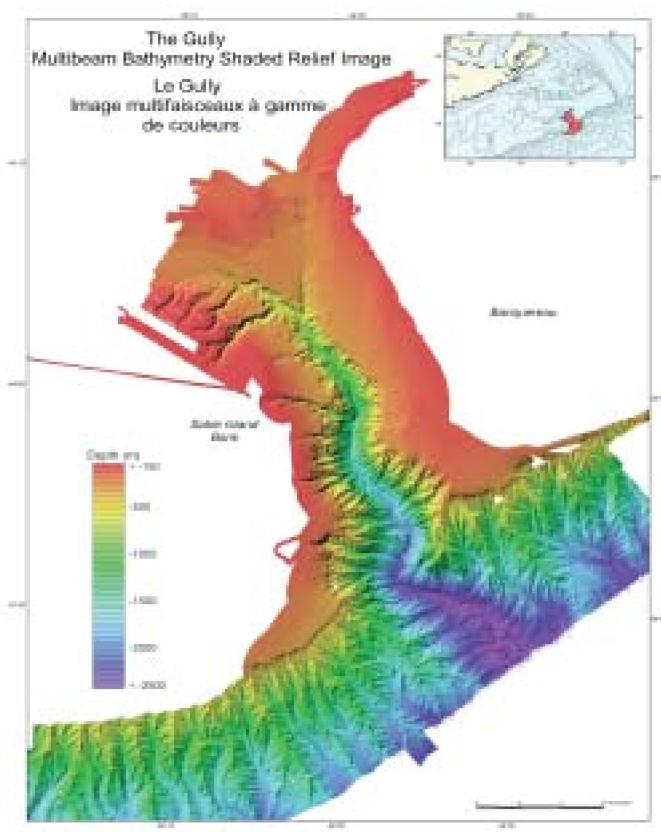
The Sable Gully

- Jason Naug

The Sable Gully (the Gully) is the largest submarine canyon in eastern North America. In recent years, the ecological characteristics of the area have attracted the attention of a number of government and non-governmental organizations. To evaluate these characteristics and associated conservation and management requirements, the Oceans and Coastal Management Division (OCMD) is assessing the Gully under the criteria of DFO's Marine Protected Area (MPA) Program. This work has been supported by extensive scientific investigations into the Gully ecosystem.

Physical setting

Bisecting the Sable Island Bank and Banquereau, the Gully is located approximately 200 km southeast of Nova Scotia on the eastern Scotian Shelf. The Gully can be divided into two general areas, the trough and the canyon. The trough is characterized as a wide (30 km x 70 km), and relatively shallow basin, on the northern portion of the Gully linking it to the inner shelf. The canyon is a narrower feature (10 km x 40 km) extending into the continental slope and characterized by steep slopes and a depth of over 2 km at its mouth. Many of the physical characteristics of the Gully have important implications for local circulation,



Multibeam bathymetry of Sable Gully (from G.B. J. Fader and J. Strang, in association with the Geological Survey of Canada, Natural Resources Canada, the Canadian Hydrographic Service, Oceans and Environment Branch of DFO and the offshore exploration industry).

nutrient fluxes, sediment dynamics, and the distribution and structure of biological communities. These communities include a wide diversity of species ranging from deep sea corals to shallow and deep water fish, pelagic seabirds, and 13 species of whales and dolphins, including a significant and vulnerable population of northern bottlenose whales.

DFO's Marine Protected Areas Program

In 1998, DFO produced a Conservation Strategy for the Gully based on a review of the current science, a description of conservation issues, and stakeholder viewpoints. The overall objective of the strategy is to, "conserve and protect the natural biological diversity and integrity of the Sable Gully ecosystem to ensure its long-term health and sustainable use". The conservation strategy included a recommendation that the Gully (encompassing approximately 1850 km^2) be identified as an Area of Interest (AOI) in the Marine Protected Area (MPA) Program under the *Oceans Act*.

Assessing the Gully as a potential MPA requires that DFO and the oceans community work together in a multi-step planning process outlined in the 1998 draft national framework for MPA establishment released by DFO.

MPA designation under Canada's *Oceans Act* is the ultimate goal for this challenging offshore site. Canadian approaches to establishing offshore MPAs remain developmental and untested. In this regard, the Gully initiative is providing a valuable learning experience for DFO, other regulators, maritime industries, researchers, and non-government organizations (NGOs).

Management activities

To evaluate the Gully as an Area of Interest under the Marine Protected Area Program, the OCMD has lead a number of activities including:

Engaging stakeholders: To date, a wide range of stakeholders with interests and responsibilities in and around the Gully have been engaged. These include federal and provincial government departments and agencies, industrial sectors such as oil and gas and fisheries, First Nations, academia, NGOs, and the public. Broad stakeholder involvement has been sought to ensure meaningful participation and lasting protection.

Assessing the Gully's socio-economic profile: An assessment of the resources and activities in the Gully area is ongoing. The resource sectors under analysis include fisheries, oil and gas exploration and development, conservation, research and education, transportation, National Defence and Coast Guard, tourism, and marine mining. In addition, important ecological components such as marine mammals and deep sea corals are also reviewed.

Interim protection measures: Since the announcement of the Gully as an Area of Interest, DFO has implemented interim protection measures that include limiting new activities. New fisheries have been excluded, and with the cooperation of the Canada-Nova Scotia Offshore Petroleum Board, oil and gas activities have been restricted in the Gully. In addition, activities in and around the Gully have been continually monitored and advice provided to regulators and users on the protection needs for the area.

Developing a Gully Management Plan: A management plan is being prepared. It will summarize the research activities to date, describe the conservation goals, evaluate the key conservation issues, and make recommendations including regulatory processes required for final MPA designation and management. This plan will be further developed in 2002 with the participation of interested parties.

Science activities

In addition to research by Dalhousie University, DFO Maritimes Region has undertaken a program of scientific activities to provide a scientific basis for decision making in the planning and management process. In 1998, a review team of DFO, Natural Resources Canada (NRCan), university, and non-governmental scientists met to review existing information, describe the ecosystem of the Gully and surrounding area, and characterize any special features. Major scientific disciplines participated and the contributions were reviewed by the Maritimes Regional Advisory Process. Many of the important characteristics of the Gully were identified and the need for further research highlighted to better characterize and understand the Gully ecosystem.

In 1999, as a result of this review, two years of research on the Gully began at BIO. This multidisciplinary effort included research into multibeam bathymetry, geology, benthic assemblages and habitats, patterns of epifaunal biomass and respiration, seasonal circulation and tidal currents, tidal mixing, nutrient chemistry, seasonal plankton production, and the seasonal abundance and distribution of plankton communities. This research was reviewed at a workshop held in May 2001, and has been a major contribution to advancing the understanding of the Gully ecosystem. The workshop report will be released in early 2002. Research is ongoing to understand the interconnections between ecosystem elements and the potential impacts of human activities.

Summary

The Gully's important physical processes and biological communities have been formally recognized by nomination to DFO's MPA Program. As a candidate MPA in the offshore, the Gully attempts to address issues related to the protection of benthic habitat, marine mammals, and biodiversity, and also provides a learning experience for DFO and other stakeholders. The OCMD has been facilitating the MPA process through engaging stakeholders, monitoring and assessing uses, and management planning. This work has been supported by scientific research by BIO staff and has provided opportunities for multidisciplinary collaboration among scientists, ocean planners, and managers. The research on this large-scale ecosystem has expanded our knowledge of deep ocean science, and has provided a basis for management of the area.

Bras d'Or Lakes Research – SIMBOL (Science for Integrated Management of the Bras d'Or Lakes)

– Gary Bugden, Ed Horne, and Brian Petrie (Ocean Sciences [DFO]),Tim Lambert (Marine Fish [DFO]), Barry Hargrave, Tim Milligan, Peter Strain, and Phil Yeats (Marine Environmental Sciences [DFO]), Ken Paul (Canadian Hydrographic Service [DFO]), David Piper, John Shaw, and Bob Taylor (Geological Survey of Canada [NRCan]), Janice Raymond (Policy and Economics [DFO]), and John Tremblay (Invertebrate Fisheries [DFO])

The Bras d'Or Lakes, situated in central Cape Breton Island in Nova Scotia, make up the last, nearly pristine, saltwater inland sea on the east coast of North America. The unique Bras d'Or Lakes ecosystem retains much of its original purity, but is increasingly threatened by the demands of a growing local population and the need for economic development. Several years ago, it became apparent that a coordinated effort was required to help stakeholders and regulators reach general agreement on the best mix of conservation, sustainable resource use, and economic development to maintain a healthy ecosystem in the lakes. Under the authority of the *Oceans Act*, DFO provides specialized information, scientific and technical advice, and research on the coastal marine environment that is needed to develop integrated management plans.

One of the first steps in defining the scientific research required for Integrated Management of the lakes was taken in March 1996 when the Cape Breton First Nations communities organized an Ecological Research and Monitoring Workshop. As a result of this workshop, several small programs were initiated at BIO. However, it was apparent that an expanded research program was necessary. In October 1999, a second workshop outlined broadened research goals for the lakes. A Memorandum of Understanding between DFO and the Unama'ki Institute of Natural Resources (a co-operative venture of the five Mi'kmaw bands of Cape Breton), for the use of a research vessel was signed at this workshop. Additional details are contained in the article on *Partnering between First Nations and DFO Science and Oceans and Environment Branches* earlier in this section of the report. Subsequent discussions have focussed on

Recovering a sediment trap from the waters of the Bras d'Or Lakes. The trap has been moored upright beneath the water surface for about six months. The small bottles visible at the bottom of the trap contain samples of the particles falling through the water collected during pre-programmed intervals.

Compact Airborne Spectral Imager (CASI) image of a small portion of the Bras d'Or Lakes showing delineation of underwater features in depths of 5-10 m. These features will be associated with benthic habitat types through ground truth studies and comparison with multibeam sonar data.

determining the scientific programs required to address the concerns raised at the 1999 workshop.

As a result of the workshop, a number of multi-disciplinary programs that span divisions, branches and government departments are underway at BIO and several more are in the planning stages. These include an ecosystem baseline study, benthic habitat mapping employing multibeam sonar combined with aircraft remote sensing, and the maintenance of an instrumented mooring in the deepest part of the lakes. The ecosystem study will permit a comparison between the Bras d'Or Lakes and nearby continental shelf ecosystems as well as describing the timing and extent of seasonal production cycles and the distribution and abundance of major populations within the lakes. The mapping project will delineate sensitive habitats and help plan future sampling programs. The mooring will provide information on physical, chemical, and biological processes during the winter and early spring. Another project of interest is the preparation of a public monograph describing the oceanography of the lakes. This publication will include chapters on the ecology of the lakes, the invertebrates, and the demographics of the surrounding population. In addition, there will be chapters on the general physics, chemistry, geology, and coastal morphology of the lakes.

The readily accessible waters of the Bras d'Or Lakes provide an area for the application of existing tools and methods as well as an excellent natural laboratory for innovative research and the development of new scientific techniques. The enclosed nature of the lakes provides more control over experimental variables than is possible in other regions. A wide variety of conditions can be found, ranging from high currents with oceanic temperatures and salinities to quiet brackish backwaters.

At each of the Bras d'Or Lakes ecosystem workshops, a common theme was more community involvement and the prompt public dissemination of research results. Each of the projects presently underway is attempting to involve the local community as much as possible, particularly through cooperation with the Unama'ki Institute of Natural Resources and the River Denys Watershed Group.

These research initiatives, combined with proper ecosystem-based management, will help ensure that future generations will be able to enjoy the unique ecosystem of the Bras d'Or Lakes.

Impact of Multibeam Surveys on Scallop Fishing Efficiency and Stock Assessment

- Ginette Robert and the Canadian Offshore Scallop Industry Mapping Group[1]

There have been progressive changes for the offshore scallop industry lately. Multibeam technologies combined with satellite tracking and better monitoring tools on scallop stocks have changed the way this industry operates and how the resource is managed. Fishing efficiency has improved. Resource management has been refined with greater insight provided on the distribution of scallop beds and habitat.

The offshore scallop license holders have formed the Canadian Offshore Scallop Industry Mapping Group (COSIMG), which includes five of the seven offshore companies. COSIMG partnered with the Canadian Hydrographic Service and the Geological Survey of Canada to map areas of commercial interest with multibeam technology. With these data, three-dimensional bathymetric charts, geological charts, and sediment maps of commercial scallop fishing areas were created.

A traditional hydrographic chart provides little information other than depth to a captain; personal knowledge of the area may be a more reliable guide. However, a three-dimensional bathymetric chart in the captain's toolbox allows him to avoid seabed hazards, reduce the area of sea bottom fished, and consequently, reduce by-catch of non-target species (Figure 1).

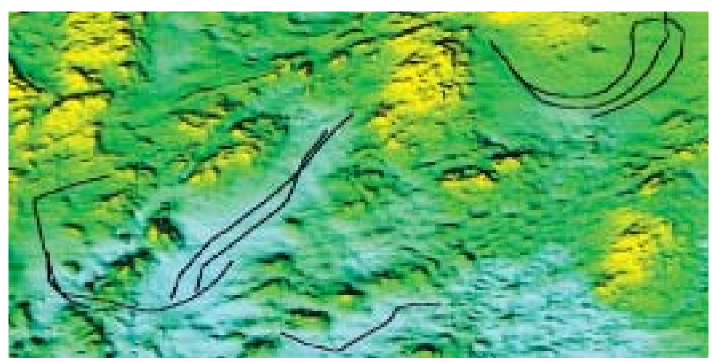


Figure 1. Using a three-dimensional bathymetric chart of Browns Bank, a captain is able to alter course during tows to avoid rough bottom and obstacles that could damage the gear.

Because of this initiative, industry-driven changes have resulted in important benefits. Attitudes have shifted among participants and relationships have improved as a result of closer working arrange-

1 The Canadian Offshore Scallop Industry Mapping Group (COSIMG) consists of the following companies: Adams & Knickle Limited, Clearwater Fine Foods Incorporated, Comeau's Sea Foods Limited, LaHave Seafoods Limited, and Scotia Trawler Equipment Limited.

ments with scientists and fishery managers.

Significant increases in efficiency have been achieved through the implementation of multibeam technology, reducing the amount of effort required to catch each tonne of scallop meat. Other benefits in efficiency and for the marine environment are presented in the following table:

ADVANTAGE OF MULTIBEAM MAPPING IMAGERY

For one tonne of scallop meat:

	Without imagery	With imagery	Reduction
Fishing effort	6.37 hours	2.41 hours	62%

For a scallop quota of 13,640 kilos:

	Before imagery	With imagery	Reduction
Time gear on bottom	162 hours	43 hours	73%
Area of bottom towed	1,176 km^2	311 km^2	74%
Fuel usage	27,697 liters	17,545 liters	36%

Because scallops grow best on certain bottom types, maps were produced from the multibeam data. The effects of these new maps on the scallop fishery have yet to be quantified although benefits to the operation of the fishery and to habitat conservation are beginning to show.

Figures 2 and 3 show fishing operations over the same scallop bed, one year apart, before and after a sediment map was available. In 1999 (Figure 2), a vessel made four 20-minute tows for an average of 20 bushels of scallops per tow. Displayed against the sediment map, the tows passed over two bottom types of which only one was prime scallop habitat. However, the captain was unaware that segments of the tows over the light blue-gray areas meant lost time, wasted fuel, and lower catch-rate.

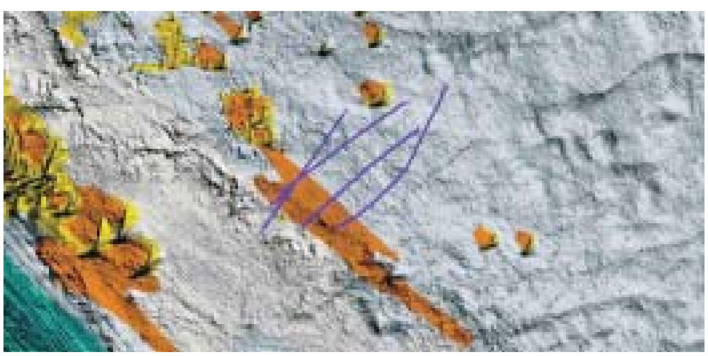


Figure 2. Path of four 20-minute tows on a scallop bed in 1999.

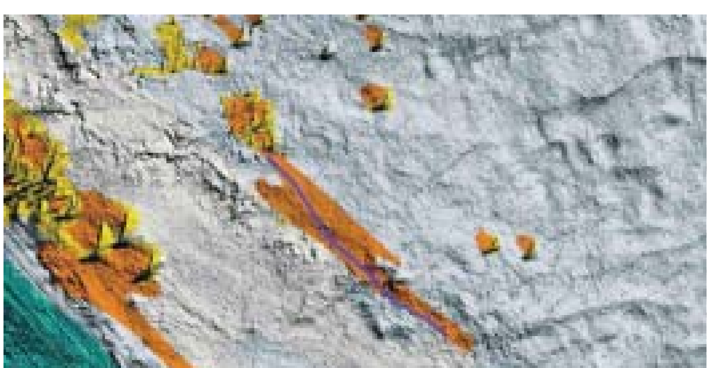


Figure 3. The new chart of the scallop bed available to the captain in 2000.

In 2000, with the new charts (Figure 3), the captain was able to target only the scallop habitat and caught 70 bushels of scallops in one tow. The tow covered a smaller area of the bottom and resulted in less by-catch of non-target species. The geological maps may help to identify potentially sensitive habitats that the scallop fleet could avoid.

The new mapping technology is also used in the management and stock assessment of the scallop fishery. From managing a fishing area such as Browns Bank, it will soon be possible to micro-manage a scallop bed. Stock assessment is moving toward defining the area of distribution and species abundance on a much finer scale. Determining the health of a scallop bed requires integrated monitoring programs on the catch and refining the sampling design for stock surveys. While monitoring tools are being developed, scallop stock surveys are distinctly focusing on scallop habitat. Scallops prefer gravelly bottoms to a mixture of gravel and sand. They may be five times more abundant on gravel than on gravel with a thin layer of sand (Figure 4). Considering scallop-preferred habitat while allocating survey tows on Browns Bank has reduced the coefficient of variation in the estimated number of scallops per tow by 33% compared to the traditional allocation design.

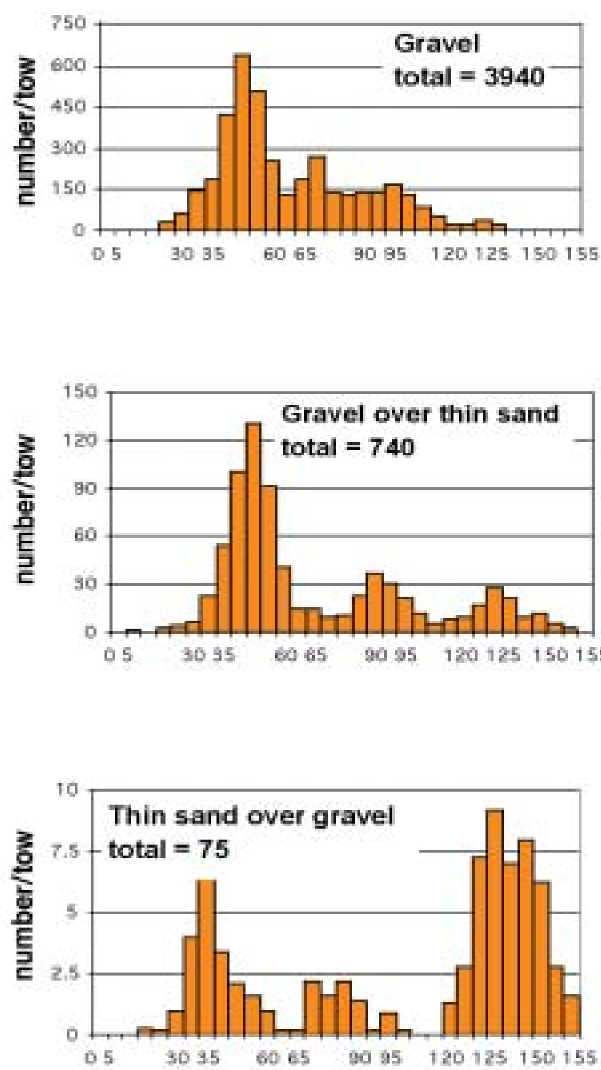


Figure 4. Number of scallops per survey tow according to bottom types grouped in 5-mm shell height intervals (x-axis).

Resource Management Highlights

Fisheries and Oceans Canada, Maritimes Regional Contribution to National Policy on Ecosystem-based Management

- Bob O'Boyle, Mike Sinclair, and Faith Scattolon

With the passage of the *Oceans Act* in 1997, Canada became one of the first countries in the world to make a legislative commitment to a comprehensive approach for the protection and development of oceans and coastal waters. Over the past century, agencies involved in managing oceans activities have typically been concerned with managing a single species or a single activity. Too often, resource development has proceeded independently in various sectors, without full consideration of long-term, direct and indirect social, economic, and environmental impacts. In contrast, the principles guiding oceans and coastal management under the *Oceans Act* include ecosystem-based management, sustainable development, the precautionary approach, conservation, shared responsibility, flexibility, and inclusiveness.

One of the major challenges facing us is to make the ecosystem-based approach, envisaged under the *Oceans Act*, a reality. Since 1997, the DFO Maritimes Region has been at the forefront of efforts to both interpret the *Oceans Act* and implement 'Integrated Management' of Canada's oceans. The first significant initiative was the Oceans Challenge Conference in February 1999, organized by the then Ocean Act Coordination Office (OACO), and held in Sydney, Nova Scotia. A general outline of what was needed to implement the *Oceans Act* rapidly became apparent. Ocean Management Areas (OMAs) would be required and within these, all ocean industries would be governed by a common set of ecosystem-level objectives, including the conservation of biodiversity and ecosystem productivity. New governance structures would also be needed to supplement those that already existed. This conference set the stage for many subsequent developments on Integrated Management, both regionally and nationally.

The Sydney conference focused on the new requirements for DFO for *Oceans Act* implementation, however, the need for outreach to those who depend upon the ocean for their livelihood was recognized as the next step. Therefore, in August 1999, a workshop was organized in Truro, Nova Scotia to discuss the implications of the *Oceans Act* for the fishing industry. Representatives from DFO management and science, provincial governments, non-governmental organizations (NGOs), and all sectors of the fishing industry discussed the concerns and issues to be addressed and activities to be jointly undertaken to implement Integrated Management. One of the key messages from the workshop was the need to take an incremental approach to change.

The initial steps focused on the concepts of Integrated Management, but now it was time to determine the detailed scientific requirements. To develop and test the approaches under the *Oceans Act*, a number of initiatives had already been started across the country. In 1998, the Eastern Scotian Shelf Integrated Management (ESSIM) project was initiated. This was the first offshore Integrated Management intiative under the *Oceans Act*. In June 2000, a science workshop was held at BIO to discuss the objectives, indicators, and reference points that would guide the conservation objectives of ESSIM. Experts were invited from Australia and the United States, nations who are active in attempting to implement an ecosystem approach to management. The workshop initiated scientific dialogue on the technical requirements of Integrated Management.

One of the main products of the ESSIM workshop was a framework for setting conservation objectives that did not exist at a national level. Those developed in the Maritimes Region were thought to have potential for national application. Therefore, in June 2000, the approach to Integrated Management developed at the ESSIM workshop was presented to DFO's National Policy Committee. The committee endorsed the approach and tasked a national working group with moving the objectives from the conceptual (for example, conservation of the diversity of Canada's ocean ecosystems) to the operational level. A national workshop of DFO scientists and managers was organized in Sidney, BC to further explore the conservation objectives of an ecosystem approach and discuss how these could be implemented. The DFO Maritimes Region was influential in organizing and conducting this successful workshop which established the basis for implementation of ecosystem-based management throughout Canada. It confirmed the need to conserve ecosystem diversity (at the community, species, and population level) and productivity (at the base of the food chain, and of ecologically linked and commercially targeted populations). It also recognized the need to conserve the physical and chemical properties of habitat. Further, the workshop outlined a means to make objectives operational. Finally, the workshop explored how the many indicators and reference points of Integrated Management could be incorporated into one overall assessment framework.

DFO Maritimes Region has been influential in the formative years of ecosystem-based management within Canada. Further national initiatives are being planned to advance the agenda of the *Oceans Act*, with scientists of the region playing important roles. The next step will be to 'road test' many of the principles discussed and debated. In the Maritimes Region, ESSIM will be the focus of this testing, and the experience gained in ESSIM, and similar projects across this country, will allow Canada to fully meet the intent and aims of that truly unique piece of legislation – the *Canada Oceans Act*.

Habitat Stewardship Projects of the Habitat Management Division

- Chad Ziai and Shayne McQuaid

The objective of the Policy for the Management of Fish Habitat is to achieve a net gain in the productive capacity of fish habitat. In working towards this objective, the Habitat Management Division (HMD) continues to support stewardship and habitat restoration projects.

In the fiscal year 2000-2001, approximately 225,000 m^2 of fish habitat was restored in Nova Scotian rivers. These fish habitat improvement projects were conducted by watershed management groups with advice from HMD. Types of projects included: in-stream habitat improvement structures, bank stabilization, water quality monitoring and improvement programs, development of watershed management plans, community education programs, and riparian zone re-planting. Three specific HMD stewardship initiatives are described below.

Habitat restoration: shoreline stabilization.

Salmon River (Clare) Project

The pH levels of waterways in southwestern Nova Scotia are extremely low due to acid precipitation. This is aggravated by the poor buffering capacity of the local geologic formation and soils. Acidic waters are detrimental to fish survival within the affected river systems. Projects to neutralize waterways have been attempted in the past through the application of limestone to winter ice or the placement of limestone behind in-stream restoration structures. These methods have had varying levels of success. The main problems are the high cost of obtaining and shipping the limestone, the intensive labour required to place the limestone in the waterways, and the tendency of the limestone to be washed downstream away from the intended area.

Calcium kiln dust (CKD), a by-product of the cement-making process, has recently been presented as a plausible alternative to limestone. CKD is inexpensive, and believed to be effective in neutralizing watercourses in concentrations as low as 7 parts per million. The trial project calls for the CKD to be applied using an automated hopper, thus greatly reducing the labour involved. LaFarge Canada has offered to supply and deliver the necessary quantities of CKD to carry out a trial neutralization project. This DFO initiative has been implemented in partnership with other government departments, private corporations, angling associations, development agencies, educational institutions, and community groups. The project will be used to determine the viability of CKD as a liming option and this method may be adapted to other parts of the region where similar problems exist.

Central Colchester Model Watershed Committee

The work of the Central Colchester Model Watershed Committee (CCMWC) is the first completely integrated watershed management model attempted by HMD within Nova Scotia. CCMWC was developed to take a holistic or ecosystem approach to watershed planning and management for the Salmon River Watershed. The committee consists of 22 partners including DFO, other government departments, private corporations, development agencies, educational institutions, forest industry representatives, First Nations, and community participants. CCMWC is currently developing a watershed management plan funded by DFO's Oceans and Environment Branch as part of their integrated management approach for coastal communities. This watershed management plan will assess the value of all natural resources within the watershed, how those resources are currently being used, and where inappropriate uses are leading to pollution and other environmental degradation. Using that information, the plan will then identify stakeholders within the watershed, and ways that they can begin to work in partnership to solve resource use problems. The CCMWC model project will complement the Nova Scotia

Water quality monitoring and improvement.

Habitat enhancement: rock sill structure.

Department of Environment and Labour's watershed stewardship initiatives and can serve as a model for other communities.

Denys Basin: A pilot project to restore a watershed on the Bras d'Or Lakes

The Denys Basin has been chosen as a pilot area for a watershed management initiative. The project started in 1997 when concerns were expressed about the water quality in the River Denys Basin. Oyster beds were being closed, due in part to fecal coliform pollution, in what was traditionally one of the most productive oyster areas in Nova Scotia.

A number of programs are currently underway in the Denys Basin, with more planned for 2002. The Eskasoni Fish and Wildlife Commission and Environment Canada are carrying out a water sampling program and a shoreline survey to identify potential sources of pollution in the watershed. A survey has been undertaken to assess the potential value of shellfish if the closed areas could be reopened, and a resource survey is planned to collect information regarding the chemistry and currents within the basin. Mapping the bottom habitats began in 1999 and will continue through 2002. Placement of in-stream habitat improvement structures including rock sills, digger logs, fording sites, and bank stabilization structures began on Big Brook with the assistance of Georgia Pacific Corporation.

A wide range of organizations and community groups are committed to the project and its long-term goal of cleaning up the Bras d'Or Lakes. Equally important, the Denys Basin initiative is a pilot project from which experiences and results can be applied to other projects in the region.

DFO – Maritimes Region and the Offshore Oil and Gas Industry

– Julia McCleave

Since the decision to proceed with the Sable Offshore Energy Project, oil and gas exploration and development in Nova Scotia's offshore has increased considerably. DFO plays an important role in both the regulation of, and research into, oil and gas exploration and development. The Oceans and Environment Branch is the lead for DFO in providing advice on the oil and gas file but it is very much a team effort with all branches and divisions involved in the many different issues related to this growing industry.

Several oil and gas exploration, development, and pipeline export system projects are currently underway or being proposed for Nova Scotia's offshore. There has been a four-fold increase in oil and gas exploration and development activity from 2000 to 2001. In June 2001, the Call for Bids for nine parcels of land resulted in total bids in excess of $527 million. The Sable Offshore Energy Project has committed $1 billion to its Tier II phase that will add three new unmanned platforms to its operations in the near future. In February 2001, PanCanadian Energy announced it had made a significant gas discovery after drilling several exploration wells under the Panuke oil fields. The Deep Panuke Offshore Gas Development Project Description was submitted to the Canada – Nova Scotia Offshore Petroleum Board (CNSOPB) in July 2001. This project, representing a work commitment of over $2 billion, is currently undergoing the environmental assessment review process with production forecast to begin in the first quarter of 2005.

DFO plays an important role in the regulatory process of oil and gas exploration and development. Many work authorizations granted by the CNSOPB must undergo an environmental assessment. DFO reviews many of these assessments in terms of impacts to fish and fish habitat as well as navigation. All offshore production projects trigger the *Canadian Environmental Assessment Act (CEAA)* and must undergo either a Comprehensive Study or Panel Study. For many of these projects (like Deep Panuke), DFO is a "Responsible Authority" and is involved in the entire regulatory process of that particular project. Finally, the CNSOPB sometimes develops class screening or generic assessments in order to streamline the regulatory process. DFO plays an important role in developing and reviewing these documents.

Scientists at DFO are conducting scientific research on the impacts of oil and gas exploration and development and providing

Jim Dickey, CNSOPB and Neil Bellefontaine, DFO signing the MOU July 2001.

scientific advice to the regulatory process. Much remains to be investigated in this area, such as the impacts of seismic activity on fish and fish larvae, the mapping of sensitive fish habitat in the offshore, and the impacts of contaminants on the marine biota. Scientists at BIO are also playing a major role in research of environmental factors such as sea ice, waves, winds, currents, seabed stability, and ocean climate variations that affect offshore oil and gas activities.

Several working groups and committees related to oil and gas have recently been formed at BIO:

- The Science Advisory Committee on Offshore Petroleum Activities (SACOPA) was formed to co-ordinate the flow of scientific advice and respond to oil and gas issues at DFO – Maritimes Region.
- The Atlantic Zone Science Advisory Committee for Oil and Gas was formed to address scientific support to oil and gas issues in the four regions of DFO's Atlantic Zone.
- The National Working Group on Oil and Gas (NWGOG) was recently formed to develop and recommend guidelines, policies, and common approaches, on a national scale, to help DFO assume, in an effective and uniform way, the responsibilities conferred by the *Fisheries Act*, the *Oceans Act*, and *CEAA* relating to oil and gas exploration, development, and monitoring.

In July 2001, DFO and the CNSOPB signed a Memorandum of Understanding (MOU) and Work Plan. The intent of the MOU is: to facilitate and promote sound management of activities and measures related to the oil and gas industry; to ensure the conservation and protection of fish species and their habitat, promote biodiversity, and protect the marine environment; and to ensure safe navigation. These documents form the basis of a strong working relationship between DFO and the CNSOPB.

The growth in the offshore oil and gas industry represents a significant increase in workload that will continue to grow along with the industry. DFO expects an increase in requests for advice and expertise from the CNSOPB and the industry and remains a critical player in this field.

Maritimes Aquatic Species at Risk Office (MASARO)

- Jerry Conway and John Loch

In 2001, the Species at Risk Office has co-ordinated a number of initiatives that contribute to the federal/provincial *Accord for the Protection of Species at Risk*, and Environment Canada's *Habitat Stewardship Program*. These programs are designed to help the recovery of species identified as being at risk of extinction. Specifically, the focus has been on the North Atlantic right whale and the leatherback turtle, both listed as endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Other species listed by COSEWIC as endangered and under review at the Species at Risk Office, are the inner Bay of Fundy Atlantic salmon and the Atlantic whitefish.

In developing these initiatives, MASARO has consulted with provincial governments, stakeholders, and with interests in the United States (including the Federal Government) as a number of these species are considered to be transboundary by virtue of their migratory patterns.

Accomplishments

The North Atlantic right whale is considered the world's most endangered large whale. The existing population of approximately 300 animals frequents the waters of Atlantic Canada during the summer months including the Bay of Fundy and Roseway Basin on the Scotian Shelf. The proximity of these whales to shore provides an excellent opportunity to study their natural life processes. The goal of this research is to develop a better understanding of why the right whale population has not recovered to a sustainable level despite international protection since 1935.

Fisheries and Oceans Canada, in partnership with World Wildlife Fund (Canada), brought together a number of stakeholders and interested parties to develop a Recovery Plan for the North Atlantic right whale. The plan made 42 recommendations that may lead to the species' eventual recovery. These recommendations deal with ship strikes, entanglement in fishing gear, human-related disturbances, habitat degradation, population monitoring, and research. To the extent possible, Canadian initiatives are complimentary to the U.S. *Right Whale Recovery Plan* for this transboundary species.

To co-ordinate the recovery program and to implement the recommendations, Fisheries and Oceans Canada, through the Species at Risk Office, established and funded the "North Atlantic Right Whale Implementation Team". This team is made up of federal and provincial representatives as well as stakeholders; it identifies and priorizes projects, reviews project proposals, and identifies resources required to carry out the projects.

In 2001, projects have focused on mitigating ship strikes, fishing

Meeting of the North Atlantic Right Whale Implementation Team, November 2001.

gear entanglements, education, and outreach. Under the auspices of the Implementation Team, the Ship Strike and Fishing Gear working groups have been established. Projects developed by the working groups were funded in part through Environment Canada's *Habitat Stewardship Program*.

The Ship Strike Working Group has focused on potential changes to the shipping lanes in the Bay of Fundy and will be presenting a proposal at the 2002 International Maritime Organization meeting in the U.K. In addition, the working group is investigating the relevance of vessel speed as a contributing factor to right whale mortality.

In collaboration with U.S. fishing interests, the Fishing Gear Working Group has been working toward "whale-friendly" modifications to fixed fishing gear. They are also part of a whale advisory system that will allow the fishing industry to plan their day to day operations with knowledge of the location of local whale populations.

To augment these and other initiatives under the Recovery Strategy, a comprehensive education and outreach program has been developed with the participation of NGOs and stakeholders. MASARO has produced a *North Atlantic Right Whale* poster as part of the endangered species program and a booklet identifying commonly found marine mammals and sea turtles within the region.

The **Nova Scotia Leatherback Turtle Working Group** (NSLTWG), in collaboration with MASARO, and with funding assistance through Environment Canada's *Habitat Stewardship Program*, has continued its community outreach programs. This involved visiting fishing wharves and attending community events across Southwestern Nova Scotia, the Eastern Shore, and Cape Breton Island to raise awareness in the fishing communities about leatherback turtles. The NSLTWG also responded to three leatherback turtle stranding events. In August 2001, at the first international conference on *Putting Fishers Knowledge to Work* held at the University of British Columbia, the NSLTWG presented a paper describing the group's methodology for establishing a network of volunteer fishers to collect scientific data.

In the summer 2001, in collaboration with the Marine Fish Division of BIO, Dalhousie University's leatherback turtle satellite telemetry study team deployed 13 satellite tags on turtles along the Scotian Shelf. Male and female animals were tagged, and for the first time, subadults. Data collected to date revealed foraging behavior in disparate areas, including southerly portions of the Laurentian Channel and waters off New York and New Jersey. Depth-sensitive transmitters deployed on three turtles collected data that will contribute to enhanced understanding of leatherback diving behavior at high latitudes. Over the past two years, a total of 18 turtles have been tagged in waters off Nova Scotia.

Managing Multiple Ocean Use in the Offshore

– Jason Naug

While traditionally considered the domain of the fishing and marine transportation sectors, Canada's ocean space is becoming increasingly shared among a wider range of users, with new and potential uses on the horizon. These new uses may pose challenges related to use of physical space and have indirect effects on the quality of the marine environment on which other users depend. The Oceans and Coastal Management Division (OCMD) of DFO Maritimes Region has been working toward the management of both ocean resource use and space based on the principles and approaches contained in Canada's *Oceans Act* (1997). These include sustainable development, integrated management, precaution, an ecosystem approach, and collaboration. While all the principles and approaches articulated in the Act are essential to ensure a balanced consideration of social, economic and environmental values, integrated management and collaboration are particularly challenging in light of the multiple uses of our oceans. In addition to fishing and marine transportation, a description of some of the key offshore users follows.

Drilling rig near Sable Island (DFO).

Offshore oil and gas

Exploration for oil and gas in Nova Scotia's offshore has expanded rapidly, resulting in an industry poised to provide a significant role in Nova Scotia's economy. To date, over 300,000 km of seismic tracks have been surveyed and 173 exploratory wells have been drilled, costing an estimated $ 4.6 billion between 1967 and 1997. Over the past decade more than $ 1.5 billion has been tendered by petroleum companies for 78,132 km^2 of petroleum license areas on the Scotian Shelf – an area 40% larger than Nova Scotia's landmass. Technical summaries of significant and commercial discoveries point to a potential resource of approximately 18 trillion cubic feet of natural gas, 366 million barrels of condensate, and 707 million barrels of oil. The activities of the offshore oil and gas industry involve the use of ocean space and may influence the ocean environment during exploration, construction, production, and abandonment phases.

Potential ocean mining

Based on the known occurrences of mineral deposits on the seabed of Nova Scotia, the potential for an offshore mineral industry is currently being explored. The eastern Scotian Shelf has been identified as being rich in large aggregate (sand and gravel) deposits including extensive areas of > 95% silica sand. These minerals are becoming increasingly required in large amounts for industries such as road construction, with potential markets in the northeastern United States and throughout Atlantic Canada. An Offshore Minerals Management Initiative is currently being discussed with the intent of making recommendations on the development and management of offshore non-fuel minerals in Canada. While an offshore ocean mining industry and associated management regime are still in the planning stages, issues relating to conflicts in ocean space, extraction methodologies, and mitigation will all have to be addressed.

Submarine telecommunication cables

Marine communications is one of the fastest growing ocean technology industries worldwide, driven by the demand generated by Internet use and corporate data traffic. Today, there are approximately 370,000 km of fibre-optic cable on the seabed, with a global value of approximately $1 trillion (US). The seabed of Canada's Atlantic continental shelf and exclusive economic zone (EEZ) is being used increasingly for the laying of submarine fibre-optic telecommunications cables to Europe and the USA. There are currently six active submarine cables on the Scotian Shelf, as well as the billion dollar trans-Atlantic fibre-optic cable linking Boston, USA; Halifax, Canada; Dublin, Ireland; and Liverpool, England. There are also numerous inactive cables, and international cables, that cross Canada's Atlantic continental shelf and link the northeastern United States with Europe. The presence of submarine cables off the coast of Nova Scotia has the potential to impact, or be impacted by, industries such as fishing whose gear may damage or be damaged by these cables. The interaction between cables and fisheries is an issue of increasing importance in the region.

Submarine cable laying vessel (DFO).

Conservation and protection

Conservation and protection, including the creation of Marine Protected Areas and other areas where productive or sensitive area considerations take precedence, are becoming recognized as legitimate forms of ocean use that compete for ocean space and resources. Currently, DFO, Environment Canada, and Heritage Canada (Parks Canada) are working toward designating specific areas of ocean space for special protection through their respective protected areas programs. The compatibility of conservation and protection with other ocean uses may vary, depending on the specific environmental objectives being pursued for a given area.

Recreation and tourism

The tourism industry in Nova Scotia generates over $ 1 billion in revenues annually and is one of the top contributors to the provincial economy. Activities in this industry include many marine-related pursuits, such as whale watching, sailing, saltwater fishing, and sea-kayaking. While many of these activities occur primarily in coastal areas, there have been recent increases in activity offshore, including a growing cruise ship industry. Marine-related tourism relies on both the accessibility and quality of the marine environment.

Cruise ship (DFO).

Maritime defence

Canada's naval presence on the East Coast is provided through Maritime Forces Atlantic (MARLANT). The MARLANT area of responsibility extends from the Canada-US boundary in the Gulf of Maine to Greenland. The Department of National Defence spending is one of the largest ocean-based contributors to the Nova Scotian economy. Defence-related activities include a wide range of domestic and national operations. These include sovereignty patrols, maritime surveillance, naval training and combat readiness, search and rescue, naval route surveys, mine countermeasures, humanitarian relief and aid to civil authorities, and operational support to other government departments, such as the RCMP (drug law enforcement) and DFO (fisheries patrols). To undertake these activities, marine vessels and equipment are employed that occupy ocean space, often exclusively, and have the potential to affect the oceanic environment.

HMCS Athabaskan.


Bulk carrier (DFO).

Other uses

In addition to the major ocean uses identified above, there is a range of uses that occur on a smaller scale or are still in the early developmental stages. These include physical and biological scientific oceanographic research, a rapidly growing coastal aquaculture industry which may expand offshore, and an oceans technology industry involved in areas such as ocean charting and survival training. Other uses that arise, may do so unexpectedly and will need to be accommodated amongst the existing marine users.

Challenges

The OCMD is addressing several key challenges arising from the application of the *Oceans Act* to the management of this diverse range of marine users. There is a need to ensure that the integrated management and planning processes, including the collection and assimilation of scientific data and meaningful stakeholder participation, are keeping pace with the rate at which offshore sectors are developing. In addition, the diversity of marine users results in potential for conflicts in both space and time. Identifying and working together to moderate these conflicts will be essential, whether they occur between or within sectors, and where the sharing of marine space may be partially or wholly incompatible. Finally, a process to prioritize activities and define the information required for decision making is needed to ensure a balance of the social, economic, and environmental values of all the sectors involved. To these ends, the OCMD is currently leading, facilitating, and participating in several ocean management projects. These include the Eastern Scotian Shelf Integrated Management and Bras d'Or Lakes initiatives and the Sable Gully candidate marine protected area. These projects involve other government departments, user groups, and the public to identify issues, coordinate regulatory processes, create governance structures and undertake planning that will ensure a balanced and equitable management process for all users.


Clam dragging vessel (DFO).

The Eastern Scotian Shelf Integrated Management (ESSIM) Initiative

– Jason Naug

Background

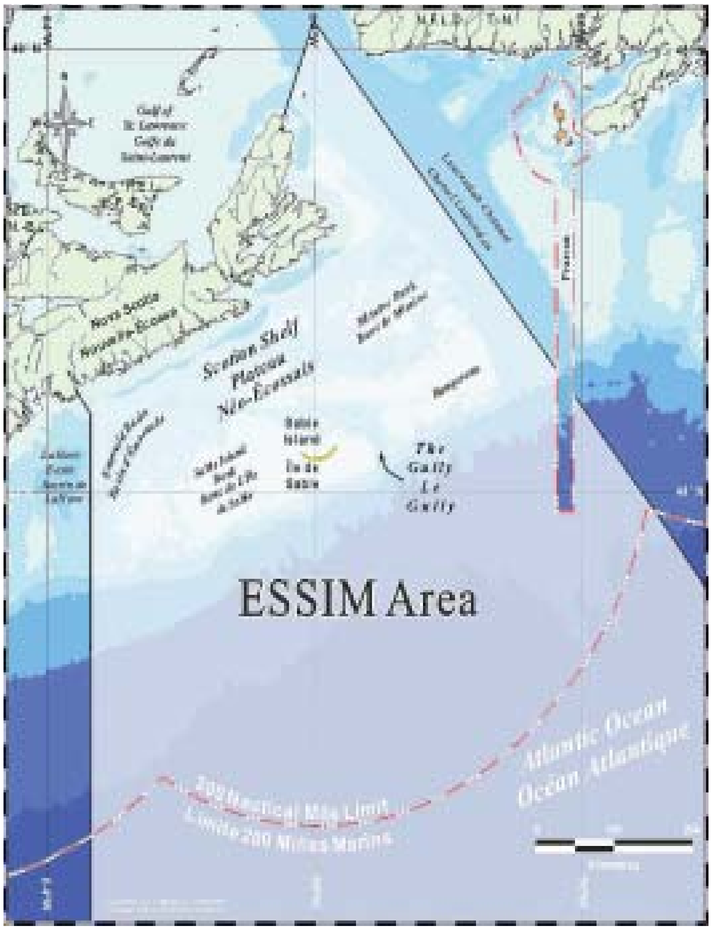
The DFO Maritimes Region, Oceans and Coastal Management Division (OCMD) is leading in the development of Canada's first Ocean Management Area with an offshore focus under the *Oceans Act*. The Eastern Scotian Shelf Integrated Management (ESSIM) initiative addresses a requirement of the *Oceans Act* that the Minister of Fisheries and Oceans "*lead and facilitate the development and implementation of plans for the integrated management of all activities or measures in or affecting estuaries, coastal waters and marine waters*" (Part II, Section 31). The eastern Scotian Shelf was chosen because of its important living and non-living marine resources, high biological diversity, and productivity. Additional reasons for selecting this area included, the increasing levels of multiple use and competition for ocean space and resources, and its position relative to the Sable Gully Area of Interest under DFO's Marine Protected Area Program. Key ocean uses across the area include fisheries, oil and gas, shipping, maritime defence operations, submarine cables, science, research and development, recreation and tourism, marine conservation, and potential offshore mineral development.

The objectives of the ESSIM initiative are to integrate the management of all activities across the area, encourage the conservation and responsible use of marine resources, support the maintenance of natural biological diversity and productivity, and foster opportunities for economic diversification and the generation of sustainable wealth. These objectives support the overall goal of designing an intergovernmental and multi-stakeholder management and planning process that develops and implements an integrated Oceans Management Plan for this large offshore marine area.

Activities

Since the formal announcement of the ESSIM initiative by the DFO Minister in December 1998, the OCMD has undertaken a number of key activities as part of the overall integrated management and planning process. These include:

Definition of management area: The Eastern Scotian Shelf Oceans Management Area has been defined with an offshore focus and encompasses approximately 325,000 square kilometres. Its boundaries have been derived through a mix of ecological, human, political, and administrative criteria to encompass an offshore ecozone based on major oceanographic and bathymetric features. The ESSIM map shows that, the western and eastern boundaries correspond generally with NAFO Division 4VW, while the outer boundary extends beyond the 200 nautical miles Exclusive Economic Zone



Eastern Scotian Shelf Integrated Management (ESSIM) Project (S. Johnston).

(EEZ). As the ESSIM initiative is focussed currently on offshore management and planning, the inner extent is defined by the 12 nautical mile territorial sea. In keeping with the dynamic nature of the planning process, the Oceans Management Area is expected to eventually cover the entire Scotian Shelf and to encompass a series of smaller, nested coastal management areas along the Atlantic Coast of Nova Scotia.

Use, issue, and regulatory overviews: Gaining an understanding of the human activities in or affecting the Ocean Management Area has been an essential component of the ESSIM process. The OCMD has been reviewing and analyzing the full range of activities and management approaches in the eastern Scotian Shelf area. This work has helped identify and understand the principal ocean activities and stakeholders involved and highlight the current regulatory, management, and legal frameworks in operation. Key oceans management issues include those related to multiple ocean use, marine resource management and conservation, marine and public safety, compliance and enforcement, and scientific research and development. The knowledge gained from these activities will assist in creating an overall Ocean Management Plan that considers all users and their needs and seeks greater regulatory efficiency.

Ecosystem overview: The ESSIM initiative has served as an important catalyst for improving our understanding of ecosystems and ecological processes in the eastern Scotian Shelf area. The initiative is providing opportunities to build and strengthen collaborative partnerships among scientists, ocean planners, and policy makers. The OCMD has recently reviewed the current state of knowledge of the Scotian Shelf ecosystems and is assisting in the development of ecosystem characterization approaches in support of the maintenance of diversity of ecosystem types in the region. In addition, DFO is developing and adopting objectives and indicators for ecosystem-based management and is involved in a number of related science initiatives. Highlights of this ongoing work include:

- an inventory and assessment of contaminants on the Scotian Shelf,
- an inventory of existing standards, guidelines, and measures for marine environmental quality,
- an understanding of the Sable Gully ecosystem through nutrient studies and the mapping of benthic communities and zooplankton, and
- an assessment of noise levels and potential impacts on whales.

This information, when captured in the management plan, will be used to ensure the protection of key ecological processes and resources.

Stakeholder engagement: One of the key activities and challenges for the ESSIM initiative has been the engagement of the numerous and diverse oceans interests involved in the area. The main focus for the OCMD has been to build support and capacity within DFO, with other levels of government, and the broader oceans community. The Maritimes Region Federal Interdepartmental Committee on Oceans includes representation from all federal oceans-related departments, boards and agencies and has provided a useful forum for exchange of information on the ESSIM initiative.

In January 2001, a Federal-Provincial ESSIM Working Group was established to move the initiative forward. The Working Group is comprised of over 20 oceans-related federal and provincial departments, agencies and boards, and provides an important forum to address policy, management, and regulatory co-ordination. Key activities of the Working Group have been issue identification and prioritization, completion of a federal-provincial regulatory overview, design of a collaborative management and planning process, development of a draft framework for the future Oceans Management Plan, and the implementation of a communication and engagement strategy for the initiative.

The OCMD has also continued to meet with stakeholders, including industry and resource user groups, First Nations, non-government organizations, community groups, academia, and the public. These meetings provide an opportunity to share information, identify and discuss oceans management issues, and facilitate involvement in the integrated management and planning process. Plans for the ESSIM initiative are focussed on establishing a multi-stakeholder ESSIM Forum that will facilitate information exchange among the groups involved and advise on the development, implementation, and operation of the Eastern Scotian Shelf Oceans Management Plan.

Summary

The OCMD is continuing to work with its partners to develop an integrated approach to oceans management in the eastern Scotian Shelf area. The initial stages of the ESSIM initiative have been successful in building a strong foundation for this long-term collaborative management and planning process.

Aquaculture Co-ordination Office – Maritimes Region

– Cindy Webster

Aquaculture is one of the world's fastest growing food production activities and presents an opportunity to provide high quality fish products to the world's food industry. The value of aquaculture to the economy of the Maritime Provinces is significant, particularly in coastal communities. Ninety percent of the production and processing jobs in the Canadian aquaculture industry are located in rural and coastal communities. Preliminary figures indicate that in 2000, aquaculture revenues totalled $271.2 million in New Brunswick and $43.5 million in Nova Scotia.[1]

Marine aquaculture site – New Brunswick.

In 1995, Fisheries and Oceans Canada was given the mandate as the lead federal agency for the aquaculture industry. The federal role in aquaculture was defined as enabling industry development, complementing the roles and responsibilities of industry, academia, provincial and territorial governments to enable a sustainable and environmentally sound aquaculture industry.

In 1999, aquaculture was identified as one of four policy renewal initiatives in DFO's strategic plan. The aquaculture policy has two key objectives: increase public confidence and increase the industry competitiveness.

In August 2000, the Honourable Herb Dhaliwal announced a $75 million investment over the next 5 years for the sustainable and environmentally sound development of Canada's aquaculture industry. Part of this funding was allocated for the establishment of the institutional structures within the federal government to support and respond to the development of aquaculture.

Although there had been an aquaculture co-ordination function within the region since 1995, the role of the office was significantly reduced during the federal government reductions in the 1996-97 period. The Aquaculture Co-ordination Office (ACO) was expanded in the Maritimes Region in the spring of 2000 as part of the policy renewal initiative. This policy and planning group is responsible for the co-ordination of regional policies and ensures a consistent approach throughout the Maritimes Region. The group also provides a seamless process within DFO for dealing with operational issues pertaining to the aquaculture industry. The ACO is a one-stop shop for DFO communications with the industry, the provinces, and the public. The office, located at BIO, has a staff of four and reports to the Associate Regional Director General. The ACO also has the responsibility to ensure that staff from all relevant DFO programs, including Science, Fisheries Management, Habitat Management, and the Coast Guard are consulted in response to aquaculture issues. Staff also work with other federal and provincial agencies with responsibilities for aquaculture. They participate or lead federal/provincial committees established under agreements on aquaculture development in N.B. and N.S., co-ordinate the review process within DFO on aquaculture site applications, and provide advice to the leasing/licensing authorities. Other responsibilities include the provision of recommendations on introductions or transfers of fish to be used in aquaculture and the co-ordination of requests by aquaculturists for broodstock/seedstock.

(1) Taken from: The Daily, September 27, 2001, Statistics Canada website at (www.statcan.ca/Daily).

Technical Support Highlights

2001 - Outreach at BIO

– Joni Henderson, Jennifer Bates, Rob Fensome, John Shaw, John Shimeld, and Graham Williams

Since 1991, the Bedford Institute of Oceanography has been conducting and continually developing a tour program that offers both guided and self-guided tours to the public. The program is intended to increase the visibility of BIO and promote science via public education. Because of a steady increase in the number of visitors, two student tour guides and an attendant for the Sea Pavilion were hired for the four-month period May-August. In an effort to meet demand, guided tours were offered on a contractual basis for the first time during the off season. Through the use of videos, exhibits, displays, and guest speakers, the tour provided visitors with an informative look at the various types of oceanographic research conducted at BIO.

As a result of visitor feedback gathered from tour evaluation forms, improvements to the tour route were implemented this year. They included new plaque-mounted maps with accompanying information panels and a continuous video on seabed mapping in the SeaMap Room. The *Iceberg Model*, which gives insight to the actual size of an iceberg beneath the water and serves to complement the *Titanic* exhibit, also received a much-needed facelift. As well, a number of microscopes were installed in Minitheatre #2 to allow visitors to view otoliths. An explanation of what otoliths are and how they are used to determine the age of fish is located on a display board above the microscopes. In the auditorium, a new large screen is available for video viewing, slide shows, and power-point presentations. Even the BIO Gift Shop, in its second year of offering promotional items for sale to the public, enjoyed some improvements including paint, paper, and displays.

BIO employees continued to support educational initiatives throughout the year. Many visited schools in the Halifax-Dartmouth area to speak on oceans-related topics, acted as judges at science fairs, and represented the Institute at exhibitions and public events. A number of highly successful student placements at BIO contributed to the success of the High School Co-operative Education Program. Staff hosted a workshop for Science, Public Relations, and Journalism students that focussed on opening lines of communications among the three disciplines. The BIO website (www.bio.gc.ca) also received some attention during the summer and further development is planned.

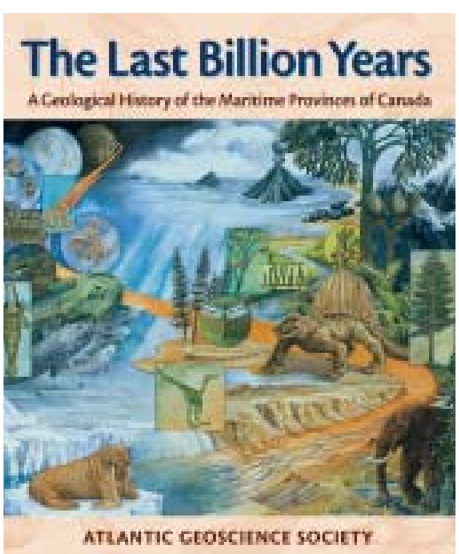
The ever popular *Oceans Day Poster Contest* received over 300 entries this year. Winners were invited to BIO where, following a tour of the Institute, they were presented with framed photographs of their entries and Oceans Day sweatshirts by DFO and NRCan Directors. The day was rounded off with a luncheon on board the CCGS, *Louis S. St.-Laurent* hosted by Captain Stu Klebert.

Kimberly Piccott, winner of the BIO Oceans Day Poster Contest *receiving a plaque from Mike Sinclair, Regional Director of Science.*

Parrsboro 2001 – EdGEO (geoscience education for teachers) Workshop.

NRCan Initiatives

Geoscientists at the Geological Survey of Canada (Atlantic) of Natural Resources Canada, with fellow members of the Nova Scotia EdGEO Workshop Committee, staged the group's eighth teachers' workshop. Thirty teachers travelled from locations throughout Nova Scotia to attend the two-day workshop held this year at the Fundy Geological Museum in Parrsboro. The program included interactive presentations on the basics (rocks and minerals, fossils, dinosaurs, and geological time) plus new sessions on soil, climate change, and oil and gas. A half day field trip gave the teachers an excellent overview of the geology of the Parrsboro area. This program is very popular with the education sector and attracts both teachers and those involved with museum programs, science centres, and private sector educational services. Funding was provided by the National EdGEO Program, the Nova Scotia Association of Science Teachers, and the Geological Survey of Canada. The Geological Survey of Canada (Atlantic), the Nova Scotia Department of Natural Resources, Dalhousie University, Fundy Geological Museum, the Halifax Regional Muncipality School Board, and Atlantic Science Links Association generously provided in-kind support. EdGEO 2002 will be held August 19-20, in Digby, Nova Scotia.



Cover image of The Last Billion Years.

This year marked the publication of *The Last Billion Years* - a book that 'unearths' the fascinating and complex story of the Maritimes' geological past. It is the first modern book written for the general reader on the geological history of the Maritime Provinces of Canada. GSC Atlantic staff led an extensive team of contributors from the geoscience and arts worlds to assemble this publication. The book is beautifully illustrated in full colour with never-before-published paintings of ancient vistas, over 150 photographs, and crisp explanatory diagrams and sketches. To supplement the story, a series of illustrated talks is taking place at the Nova Scotia Museum of Natural History in Halifax until May 2002. The talks are geared toward a general audience. The public and schools have expressed keen interest in the book that has resulted in the first two printings being sold out within weeks of the date of release. The publisher is considering a third printing in the spring of 2002. A website (agc.bio.ns.ca/lby/) presents excerpts from the book and purchasing information. The book is co-published by the Atlantic Geoscience Society and Nimbus Publishing.

EarthNet, the educational website for Canadian teachers and the public (earthnet.bio.ns.ca), continues to increase its readership and garner comments from users such as, "EarthNet is one of the most useful educational sites I've seen", and "What a terrific resource for teachers!!" Developments in 2001 included Geology of Communities, GeoToolbox, and Hall of Fame as well as additions to the teaching resource database, activities, and the illustrated glossary. Also, in 2001, EarthNet was a featured site on StudyWeb, an on-line instructional site that named it one of the best educational resources on the web. EarthNet is sponsored and funded by a number of Canadian geoscience organizations and would not exist without the contributions made by the many geoscientists and educators from across Canada.

BIO 2002

BIO has been humming with Open House preparatory activity during 2001. Much planning and exhibit preparation has already gone into what will be our largest Open House ever taking place in the spring of 2002. One exciting addition will highlight our scientists of the future when the regional winners of junior and senior high school science fairs from around the Province come together in a single exhibit at Open House. The Open House will be one of a series of special events to take place in commemoration of the 40th anniversary of BIO.

BIO Supporting the Community

– Shelley Armsworthy

Each year, staff and retirees of the Bedford Institute of Oceanography support the community by donating time, financial support, and goodwill to numerous charitable events. Some of the formal events conducted at BIO are described below.

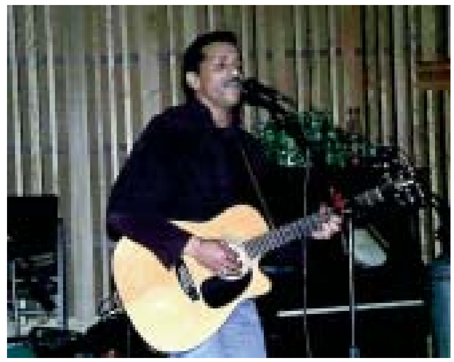
The Government of Canada Workplace Charitable Campaign in the Halifax/Dartmouth area is the largest organized charitable event and involves the United Way/Centraide, Health Partners, and numerous other registered charities across Canada. In 2001, the Government of Canada Workplace Charitable Campaign raised $31,162 at BIO. In addition to cash donations from staff and retirees, substantial funds were raised from a number of interesting and entertaining charitable events organized and hosted by volunteering BIO staff. These events included monthly 50/50 draws, a golf tournament at Fox Hollow Golf Club in Stewiacke, a book sale, a silent auction, and the 11th annual staff hockey game, family skate, and Christmas party.

In February and March, 180 bouquets of daffodils were sold at BIO and raised $1080 for the Canadian Cancer Society. As part of the Canadian Cancer Society's *Head for a Cure Event*, Kees Zwanenburg raised $1365 by having his head shaved at an outdoor, lunch-hour gathering in the BIO courtyard in July.

In April, the third annual *Beat the Winter Blues Kitchen Party* was held in the BIO Auditorium featuring a combination of musical talent from within BIO and from the local folk music community. Admission, in the form of either a cash donation or a non-perishable food item, provided 16 bags of groceries and $155 for the Parker Street Furniture and Food Bank in Halifax.

BIO staff collected personal care items on behalf of the Canadian Red Cross for airline passengers stranded in Halifax after the terrorist attack on New York and Washington, USA on September 11, 2001.

Just before Christmas, volunteers from BIO assembled and delivered boxed Christmas dinners to people in need on behalf of the Parker Street Furniture and Food Bank. The process took three days to complete and involved unloading groceries from trucks, sorting and repackaging it for delivery. The boxes included typical ingredients for a complete Christmas dinner. Those who were not able to pick-up their box at the food bank had them delivered by BIO staff. This year the volunteers prepared 550 food boxes.



George States at the Beat the Winter Blues Kitchen Party - *BIO 2001.*

BIO volunteers assembling Christmas dinners at the Parker Street Furniture and Food Bank.

Not only have BIO staff and retirees demonstrated their philanthropy in 2001, but have also shown compassion and generosity for homeless or abused domestic animals. Lynn Doubleday, of the BIO cafeteria, represents the Society for Prevention of Cruelty to Animals (SPCA). Throughout the year, Lynn collects donations of old blankets and towels, cleaning products, non-perishable pet food items, and Sobey's receipts. Hand-made crafts and pet emergency door stickers are sold seasonally in the cafeteria. In 2001, Lynn collected over $1000 for the SPCA. The society uses the donations and sales proceeds to help our four-legged friends whose situations are dire.

The generosity and participation of staff and retirees makes BIO a vibrant part of the community.

Public Works and Government Services (PWGSC) Wharf Rejuvenation for Bedford Institute of Oceanography

– Wilf Lush

BIO in the autumn of 2001 showing the jetty and the new warehouse complex.

The Bedford Institute of Oceanography is being rejuvenated through a series of building and infrastructure upgrades that started in 2000 and are scheduled for completion in 2009. Public Works and Government Services Canada is the Real Property Service agent to Fisheries and Oceans Canada and is the manager of these projects.

The Institute's jetty was completely renovated in 2001. This was the first major upgrade of the jetty since its original construction in 1961-62. The majority of the work consisted of removal of the structure's original concrete and replacement with reinforced concrete to obtain a stable surface. After forty years of exposure, the original concrete was severely deteriorated, particularly in the tide range.

Within the same contract, the jetty infrastructure in support of the fleet was replaced to address a list of Occupational Safety and Health issues, thereby providing a safer work place. All services were designed to eliminate, or minimize, the requirement for access to the jetty service tunnel (classified as a confined space) to perform required maintenance. The main projects included:

- Replacement of the ship's water supply lines, which frequently froze during the winter months, and were considered inadequate for fire protection.
- Installation of new lighting, electrical, and communications systems to meet current code standards.
- The jetty's main electrical building was enlarged with built-in capacity to convert from 480v to 600v in anticipation of the arrival of the Canadian Coast Guard ships.
- A new marina electrical building was constructed, as well as a new tide gauge building for the Canadian Hydrographic Service.

Also in 2001, an 800m^2 warehouse complex (noted by the arrow) was constructed north of the main building to replace "in house" storage.

In 2002, a new cooling plant is planned to provide BIO with a centralized air conditioning component to its air handling system, and replacement of the existing steam heating system with a hydronic (hot water) system. The new cooling plant will replace several disparate chillers and window-installed residential type air conditioning units.

The construction of a new laboratory building will begin in mid 2003 and is slated for completion in late 2004. This building is designed to Level II containment standards and will centralize several laboratory support spaces.

Other Programs

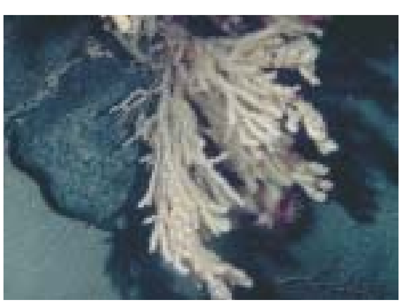
The Center for Marine Biodiversity

– Ellen Kenchington

The Center for Marine Biodiversity (CMB) is a non-profit society that was established in the autumn of 2000 to enhance scientific capacity in support of protection of marine biodiversity in the Northwest Atlantic. The CMB office is on the campus of the Bedford Institute of Oceanography with Dr. Ellen Kenchington as the Director. Membership includes specialists from university, government, industry, and non-governmental organizations throughout eastern and central Canada.

The CMB was formed in response to the 1992 Convention for Biological Diversity and the Code of Conduct for Responsible Fishing of the United Nations' Fisheries and Agriculture Organization (FAO). Both have established an international framework for broader conservation objectives for managing ocean-use activities. In 1997, Canada's *Oceans Act* defined our obligation to incorporate ecosystem considerations within an Oceans Management Strategy. In addition, the pending legislation under the *Species-At-Risk Act* (SARA) addresses a high profile component of these broader conservation objectives. Under the new legislation, Fisheries and Oceans Canada will take the lead in developing the Oceans Management Strategy, and will be responsible for protection of marine species identified under SARA.

The administrative arm of the CMB is led by an advisory board with members from a variety of backgrounds. Currently, the advisory board consists of an international group of individuals with diverse expertise and includes representatives from: the Sloan Foundation, Dalhousie University, Fisheries and Oceans Canada, the World Wildlife Fund of Canada, and the government of Nova Scotia.



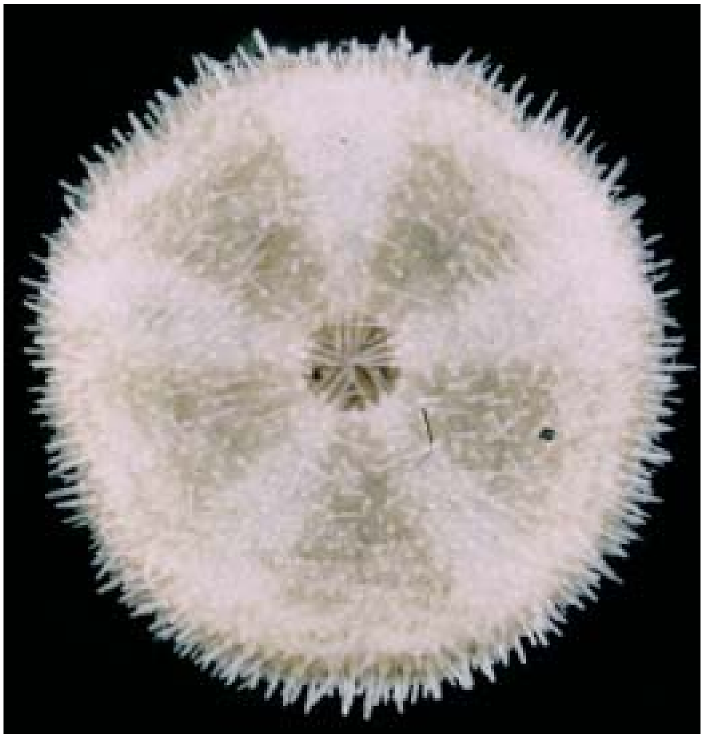
The gorgonacean, Primnoa resedaeformis, *one of the most common and abundant corals off Atlantic Canada - photographed with Campod in the Northeast Channel at around 400 meters - DFO photo.*

The mandate of the Center is to provide a focus for structuring independent research efforts toward an overall synthesis of information on marine biodiversity. Scientists working under the auspices of the CMB undertake leading-edge research in fisheries, marine ecology, physical oceanography, and related sciences. When combined with other CMB projects, this research will contribute to an overall ecosystem approach to fisheries management and biodiversity issues.

Ampelisca macrocephalia – *photo by Dan Jackson.*

Since the CMB has only recently been established, research activities are in their initial stages and are "works in progress". Some ongoing initiatives include:

- A program to uncover the links between habitat and fisheries within the Eastern Scotian Shelf Integrated Management (ESSIM) area (see the article on ESSIM in the *Resource Management Section* of this report for a map of the area). Research will attempt to answer questions regarding how the different demersal fish utilize benthic habitat and associated epibenthic organisms during their life stages. It will include an examination of the kinds of habitat required to support these fish at their various life stages, the spatial distribution of these habitats, and their vulnerability to species interactions and to human disturbances. This work involves a pro-



Echinarachnius parma - *photo by Dan Jackson.*

posed three-year program and will build on previous initiatives of DFO and Natural Resources Canada.

- The development of historical and contemporary inventories of finfish species richness. One of the most profound and important empirical observations in ecology is that species diversity is predictably related to the area of habitat in both continental and island faunas. This is known as the species-area relationship. Recent research has established the existence of a highly significant positive relationship between the number of finfish species and bank area. Banks of similar size yield similar species richness regardless of the distance between them. The ecological basis of this relationship is being explored. Other aspects of this work include application of analytical techniques to establish an appropriate sample size for quantifying finfish diversity, and understanding population dynamics and finfish migration through a metapopulation community model. Dr. K. Frank of Fisheries and Oceans Canada at BIO is undertaking this research.

- An assessment of the impact of invading species on the structure and function of a marine ecosystem in Canadian waters. Synergistic interactions between invasive species such as an epiphytic bryozoan, *Membranipora membranacea*, and a green alga, *Codium fragile* ssp. *tomentosoides* have resulted in large-scale replacement of kelps by the alga along the rocky coast of Atlantic Nova Scotia. Changes in species composition and abundance of invertebrates and fish associated with this alteration of biogenic habitat have important implications for the management of coastal resources, including assessment of biodiversity and identification of species/habitats at risk. Drs. R. Scheibling of Dalhousie and E. Kenchington, Fisheries and Oceans Canada are undertaking this research.

- Capital support has been provided for genetic and species-area relationship programs. Genetic diversity and maintenance of within-species diversity are both elements of biodiversity. The CMB is involved with Live Gene Bank facilities currently operating for Atlantic salmon and whitefish. This project links directly to the recovery plan for the Atlantic salmon, whitefish, and the dwarf smelt.

Additional projects include research on deep-sea coral, the ecology of non-commercial marine fish species, research on sponges and hydroids, and a working group on the State of the Ecosystem in the Northwest Atlantic.

Membership is open to individuals with an active involvement in scientific issues related to marine biodiversity and who concur with the mandate of the society. The CMB does not have an advocacy function.

The Center for Marine Biodiversity has established a public lecture series on biodiversity issues. We invite you to visit our website at (www.marinebiodiveristy.ca) for additional information on the lecture series, the CMB, or biodiversity in Canada.

The BIO Oceans Association Beluga Recognition Award

- Dale Buckley

Congratulations to Roger Belanger, the first recipient of the Bedford Institute of Oceanography's Oceans Association (BIO-OA) Beluga Recognition Award. Roger joined the BIO photographic unit in 1966, after working with photo-reconnaissance units in the military for 11 years. Over the years, Roger has provided photographic records, archives, and technical documentation for numerous and diverse ocean research projects.

Early oceanographic expeditions included a CCGS *Hudson* voyage to the Mid-Atlantic Ridge, and a multidisciplinary project in the Caribbean. After the major oil spill from the tanker *Arrow* in Chedabucto Bay in 1970, Roger was involved in photographic documentation of the immediate impact of the spill, as well as follow-up studies over the next two decades. In 1979, Roger participated in a pioneering survey of the Arctic Ocean from an ice camp on the LOREX experiments, where he helped develop a system to lower and recover deep-sea cameras through the ice.

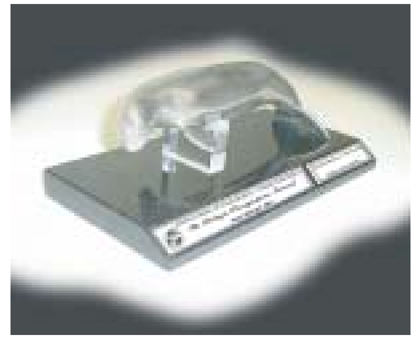
Roger made a number of innovative contributions to oceanographic photography and TV imaging using scuba. He was involved in developing photographic and electronic imaging technology from submarines and remotely-operated submersibles. In addition, he helped develop a photographic system for remotely monitoring sediment movement in inter-tidal areas of the Bay of Fundy using a tethered balloon. In the later years of his career, he developed a photographic system to be used on Coast Guard helicopters to document coastal features, oil spills, coastal erosion, and sewage effluents.

Not all of Roger's contributions were scientific or technical. He

Roger Belanger (right) receiving the Beluga Recognition Award from Dr. Paul Brodie.

has an artist's eye for aesthetics and evidence of his talents in photography is still found around BIO and in treasured memories of many who have worked at the Institute.

Roger retired in 1991 to spend time at his home in Grand Desert (near Lawrencetown, N.S.) where he devotes part of his time to assembling personal photographic memoirs of his career at BIO.



The BIO Oceans Association Beluga Recognition Award.

The Beluga Award was conceived by the BIO Oceans Association and was introduced in 2001 to honour individuals who have contributed their talents and work to making BIO a successful and well-recognized oceanographic institute. Any person who has worked, or is still working, at BIO is eligible for consideration. The beluga whale was chosen because it is a well-recognized symbol of the oceans and is a recognized Canadian symbol. Dr. Paul Brodie, a renowned marine mammalogist and sculptor, created the 11 inches model beluga whale. Amos Pewter of Mahone Bay, Nova Scotia cast the whale. The final product, a pewter whale, has a satin polish finish and sits on a granite and acrylic base that was fabricated by Atlantex Creative Works, East Chezzetcook, Nova Scotia.

The Third Meeting of the Partnership for Observation of the Global Oceans (POGO)

– Shubha Sathyendranath

The Third Annual Meeting of the Partnership for Observation of the Global Oceans took place at White Point in Nova Scotia, Canada on 27-29 November 2001. Participants representing oceanographic institutions from some thirteen countries (Argentina, Australia, Brazil, Canada, Chile, Germany, Japan, New Zealand, Norway, Russia, South Africa, United Kingdom, and the United States of America) attended the meeting. Several international organizations, such as the Argo Programme, CLIVAR (CLImate VARiability and predictability), CoML (Census of Marine Life), COOP (the Coastal Ocean Observation Panel), IOC (Intergovernmental Oceanographic Commission), IOCCG (International Ocean Colour Co-ordinating Group), JCOMM (Joint Commission on Oceanography and Marine Meteorology), PICES (North Pacific Marine Science Organisation), and SCOR (Scientific Committee on Oceanic Research) were also represented. In all, there were over forty participants. The meeting was hosted by Dr. Mike Sinclair, Director of the Bedford Institute of Oceanography. Mr. Neil Bellefontaine, Regional Director General, Fisheries and Oceans Canada (DFO), welcomed the participants.

The meeting began with presentations related to some of the main themes of POGO: the Argo project (a fleet of buoys distributed on the world's oceans to collect oceanographic data), time-series observations, and biological observations. Dr. Dean Roemmich, Chairman of the Argo Science Team, provided updates on the programme. He suggested that POGO member institutions encourage the applications of the Argo data stream, which is freely available, as this was essential to ensure the long-term viability of the programme. Dr. Bob Weller

Participants at the third meeting of POGO at White Point Beach Resort.

reported on the findings of the first meeting of the Time Series Working Group. Prof. John Field summarized the recommendations from the POGO Biology Workshop, and Dr. Jesse Ausubel spoke of recent advances in the Census of Marine Life (CoML) and its links with POGO.

The group reviewed issues related to capacity building on the second day of the meeting. The POGO-IOC-SCOR Fellowship Programme, which was initiated at POGO-2, is now well established. The programme receives generous financial support from IOC and SCOR. So far, 13 fellowships have been offered under this programme, which allows trainees from developing countries and economies in transition to travel to oceanographic laboratories in other countries for training on selected aspects of ocean observation. POGO also participated in, and co-sponsored, training programmes in South America (through the Austral Summer Institute organized by the University of Concepción and the Woods Hole Oceanographic Institution) and in India (in collaboration with the IOCCG). The members resolved to continue such efforts in the future. IOC and SCOR have decided to continue their support of the Fellowship Programme. There were also discussions on the possibility of organizing a training cruise on board a Russian research vessel, in collaboration with the IOCCG. POGO decided to continue its support of SEREAD (Scientific Educational Resources and Experience Associated with the Deployment of Argo drifting floats in the South Pacific Ocean).

As an impressive follow-up to the São Paulo Declaration of POGO, which called for increased observations in the Southern Hemisphere, the JAMSTSEC team proposed a circumpolar cruise on their research vessel *Mirai*, in the Southern Hemisphere, in partnership with other members of POGO. This was seen as an important step towards rectifying the imbalance in observations between the northern and southern hemispheres. The proposal was received warmly by the POGO members, and there were many offers of help and collaboration. Prof. Ulloa from Chile spoke of their plans to enhance the observational capacity of Chile, and in particular, of their efforts to obtain a replacement for their ageing research vessel. Members were invited to explore possibilities for addressing the matter.

There were presentations at the meeting regarding CoML, COOP, CLIVAR, the Global Ocean Observing System (GOOS), IOC, IGOS, IOCCG, JCOMM, the Ocean Observing Panel for Climate (OOPC), and PICES, and their links to POGO. There were presentations from several institutions, including: AOML (Atlantic Oceanographic and Meteorological Laboratory), BIO, Dalhousie University, the New Zealand National Institute for Water and Atmospheric Research (NIWA), the Shirshov Institute of Oceanology (Russia), University of Cape Town (South Africa), and University of Concepción (Chile) regarding their on-going activities of relevance to POGO.

A principal focus of this meeting was biological observations. Following the recommendations of the biology workshop, the Partnership resolved to initiate a biological observation system to monitor phytoplankton dynamics, and to organize a workshop in South America to promote regional observations of marine biodiversity. The establishment of a network of open-ocean, fixed-point, time-series observations also received special attention. The activities of the Time Series Working Group are to continue, and the next meeting is to take place in Hawaii, in February 2002.

In 2001, POGO was registered as a not-for-profit society in Nova Scotia, Canada. Several institutions and consortia of institutions have become members of the Society, and more are poised to become members in 2002. This strengthens the position of POGO as a self-funded, non-governmental organization. Dr. Rolf Weber (University of São Paulo) and Dr. Robert Gagosian (Woods Hole Oceanographic Institution) rotated out of the POGO Executive Committee. Dr. Howard Roe (Southampton Oceanography Centre) was elected the incoming Chair, and Mr. Takuya Hirano (President, Japan Marine Science and Technology Centre) and Dr. Nan Bray (Director, CSIRO Marine Research) became the new members of the POGO Executive. Dr. Charles Kennel (Scripps Institution of Oceanography) continues for one more year as the POGO Chair.

It was resolved to hold the next meeting of POGO in January 2003 in Hobart, Tasmania, Australia. The regional focus of the meeting is to be the Indian Ocean.

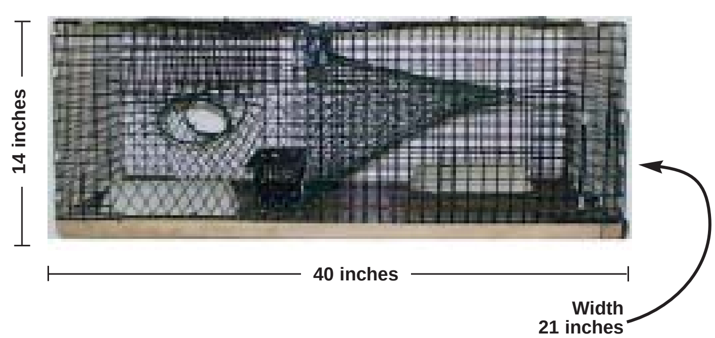
Fishermen and Scientists Research Society (FSRS) Lobster Recruitment Index from Standard Traps (LRIST)

- by John Tremblay, Carl MacDonald, Douglas Pezzack, and Peter Hurley

The Fishermen and Scientists Research Society is a non-profit organization formed to foster cooperation between those who spend a good part of their lives on the water, and those who are active in studying the dynamics of marine populations. Started in 1994, the FSRS has undertaken a number of projects with the cooperation of interested fishermen and scientists. The society has an office at BIO.

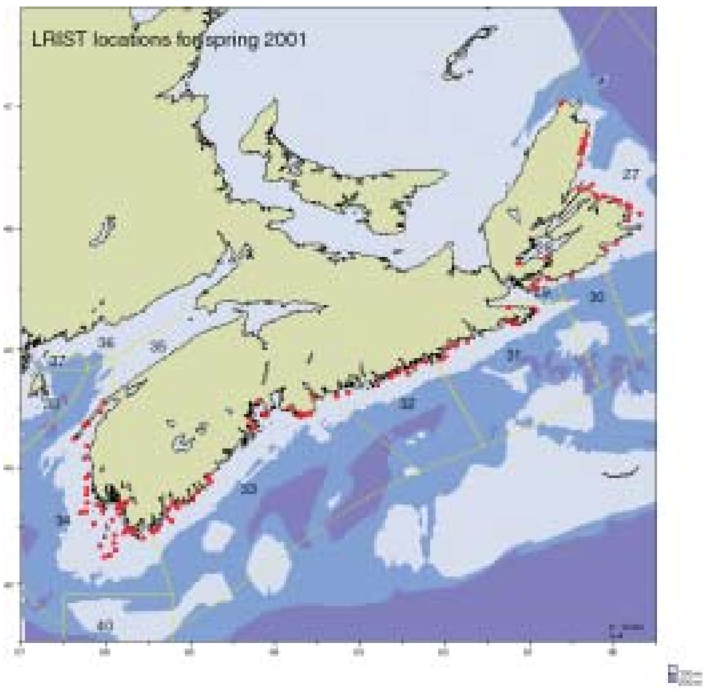
In 1999, the LRIST project was initiated to monitor the catch rates of sub-legal sizes of lobsters captured in traps. The objective of the project is to develop an index of the quantity of lobsters that will enter the fishery in one to two years.

One of the strengths of this FSRS project is the level of involvement of fishermen. Fishermen were involved in the design of the standard recruitment trap used in the project and in the planning phase of the project. Annual training sessions for data collection are held before the fishing season. The project results are reviewed at workshops at the end of each lobster season. The FSRS employs six community technicians, with support from DFO, through the Science and Technology Youth Internship Program, to work on Society projects. Intern duties include working directly with participating lobster fishermen, and sampling catches at sea. Support for the project also comes from the participating fishermen, who purchase the standard recruitment traps at a reduced cost from the FSRS. Hence, all participants contribute towards the goal of understanding lobster recruitment within the project area.



Standard trap used in LRIST.

In coastal Nova Scotia, lobsters are fished during the spring (Cape Breton and the Eastern Shore) and from fall to spring (South Shore, Southwest Nova Scotia, Bay of Fundy). The LRIST project had 67 fishermen participants in the 2000-2001 fall-winter fisheries, and 123 fishermen participants in the spring 2001 fisheries. The spring 2001 participants were spread along the Atlantic coast of Nova Scotia.



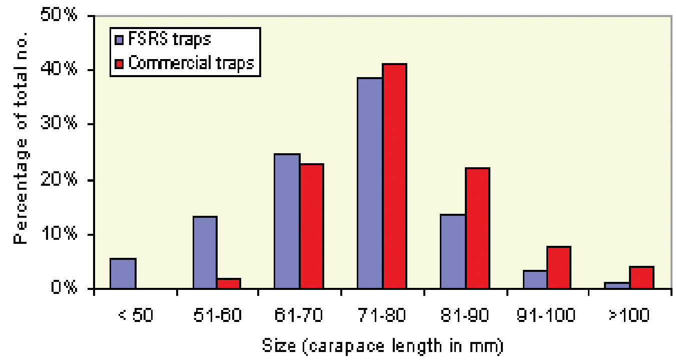
Location of recruitment traps during the spring fisheries. The numbered areas outlined on the map are Lobster Fishing Areas (LFAs).

Participating fishermen fish between 1 and 5 recruitment traps, and record daily catch numbers, sex of lobsters, and size using a project measuring gauge.

Lobster measuring guage.

The LRIST traps have reduced mesh openings (1") and no escape gaps. In regular commercial traps such gaps are required to allow the escape of sublegal sizes that are attracted to the baited traps.

The combination of the smaller mesh openings and no escape gaps results in greater retention of smaller lobsters compared to commercial traps.

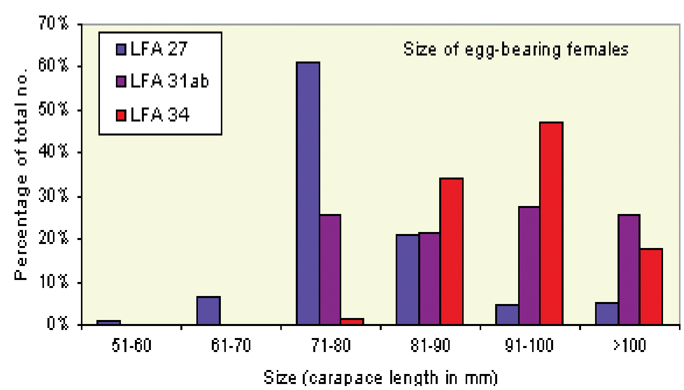


Size composition of lobsters captured in FSRS traps and commercial traps off Northern Cape Breton. 1143 lobsters were captured in 533 FSRS trap hauls and 4370 lobsters were captured in 1829 commercial trap hauls.

To evaluate whether the catch rate data are useful for predicting recruitment, a time series of five or more years is needed. In the interim, the LRIST data are proving useful for other purposes. These include:

- supplementing data collected by DFO's Invertebrate Fisheries Division used to assess lobster stock status,
- developing of a method for estimating fishing mortality (based on seasonal changes in the retained and non-retained portions of the catch), and
- evaluating area differences in population biology.

An example of the area differences in population biology is the smaller egg-bearing females in the north (LFA 27) compared to those from the south (LFA 34). This observation is consistent with independent measurements of female maturity.



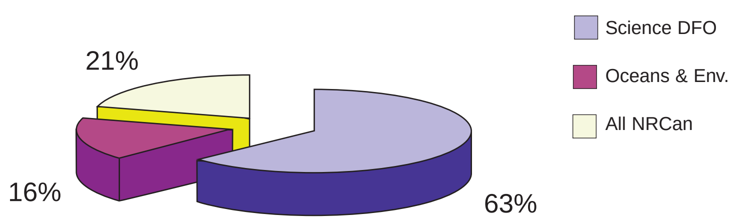
Size composition of egg-bearing females captured in FSRS traps in spring 2001.

In the future, the FSRS data have the potential to be important in the development of criteria for evaluating stock status. The fact that the data are collected by volunteer fishermen provides an opportunity for better discussion of the various management options.

Financial and Human Resources

Where the Institute obtains funding and how it is spent.

Annual appropriation from government by parliametary vote

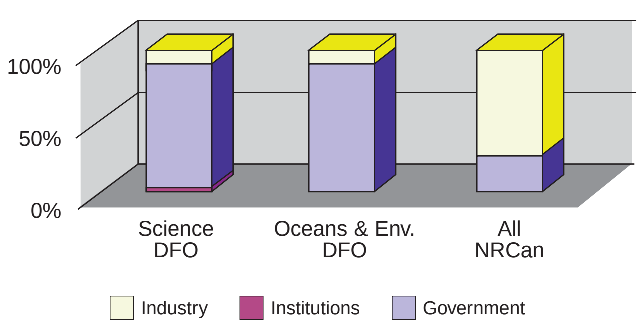


DEPARTMENT	SECTOR	AMOUNT ($000)
DFO	Science	24,409*
DFO	Oceans	6,170
NRCan	All	8,072

**Includes funds allocated for the operation and maintenance of research vessels.*

Environment Canada and DND have staff working at BIO. These resources are not captured in the above figures.

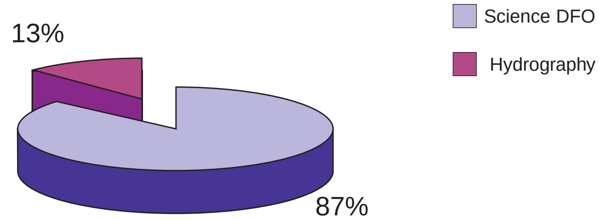
Other sources of funding



DEPARTMENT	SECTOR	GOVERNMENT ($000)	INSTITUTIONS ($000)	INDUSTRY ($000)
DFO	Science	8,298	0.71	832
DFO	Oceans	2,573		276
NRCan	All	845		2,000

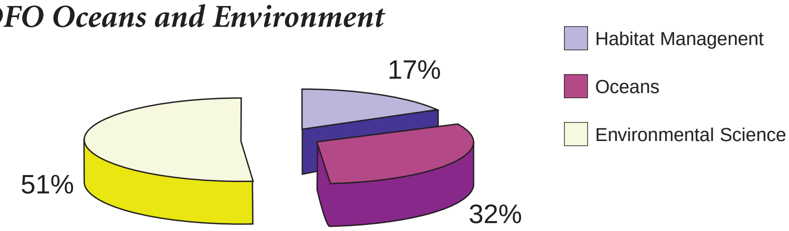
Program spending

DFO Science



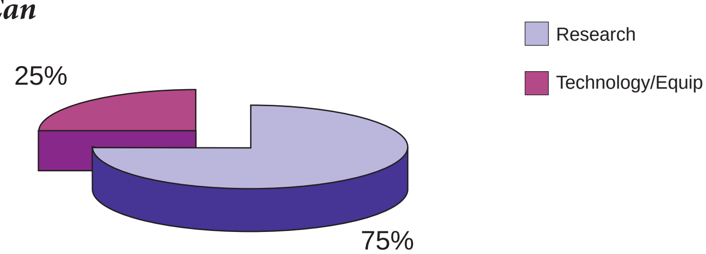
SECTOR	AMOUNT ($000)
Science Branch	21,186
Hydrography	3,223

DFO Oceans and Environment



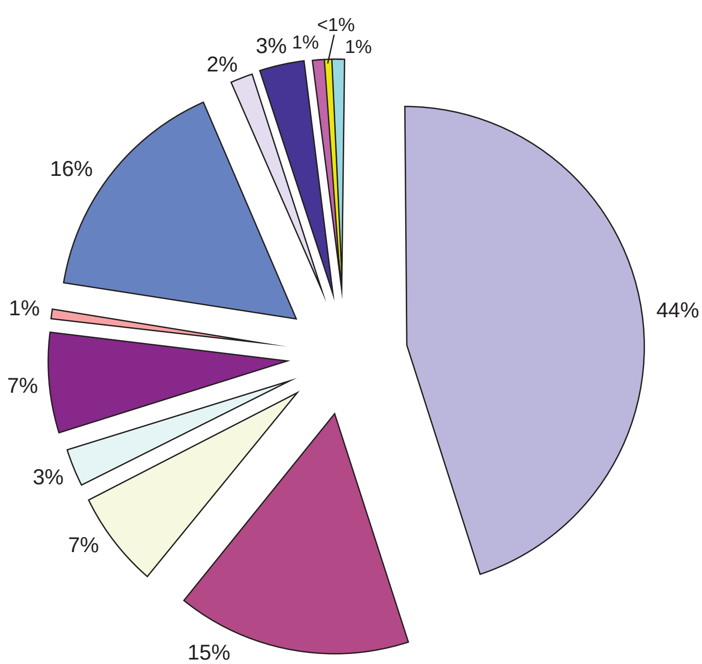
SECTOR	AMOUNT ($000)
Habitat Management	1,525
Oceans	2,887
Environmental Science	4,605

NRCan



	AMOUNT ($000)
Research	8,212
Technology/Equipment	2,705

BIO staff by Department/or organizational unit



DFO - Science	266
DFO - Oceans & Ev	93
DFO - Informatics	40
DFO - Library, Finance & Adm.	15
DFO - Coast Guard Tech Services	40
DFO - Aquaculture Coordination	4
NRCan - GSC Atlantic	94
DND - Route Survey	10
PWGSC - Site Operations	18
EC - Operational Laboratories	5
Health Canada - Nursing Unit	1
Other - Research Coordination Units	5
Total	591

Numbers are taken from the staff list and do not include contractors, students, or emeritus scientists.

People at BIO in 2001

DEPARTMENT OF NATIONAL DEFENCE

LCdr Jim Bradford
Lt(N) Scott Moody
CPO2 Ian Ross
PO1 Nancy Kent
PO2 Claude Pageau
PO2 Chris Moncrief
MS Jim Bartlett
MS Corey Brayall
MS Krista Smith
LS Sean Truswell

ENVIRONMENT CANADA

Christopher Craig
Kate Collins, Student
Earland Hart, Student
David MacArthur
Rick McCulloch, Student
Bernard Richard
Mike Ripley, Student
Diane Tremblay
Jamie Young

DEPARTMENT OF FISHERIES AND OCEANS

Canadian Coast Guard – Technical Services

Mechanical & Oceanographic Systems Development
George Steeves, Supervisor
Garon Awalt
Arthur Cosgrove
Kelly Bentham
Bob Ellis
Francis Kelly
Mike LaPierre
Daniel Moffatt
Glen Morton
Neil MacKinnon
Val Pattenden
Todd Peters
Nelson Rice
Greg Siddall
Heinz Wiele

Technical Maintenance
Jim Wilson, Supervisor
Gerry Dease
Don Eisener
Roger Gallant
Jason Green
David Levy
Robert MacGregor
Morley Wright
Mike O'Rourke
Mark Robbins

Vessel Support
Andrew Muise, Supervisor
Derrick Andrews
George Lake
Martin LaFitte
Richard LaPierre
Leonard Mombourquette
Richard Myers
Stanley Myers
Steve Myers
Lloyd Oickle
Bill Preston
Harvey Ross
Freeman Savoury
Raymond Smith
David Usher

Science Branch

Regional Director's Office
Michael Sinclair, Director
Alyson Campbell, Student
Lori Chisholm, Student
Marie Charlebois-Serdynska
Richard Eisner
Dianne Geddes
Gabriela Gruber
Joni Henderson
Sharon Morgan
Bettyann Power

Canadian Hydrographic Service (Atlantic)
Richard MacDougall, Director
Bruce Anderson
Carol Beals
Dave Blaney
Frank Burgess
Bob Burke
Fred Carmichael
Mike Collins
Chris Coolen
Gerard Costello
Andy Craft
John Cunningham
Elizabeth Crux
Tammy Doyle
Theresa Dugas
Mike Earle
Steve Forbes
John Ferguson
Claudine Fraser
Doug Frizzle
Jon Griffin
James Hanway
Judy Hammond
Malcolm Jay
Roger Jones
Heather Joyce
Glen King
Mike Lamplugh
Christopher LeBlanc
Kirk MacDonald
Bruce MacGowan
Grant MacLeod
Clare McCarthy
Dave McCarthy
Paul McCarthy
Mark McCracken
Dale Nicholson
Larry Norton
Stephen Nunn
Charlie O'Reilly
Nick Palmer
Richard Palmer
Paul Parks
Stephen Parsons
Ken Paul
Bob Pietrzak
Vicki Randhawa
Doug Regular
Glenn Rodger
Dave Roop
Tom Rowsell
Chris Rozon
Mike Ruxton

Term and casual employees, interns, students, and contractors are listed if they worked at BIO for at least four months in the year 2001.
*Retired in 2001.

Cathy Schipilow
June Senay
Alan Smith
Andrew Smith
Nick Stuifbergen
Michel Therrien
David Trudel
Herman Varma
Dustin Whalen
Keith White
Wendy Woodford
Craig Zeller

Diadromous Fish Division
Larry Marshall, Manager
Doug Aitken
Peter Amiro
Rod Bradford
Henry Caracristi
Carolyn Harvie
Phil Hubley
Eric Jefferson
Brian Jessop
Paul LeBlanc
Dave Longard
Blythe Mahaney
Shane O'Neil
Patrick O'Reilly
Kimberley Robichaud-LeBlanc
Karen Rutherford
Debbie Stewart
Katherine McKeen Sweat
Daisy Williams

Invertebrate Fisheries Division
René Lavoie, Manager
Jerry Black
Ann Butler
Maureen Butler
Manon Cassista
Amy Chisholm
Victoria Clayton
Ross Claytor
Michele Covey
Ron Duggan
Emily Dumaresq
Cheryl Frail
Ken Freeman*
Amanda Ginnish
Raj Gouda, Student
Nathalie Green
Lea-Anne Henry, Student
Daniel Jackson
Shaka James, Student
Ellen Kenchington
Peter Koeller
Mark Lundy
Barry MacDonald
Bob Miller
Stephen Nolan
Doug Pezzack
Alan Reeves
Ginette Robert
Dale Roddick
Amanda Sabattis
Bob Semple
Glyn Sharp
Stephen Smith
Amy Thompson
John Tremblay
Bénédikte Vercaemer
Cathy Wentzell
Tim Willis, Intern
Kristana Worcester

Marine Fish Division
Wayne Stobo, Manager
Susan Baker
Diane Beanlands
Don Bowen
Bob Branton
Alida Bundy
Steve Campana
Peter Comeau
Paul Fanning
Wanda Farrell
Mark Fowler
Ken Frank
Caihong Fu
Darren Gillis, Visiting Scientist
Ralph Halliday
Lei Harris
Peter Hurley
Bill MacEachern
Linda Marks
Jim McMillan
Jeff McRuer
Bob Mohn
Jim Reid
Nancy Shackell
Mark Showell
Jim Simon
Nancy Stobo
Iain Suthers, Visiting Scientist
Kim Whynot
Scott Wilson
Gerry Young
Kees Zwanenburg

Ocean Sciences Division
Allyn Clarke, Manager
Barbie Henneberry
Pat Williams

Biological Oceanography
Glen Harrison, Head
Jeffrey Anning
Florence Berreville, Student
Heather Bouman, Student
Jay Bugden
Carla Caverhill
Emmanuel Devred, PDF
Paul Dickie
Andrew Edwards, PDF
Gretchen Fitzgerald, Student
Cesar Fuentes-Yaco, PDF
Lee Geddes
Rajashree Gouda, Student
Leslie Harris
Erica Head
Edward Horne
Brian Irwin*
Mary Kennedy
Paul Kepkay
Marilyn Landry
William Li
Svetlana Loza, PDF
Heidi Maass
Anitha Nair, Student
Markus Pahlow, PDF
Kevin Pauley
Linda Payzant
Trevor Platt
Catherine Porter
Douglas Sameoto
Dawn Shepherd, Student
Jeffrey Spry
Alain Vézina
Louisa Watts, PDF
George White

Coastal Ocean Science
Peter Smith, Head
Dave Brickman
Gary Bugden
Sandy Burtch
Jason Chaffey
Joel Chassé
Brendan DeTracey
Ken Drinkwater
Frederic Dupont, PDF
Dave Greenberg
Charles Hannah
Nicolai Kliem, PDF
Don Lawrence
Bob Lively
Mathieu Ouellet
Ingrid Peterson
Brian Petrie
Liam Petrie
Roger Pettipas

Term and casual employees, interns, students, and contractors are listed if they worked at BIO for at least four months in the year 2001.
*Retired in 2001.

Simon Prinsenberg
Howard Reid
Charles Tang
Ted Tedford
Tom Yao
Chou Wang
Zhigang Xu

Ocean Circulation
John Loder, A/Head
Robert Anderson
Karen Atkinson
Nancy Chen
Sharon Gillam-Locke
Blair Greenan
Douglas Gregory
Helen Hayden
Ross Hendry
Anthony Isenor
Jeff Jackson
Peter Jones
David Kellow
Zhenxia Long, PDF
Neil Oakey
William Perrie
Marion Smith
Brenda Topliss
Bash Toulany
Dan Wright
Frank Zemlyak

Ocean Physics
Michel Mitchel, Head
Brian Beanlands
Don Belliveau
Norman Cochrane
Katherine Collier
John Conrod
George Fowler
Jim Hamilton
Alex Herman
Randy King
George States
Ted Phillips
Scott Young

Technical Operations
Dave McKeown, Head
Larry Bellefontaine
Rick Boyce
Derek Brittain
Bert Hartling
Bruce Nickerson
Bob Ryan
Murray Scotney

Maritimes Regional Advisory Process (RAP)
Bob O'Boyle, Coordinator
Valerie Myra

Maritimes Aquatic Species at Risk Office
John Loch, Manager
Bob Barnes
Jennifer Barton
Jerry Conway
Lynn Cullen

Oceans and Environment Branch

Regional Director's Office
Faith Scattolon, Regional Director
Jane Avery
Ted Potter
Robert St-Laurent

Habitat Management Division
Brian Thompson, Manager
Brooke Cook
Joey Crocker
Rick Devine
Joy Dube
Joanne Gough
Anita Hamilton
Tony Henderson
Darren Hiltz
Craig Hominick
Brian Jollymore
Darria Langill
Jim Leadbetter
Jack Leeman
Melanie MacLean
Shayne McQuaid
Marci Penney-Ferguson
Jim Ross
Carol Sampson
Carol Simmons
Reg Sweeney
Phil Zamora
Chad Ziai

Marine Environmental Sciences Division
Paul Keizer, Manager
Jim Abriel
Byron Amirault
Debbie Anderson
Carol Anstey
Shelley Armsworthy
Mark Beasy
Robert Benjamin
Paul Boudreau
Cynthia Bourbonnais
Chiu Chou
Pierre Clement
Susan Cobanli
Peter Cranford
John Dalziel
Jason Dearing
Jennifer Dixon
Lisa Doucette
Grazyna Folwarczna
Don Gordon
Gareth Harding
Barry Hargrave
Jocelyn Hellou
Kory Jollymore
Thomas King
Brent Law
Ken Lee
Jim Leonard
Kevin MacIsaac
Sarah Magee, Intern
Tim Milligan
John Moffatt
Lene Mortensen
Pål Mortensen, PDF
Rick Nelson
Sherry Niven
Lisa Paon
Georgina Phillips
Sarah Robertson
Sylvia Rumbolt
Sheila Shellnut
Judy Simms
John Smith
Sean Steller
Andrew Stewart
Peter Strain
Peter Vass
Gary Wohlgeschaffen
Philip Yeats

Oceans and Coastal Management Division
Joe Arbour, Manager
Debi Campbell
Lesley Carter
Scott Coffen-Smout
Chantal Couture
Dave Duggan
Derek Fenton
Jennifer Hackett
Tim Hall
Glen Herbert
Stanley Johnston
Paul Macnab
Denise McCullough
Jason Naug
Celeine Renaud
Bob Rutherford
Maxine Westhead

Term and casual employees, interns, students, and contractors are listed if they worked at BIO for at least four months in the year 2001.
*Retired in 2001.

Aquaculture Coordination

Mike Murphy, Coordinator
Darrell Harris
Cindy Webster
Sharon Young-Currie

Finance & Administration

Library
Anna Fiander, Manager
Susan Boutilier
Carole Broome, Student
Cathy Budgell
Rhonda Coll
Lori Collins
Helen Dussault
Lois Loewen
Maureen Martin
Marilynn Rudi
Diane Stewart

Procurement
Joan Hebert-Sellars

Stores
Larry MacDonald
Charles Mitchell, Intern
Bob Page
Ray Rosse

Communications Branch

Carl Myers

Informatics

Technology Services
Gary Somerton, Chief
Chris Archibald
Eric Ashford
Patrice Boivin
Doug Brine
Mike Clarke
Jim Cuthbert
Gary Collins*
Paul Dunphy
Bruce Fillmore
Heather Fraser
Judy Fredericks
Pamela Gardner
Lori Gauthier
Ron Girard
Marc Hemphill
Mike Lemay
Jacqueline Leschied
Charles Lever
Nancy MacNeil
Charles Mason
Sue Paterson
Kevin Ritter
Mike Stepanczak
Charlene Williams
Paddy Wong

Client Services
Sandra Gallagher, Head
Kevin Dunphy
Carol Levac
Juanita Pooley

Records
Jim Martell, Site Supervisor
Myrtle Barkhouse
Carla Sears

Applications
Tobias Spears, A/Head
Lenore Bajona
Shelley Bond
Flo Hum
Anthony Joyce
Roger Soulodre
Kohila Thana

NATURAL RESOURCES CANADA

Geological Survey Of Canada (Atlantic)

Director's Office
Jacob Verhoef, Director
Pat Dennis

Administration
George McCormack, Manager
Cheryl Boyd
Terry Hayes
Terry Henderson
Cecilia Middleton
Barb Vetese

Marine Resources Geoscience
Don McAlpine, Manager
Mike Avery
Jennifer Bates
Darrell Beaver
Bernie Crilley
Rob Fensome
Gary Grant
Ken Hale
Iris Hardy
Evelyn Inglis
Arthur Jackson
Chris Jauer
Nelly Koziel
Paul Lake
Bill MacMillan
Andrew MacRae
Anne Mazerall
Susan Merchant
Phil Moir
Phil O'Regan
John Shimeld
Frank Thomas
Hans Wielens
Graham Williams

Marine Environmental Geoscience
Dick Pickrill, Manager
Ken Asprey
Anthony Atkinson
Steve Blasco
Austin Boyce
Calvin Campbell
Borden Chapman
Donald Clattenburg*
Ray Cranston
Gordon Fader
Robert Fitzgerald
Donald Forbes
David Frobel
Pierre Gareau
Mike Gorveatt*
Jennifer Strang
Robert Harmes
David Heffler
Kimberley Jenner
Fred Jodrey
Heiner Josenhans
Edward King
Bill LeBlanc
Michael Li
Maureen MacDonald
Bill MacKinnon
Gavin Manson
Sabastian Migeon
Bob Miller
David Mosher
Peta Mudie*
Bob Murphy
David Piper
Kevin Robertson*
Andre Rochon
John Shaw
Andy Sherin
Steve Solomon
Gary Sonnichsen
Bob Taylor

Term and casual employees, interns, students, and contractors are listed if they worked at BIO for at least four months in the year 2001.
*Retired in 2001.

Brian Todd
Bruce Wile

Marine Regional Geoscience
Mark Williamson, Manager
Ross Boutilier
Bob Courtney
Claudia Currie
Sonya Dehler
Carmelita Fisher
Peter Giles
Paul Girouard
Nathan Hayward
Ruth Jackson
Ron Macnab*
Gordon Oakey
Russell Parrott
Stephen Perry
Patrick Potter
Wayne Prime
Matt Salisbury
Philip Spencer
Barbara Szlavko
Marie-Claude Williamson

BIO TOUR GUIDES

Steven Fancy, Student
Jasmine Marshall, Student
Darcy O'Brien, Student

PUBLIC WORKS AND GOVERNMENT SERVICES

Leo Lohnes, Property Manager
Diane Andrews
Bob Cameron
Paul Fraser
Jim Frost
Geoff Gritten
Greg Gromack
Wilf Lush
Ralph Lynas
Allan MacNeil
Garry MacNeill
June Meldrum
John Miles
Paul Miles
Richard Netherton
Fred Rahey
Phil Williams
Bill Wood

HEALTH CANADA

Heather Skinner

NATIONAL RESEARCH COUNCIL CANADA

Don Douglas

COMMISSIONAIRES

William Bewsher
Paul Bergeron
Dave Cyr
John Dunlop
Donnie Hotte
Rex Lane
Leonard MonMinie
Francis Noonan
Pierre Remillard
Yves Tessier
Lester Tracey

CAFETERIA STAFF

Kelly Bezanson
Randy Dixon
Valerie Donovan
Lynn Doubleday
Mark Vickers

OTHERS ON THE BIO CAMPUS

International Ocean Colour Coordinating Group (IOCCG)

Venetia Stuart, Executive Scientist
Abhijit Bhadé
Bart Hulshof

Partnership for Observation of the Global Oceans (POGO)

Shubha Sathyendranath, Executive Director

SeaMap

Gary Rockwell

Fishermen and Scientists Research Society (FSRS)

Jeff Graves
Carl MacDonald
Jill Moore, Intern
Shannon Scott

Geoforce Consultants Ltd.

Mike Belliveau
Graham Standen
Martin Uyesugi

Maritime Tel & Tel

Paul Brown
Tim Conley

Contractors

Kumiko Azetsu-Scott, Ocean Circulation
Linda Bonang, Records
Shawna Bourque, CHS
Pierre Brien, Marine Fish
Derek Broughton, Marine Fish
Walter Burke, CHS
Clare Carver, Invertebrates
Erin Carruthers, Ocean Circulation
Benoit Casault, Biol. Oceanography
Barbara Corbin, Records
Tania Davignon-Burton, Marine Fish
Ewa Dunlap, Ocean Circulation
Mike Friis, Records
Bob Gershey, Ocean Circulation
Yuri Geshelin, Coastal Ocean Sci.
Bin He, Ocean Circulation
Gary Henderson, CHS
Yongcun Hu, Ocean Circulation
Tara Jewett, Marine Fish
Warren Joyce, Marine Fish
Edward Kimball, Ocean Circulation
Carrie MacIsaac, CHS
Kee Muschenheim, MESD
Sean Oakey, Coastal Ocean Sci.
Tim Perry, Biol. Oceanography
Bret Pilgrim, Invertebrates
John Price, Ocean Circulation
Sylvie Roy, MESD
Victor Soukhovtsev, Coastal Ocean Sci.
Jacqueline Spry, Biol. Oceanography
Patricia Stoffyn, MESD
Tieneke Van der baaren, Coastal Ocean Sci.
Rosalie Wamboldt, Coastal Zone Canada Assn.

Term and casual employees, interns, students, and contractors are listed if they worked at BIO for at least four months in the year 2001.
*Retired in 2001.

Pamela Wentzell, Invertebrates
Wesley White, Diadromous Fish
Craig Wright, CHS
Igor Yashayaev, Ocean Circulation
Ina Yashayaev, Ocean Circulation
Alicia York, Marine Fish

Scientist Emeritus

Piero Ascoli
Dale Buckley
Lloyd Dickie
Fred Dobson
Jim Elliott
Alan Grant
Peter Hacquebard
Lubos Jansa
Charlotte Keen
Tim Lambert
John Lazier
Mike Lewis
Doug Loring
Brian MacLean
Ken Mann
Clive Mason
George Needler
Charlie Quon
Charlie Ross
Hal Sandstrom
Charles Schafer
Stuart Smith
Shiri Srivastava
James Stewart
John Wade

Recognition
BIO staff wish to recognize the contribution and support provided by the Captains and crew of Canadian Coast Guard vessels tasked to assist BIO-based research.

Individuals who retired in 2001

Fisheries and Oceans Canada

Gary Collins retired from the Informatics Branch in April 2001 after 30 years of outstanding service. Gary originally emigrated from Ireland after working for the British Nuclear Commission. Upon his arrival in Canada he worked for Atomic Energy before joining DFO in 1970. He was chief of Statistics and Computing Services at corporate headquarters prior to transferring to BIO in 1980. Gary initially worked for Science Computing Services and was instrumental in the replacement of the Cyber mainframe and the integration of mass storage management. Gary is well respected by his colleagues and clients alike. His hobbies include photography, classical guitar, astronomy, and skydiving.

After 35 years of service, **Ken Freeman** retired effective October 24th, 2001. Over many years at BIO, the Halifax Fisheries Research Laboratory, and then back to BIO, Ken developed a reputation as a shellfish biologist who worked hard to serve the industry. He is well known and appreciated by the mussel culture industry. Ken also contributed a great deal to the industry's awareness of the potential impacts on shellfish growers and fishermen of disease and contamination.

Brian Irwin retired in May 2001 after 35 years of outstanding service in the Biological Oceanography Section at BIO. Brian was head of the Section's sea-going and laboratory technical support group and ran the primary production program for three decades. Brian's research took him to virtually all of the major oceans of the world during his career.

Natural Resources Canada

For 34 years, **Donald Clattenburg** ran the NRCan sedimentology laboratory. He developed the lab into a world class facility and mentored many students.

Mike Gorveatt retired in November after 34 years with Natural Resources Canada. During the latter half of Mike's career he managed the NRCan Technical Support group, and was responsible for mobilizing field programs throughout Canada, including the Arctic.

Ron Macnab retired in November after 33 years with Natural Resources Canada. During his tenure at NRCan, Ron led several international efforts to compile unique data sets, and was a key resource for issues related to the Law of the Sea.

After 20 years, **Peta Mudie** retired in December as a palynologist. Dr. Mudie will be remembered for her contribution to paleoceanographic studies in the Atlantic and Arctic oceans.

After 35 years with Natural Resources Canada, **Kevin Robertson** retired as NRCan's Laboratory Manager in October 2001. Throughout his career, Kevin played a pivotal role in the development of the laboratory infrastructure, facilitating cooperative programs within the Institute, and on health and safety committees.

Term and casual employees, interns, students, and contractors are listed if they worked at BIO for at least four months in the year 2001.
*Retired in 2001.

Publications and Products 2001

FISHERIES AND OCEANS CANADA – MARITIMES REGION

1) Biological Sciences

Recognized Scientific Journals:

Addison, R.F., and W.T. Stobo. 2001. Trends in organochlorine residue concentrations and burdens in grey seals *(Halichoerus grypus)* from Sable Is., N.S., between 1974 and 1994. Environ. Pollut. 112: 505-513.

Bowen, W.D., D.J. Boness, S.J. Iverson, and O.T. Oftedal. 2001. Foraging effort, food intake, and lactation performance depend on maternal mass in a small phocid seal. Funct. Ecol. 15: 325-334.

Bowen, W.D., S. Ellis, S.J. Iverson, and D.J. Boness. 2001. Maternal effects on offspring growth rate and weaning mass in harbour seals. Can. J. Zool. 79: 1088-1101.

Bundy, A. 2001. Fishing on ecosystems: The interplay of fishing and predation in Newfoundland-Labrador. Can. J. Fish. Aquat. Sci. 58(6): 1153-1167.

Bundy, A., and D. Pauly. 2001. Selective harvesting by small scale fisheries: Ecosystem analysis of San Miguel Bay, Philippines. Fish. Res. 53(3): 263-281.

Campana, S.E. 2001. Accuracy, precision and quality control in age determination, including a review of the use and abuse of age validation methods. J. Fish Biol. 59: 197-242.

Campana, S.E., and S.R. Thorrold. 2001. Otoliths, increments and elements: keys to a comprehensive understanding of fish populations? Can. J. Fish. Aquat. Sci. 58: 30-38.

Comeau, L.A., S.E. Campana, G.A. Chouinard, and J.M. Hanson. 2001. Timing of Atlantic cod *Gadus morhua* seasonal migrations in relation to serum levels of gonadal and thyroidal hormones. Mar. Ecol. Prog. Ser. 221: 245-253.

Duggan, R.E., and R.J. Miller. 2001. External tags for the green sea urchin. J. Exp. Mar. Biol. Ecol. 258: 115-122.

Fu, C., R.K. Mohn, and L.P. Fanning. 2001. Why the Atlantic cod *(Gadus morhua)* stock off eastern Nova Scotia has not recovered. Can. J. Fish. Aquat. Sci. 58: 1613-1623.

Gislason, H., M. Sinclair, K. Sainsbury, and R.N. O'Boyle. 2000[1]. Symposium overview: Incorporating ecosystem objectives within fisheries management. ICES (Int. Counc. Explor. Sea) J. Mar. Sci. 57: 468-475.

Hansen, M.M., E. Kenchington, and E.E. Nielsen. 2001. Assigning individual fish to populations using microsatellite DNA markers. Fish Fish. Ser 2: 93-112.

Kenchington, E.L.R., J. Prena, K.D. Gilkinson, D.C. Gordon, Jr., K. MacIsaac, C. Bourbonnais, P.J. Schwinghamer, T.W. Rowell, D.L. McKeown, and W.P. Vass. 2001. Effects of experimental otter trawling on the macrofauna of a sandy bottom ecosystem on the Grand Banks of Newfoundland. Can. J. Fish. Aquatic. Sci. 58: 1043-1057.

[1]Citation year is 1999 or 2000; however, publication occurred after publication of *Bedford Institute of Oceanography 2000.*

Koeller, P.A. 2000[1]. Relative importance of environmental and ecological factors to the management of the northern shrimp *(Pandalus borealis)* fishery on the Scotian Shelf. J. Northw. Atl. Fish. Sci. 27: 21-33.

Koeller, P.A., R. Mohn, and M. Etter. 2000[1]. Density dependent sex-reversal in pink shrimp *(Pandalus borealis)* on the Scotian Shelf. J. Northw. Atl. Fish. Sci. 27: 107-118.

Koeller, P.A., L. Savard, D. Parsons, and C. Fu. 2000[1]. A precautionary approach to assessment and management of shrimp stocks in the Northwest Atlantic. J. Northw. Atl. Fish. Sci. 27: 235-246.

Lidgard, D.C., D.J. Boness, and W.D. Bowen. 2001. A novel mobile approach to investigating mating tactics in male grey seals *(Halichoerus grypus)*. J. Zool., Lond. 255: 313-320.

Nielsen, E.E., and E. Kenchington. 2001. Prioritizing marine fish and shellfish populations for conservation: A useful concept? Fish Fish. Ser. 2: 328-343.

Pinhorn, A.T., and R.G. Halliday. 2001. The regulation of exploitation pattern in North Atlantic groundfish stocks. Fish. Res. 53: 25-37.

Ramseier, R.O., C. Garrity, D.G. Parsons, and P. Koeller. 2000[1]. Influence of particulate organic carbon sedimentation within the seasonal sea-ice regime on the catch distribution of northern shrimp *(Pandalus borealis)*. J. Northw. Atl. Fish. Sci. 27: 35-44.

Tremblay, M.J., and S.J. Smith. 2001. Lobster *(Homarus americanus)* catchability in different habitats in late spring and early fall. Mar. Freshw. Res. 52: 1321-1332.

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Carr, J. 2001. A review of downstream movements of juvenile Atlantic salmon *(Salmo salar)* in the dam-impacted Saint John River drainage. Can. Manuscr. Rep. Fish. Aquat. Sci. 2573. 76 p.

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CA476035. Chart No. 4115. Passamaquoddy Bay and St. Croix River

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CA576003. Chart No. 4202. Halifax Harbour - Point Pleasant to/à Bedford Basin

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CA376047. Chart No. 4241. Lockeport to/à Cape Sable

CA376014. Chart No. 4242. Cape Sable Island to/aux Tusket Islands

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CA476285. Chart No. 4306. Strait of Canso and/et Southern Approaches/et les approches sud

CA576282. Chart No. 4306. Canso Lock

CA476221. Chart No. 4308. St. Peter's Bay to Strait of Canso

CA576548. Chart No. 4342. North Head Wharves

[1]Available from Nautical Data International, Inc. at (http://www.digitalocean.ca)

CA376303. Chart No. 4375. Guyon Island to Flint Island

CA376242. Chart No. 4462. St. George's Bay

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CA276236. Chart No. 4520. Cape St. John to Cape Bonavista

CA576343. Chart No. 4524. Botwood Wharves

CA576342. Chart No. 4524. Botwood Harbour

CA576227. Chart No. 4587. Marystown Wharves/Quais

CA476327. Chart No. 4596. Bay of Exploits - Sheet II (Middle)

CA576302. Chart No. 4617. Buffett Harbour

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CA576186. Chart No. 4652. Corner Brook

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CA376070. Chart No. 4845. Renews Harbour to/à Motion Bay

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CA476071. Chart No. 4845. Bay Bulls and/et Witless Bay

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CA576114. Chart No. 4848. Long Pond

CA576118. Chart No. 4848. Holyrood (Marina)

CA576117. Chart No. 4848. Generator Plant (Wharf)

CA576116. Chart No. 4848. Ultramar (Wharf/Quai)

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CA376807. Chart No. 4855. Bonavista Bay (Southern Portion)

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CA476804. Chart No. 4863. Bacalhao Island to Black Island

CA476802. Chart No. 4863. Bacalhao Island to Black Island

CA476803. Chart No. 4863. Bacalhao Island to Black Island

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CA476495. Chart No. 5138. Continuation A - Sandwich Bay

CA576498. Chart No. 5138. Cartwright Harbour

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CA476214. Chart No. 5143. Sebaskachu Bay

CA276113. Chart No. 8048. Cape Harrison to/à St Michael Bay

Sunrise at sea from the CCGS Alfred Needler *– eastern Scotian Self, July 2001 – photo by J.G. Reid.*

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