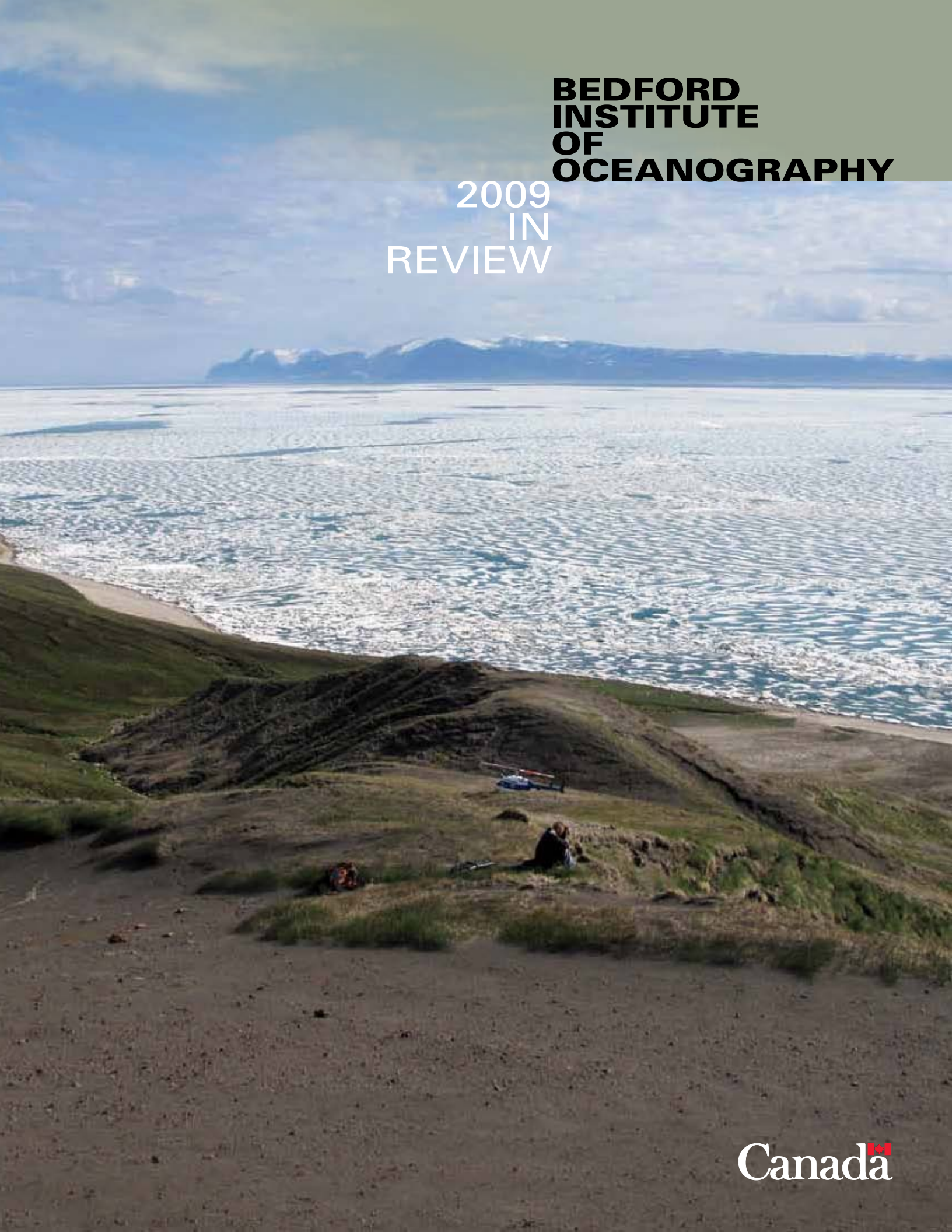
BEDFORD INSTITUTE OF OCEANOGRAPHY

2009 IN REVIEW



Canada

The Bedford Institute of Oceanography, 2009

Front cover photo: *A team of research scientists from the Geological Survey of Canada has just arrived by helicopter on Bylot Island to study rock formations in relation to petroleum systems.*

Back cover photo: *Lisel Currie of the Geological Survey of Canada surveys the glaciers and terrain of Bylot Island from atop a Cretaceous outcrop.*

Front and back cover photos are courtesy of Hans Wielens of Natural Resources Canada. After finishing his doctorate in The Netherlands in 1979, Hans moved to Calgary to work as an oil explorer. Twenty years later he joined the Geological Survey of Canada (Atlantic) at BIO to explore for petroleum systems offshore eastern Canada. The research discoveries on Bylot Island are described within, in the article *Geological Field Work on Magnificent Bylot Island.*

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INTRODUCTION

The Bedford Institute of Oceanography (BIO) is a major oceanographic research facility, established in 1962 by the Government of Canada and located in Dartmouth, Nova Scotia, on the shore of Bedford Basin. It has grown to become Canada's largest centre for ocean research. Scientists at BIO perform 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. Environmental planning and integrated coastal and oceans management are expanding activities at the Institute.

Fisheries and Oceans Canada (DFO) is represented by five divisions within its Science Branch including the Canadian Hydrographic Service (CHS), five divisions within the Oceans, Habitat and Species at Risk Branch, Informatics, and the Canadian Coast Guard Technical Services for technical and vessel support. Together they provide scientific knowledge and advice on issues related to climate, oceans, environment, marine and diadromous fish, marine mammals, shellfish, and marine plants. As well, they are responsible for the fish habitat management protection program, environmental assessments, integrated coastal and oceans management, species-at-risk coordination, and oceans planning initiatives.

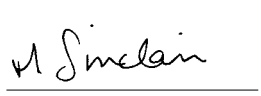
Natural Resources Canada (NRCan) is represented by the Geological Survey of Canada (Atlantic) (GSC Atlantic), Canada's principal marine geoscience facility, and by the United Nations Convention on the Law of the Sea (UNCLOS) Program Office. NRCan's scientific research expertise focuses on marine and petroleum geology, geophysics, geochemisty, and geotechnology. The GSC Atlantic is also the source of integrated knowledge and advice on Canada's coastal and offshore landmass.

The Department of National Defence (DND) is represented by the Route Survey Office of Maritime Forces Atlantic, which supports ocean surveillance activities. In cooperation with the CHS and the GSC Atlantic, surveys are conducted in areas of the sea floor of specific interest to DND.

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

Altogether, approximately 700 scientists, engineers, technicians, managers, support staff, and contractors from a variety of disciplines work at BIO.

This review highlights research activities at the Institute, as well as activities associated with ocean-use management.



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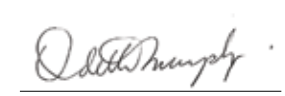

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Sub-tropical Pupping Grounds for a Cold-water Shark

Steven E. Campana, Warren Joyce, Anna Dorey, and Mark Fowler

Figure 1. A Porbeagle Shark is brought to the boat for tagging.

Since the release of the movie *Jaws* in 1975, sharks have been viewed as the most dangerous and terrifying predators of the sea, a perception which made them the preferred target of numerous sport fishermen around the world, and the scourge of many commercial fishermen. Now, 35 years after *Jaws*, many shark species around the world are in serious decline, some to the point of being endangered. A low birth rate and a delayed age at sexual maturation make many shark species slow to replenish their numbers. These characteristics, together with a low rate of natural mortality, make the fish very sensitive to fishing-induced mortality. Although sharks are sometimes the target of a commercial fishery, more often they are merely a by-catch of other fisheries, particularly those for tuna and swordfish. In an ironic turn of events, the apex predator of the ocean is now being threatened by the apex predator of the world – man.

The Canadian Shark Research Laboratory at BIO is responsible for research and stock assessment on the shark species found off the eastern coast of Canada, particularly those that are fished commercially or recreationally. Of the 14 shark species regularly found in our waters, the Porbeagle Shark (*Lamna nasus*) has been the most intensively studied. Recent research has focused on tracking their movements with satellite tags, and the results have been eye-opening.

Porbeagles are large pelagic (near-surface dwelling) sharks, related to both Mako and Great White sharks, and apparently restricted to the cold waters of the North and South Temperate Zones. The population in the northwest Atlantic is at a stable but depleted level of population abundance, and is largely confined to the continental shelf off eastern Canada and the northeastern United States. Experimental pelagic longline fishing in the 1960s, during a period when the population abundance was high, demonstrated that the species extended as far south as latitude 37°N, but that most of the population was concentrated in

Canadian waters north of latitude 41°N. All life-history stages, from young-of-the-year to sexually mature adults, are most abundant on or near the continental shelf, despite the presence of some individuals in international waters to the east. Summer/fall mating grounds have been documented on the continental shelf south of Newfoundland and on Georges Bank. However, the pupping (birthing) grounds have never been identified.

To track the sharks, in summer Porbeagles were captured with pelagic longlines onboard commercial shark-fishing vessels (Figure 1), then tagged with pop-up archival transmission tags (PATs). PATs were attached to Porbeagles by darting a nylon umbrella tip into the dorsal musculature of the shark, just behind the first dorsal fin (Figure 2).

PAT tags were programmed to record depth (± 0.5 m), temperature (± 0.1°C), and light intensity at 10-second intervals for up to 12 months after the shark's release. The timing of the tag's release from the shark was also programmed. The tag data were internally binned by 6-hour intervals and the summarized data transmitted to an Argos satellite after release of the PAT from the shark. More than 92% of the 23 tags transmitted successfully after release. (Each PAT was fitted with an emergency cut-off device which physically released the tag if it went below 1,800 m, the maximum nominal safe depth for tag operation).

Shark location at the time of pop-up was determined with an accuracy of <1 km through calculations provided by the Argos Data Collection and Location Service. The reconstruction of the migration pathway between the time of tagging and pop-up was based on sea-surface temperature and ambient light at depth measurements recorded by the PAT, and analyzed with a state-space model (*ukfsst*). The requirement for PAT temperature measurements near the surface limited the availability of geolocation (track reconstruction) estimates during periods when the shark was deep in the water column, such as the majority of the time in the Gulf Stream and Sargasso Sea.

Transmissions were received from 21 pop-up tags applied in the summers between 2001 and 2008 to Porbeagles off the eastern coast of Canada. Males and immature sharks of both sexes remained primarily in cool temperate waters on the continental shelf, and always north of latitude 37°N, for periods of up to 348 days after tagging. In contrast, all mature female Porbeagles exited

Figure 2. A female Porbeagle is lowered into the water after tagging. Note the archival satellite pop-up tag hanging from just above the dorsal fin.

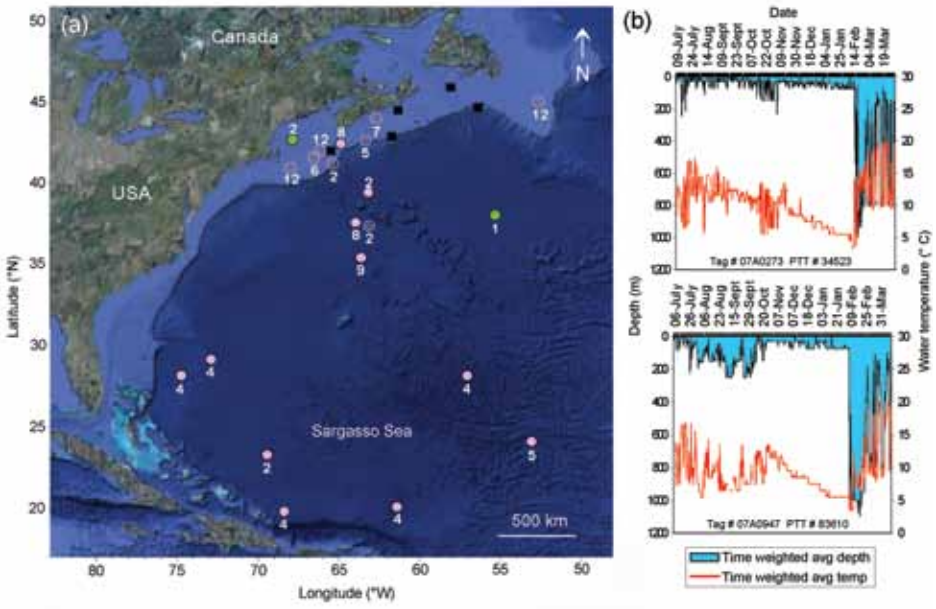


Figure 3. (A) Map shows tagging (■) and pop-up locations for 21 Porbeagles tagged during summer off the eastern coast of Canada. Month of pop-up is indicated by number. Male (●) and immature female (◉) sharks stayed north of latitude 37°N, while all mature females (●) migrated to the Sargasso Sea by April. The Sargasso Sea begins at latitude 35°N. (B) Indicated are depth and temperature of two mature female Porbeagles, representative of other mature females. Geolocation estimates indicate that entry into the Gulf Stream coincided with the abrupt increase in depth and water temperature recorded by the PAT.

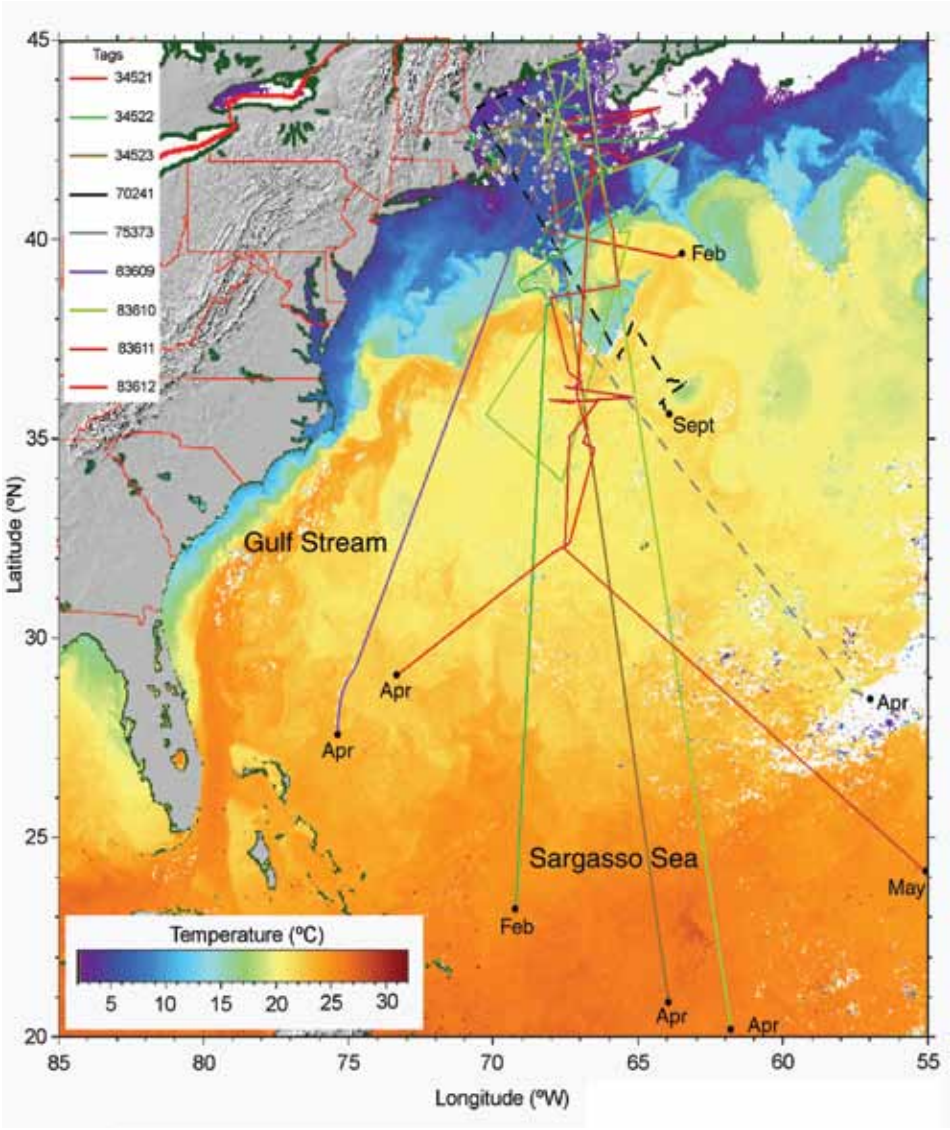


Figure 4. Reconstructed migration pathways of mature female Porbeagles tagged with PATs are overlaid on the SST satellite imagery of March 1, 2009 showing the Gulf Stream and the Sargasso Sea. Solid lines show tracks of sharks entering the Gulf Stream within 2 weeks of March 1, 2009, for which the satellite imagery would be a good match. Dashed lines show tracks of sharks in 2007 and 2008, for which the temperature field would only be approximate. Tag pop-up month is indicated. The map covers the eastern coast of North America, from Nova Scotia to Florida.

the continental shelf by December, swimming distances of up to 2,356 km into the Sargasso Sea (south of latitude 35°N) before the PAT released from the shark (Figure 3A). All seven of the mature females with PATs programmed for a spring release encountered the Gulf Stream between December 22 and March 9 (Figure 4); the date and location of entry into the Gulf Stream was readily distinguished on the PAT record by the abrupt temperature discontinuity and the almost instantaneous initiation of deep-diving behaviour (daily maximum depth of <248 m before entry and a mean of 845 m after entry) (Figure 3B). Entry into the Gulf Stream was also accompanied by a shift from a weakly diurnal diving behaviour (75 m and 10.5°C during night to 129 m and 9.5°C during day) to a strongly diurnal vertical movement (243 m and 18.3°C during night to 614 m and 13.1°C during day). The current flow and the temperature of the Gulf Stream are greatly minimized at depths >400 m, suggesting that the Porbeagles are diving underneath the main flow of the Gulf Stream during their migration, both to maximize their net swimming speed and to minimize their ambient temperature. Although all lamnid sharks are capable of regulating their own temperatures, no Porbeagles were recorded in waters with a six-hour mean temperature >21.9°C, suggesting that the warm surface waters (22-29°C) of the Gulf Stream and Sargasso Sea were uninhabitable for the overwintering females. Porbeagles have not previously been reported south of latitude 37°N, presumably because their mean migratory depth of 489 m is too deep for detection by fishing fleets or other observers. One shark dove to 1,360 m during its migration, which is the deepest recorded by any shark species.

The Sargasso Sea is well known as the spawning area for European and American eels, but has not previously been suggested as a pupping ground for any species of shark. Porbeagle pupping was inferred based on the observation that the southward migration was made by only sexually mature, pregnant females. In addition, the residency period in the Sargasso Sea overlapped the known pupping period of early April to early June. Although pupping has never been observed in a lamnid shark, and thus the pupping environment is unknown, no obvious birthing events were visible in the PAT records; each shark undertook multiple ascents and descents between about 50 and 850 m in waters between about 8 and 23°C (maximum recorded temperature of 25.4°C) during the April-May period. Mean daily depth and temperature during April and May was 480 m and 14.8°C, indicating that most of the pupping period was spent at depth. Porbeagle young-of-the-year are first captured off the eastern coast of Canada in July, suggesting that the Gulf Stream aids in the return transport of the young sharks much as it does squid and other North Atlantic organisms.

Porbeagles are fished commercially, in Canadian and international waters. Although not considered a species at risk, the abundance of the northwest Atlantic population is currently at about 25% of unfished levels, and thus is under strict regulation and cautious management in Canadian waters to promote recovery. Porbeagle mating grounds have been closed to shark fishing to aid in conservation efforts. Although the International Commission for the Conservation of Atlantic Tunas supports Canadian conservation efforts, and has recommended that there be no directed Porbeagle fishery in international waters, high-seas catches of Porbeagles have been reported by numerous countries. The discovery of a key life-history stage in relatively unprotected international waters raises the possibility that stock recovery efforts in Canada and elsewhere could be compromised.

Monitoring Nearshore Benthic Biodiversity: The NaGISA Project

*Melisa C. Wong and Gerhard Pohle**

NaGISA rocky shore site at Boyds Cove, Kejimkujik National Park Seaside Adjunct, NS

NaGISA, a program of the Census of Marine Life (CoML), is an international collaborative effort that monitors coastal biodiversity (www.nagisa.coml.org). As well as being the acronym for Natural Geography In Shore Areas, NaGISA is a Japanese word that refers to the coastal environment. The international program headquarters are in Japan, while regional offices oversee NaGISA activities in the Atlantic Ocean, Caribbean Sea, eastern Pacific Ocean, European seas, Indian Ocean, Polar seas, South American seas, and western Pacific Ocean. Currently, the program is conducted at 245 sites in 28 countries. The office for the Atlantic Ocean region oversees mainly sites in the northwest Atlantic and is located at the Huntsman Marine Science Centre, in St. Andrews, New Brunswick (NB). DFO supports the NaGISA program in its Gulf and Atlantic regions, with participants from BIO, the St. Andrews Biological Station (SABS), and the Gulf Fisheries Centre in Moncton, NB.

The aim of the program is to quantify the biodiversity of benthic flora and fauna in coastal habitats at sites throughout the world. This is the first systematic monitoring of nearshore biodiversity across such a large geographic range and at such fine resolution. Emphasis is on developing long-term datasets that span 10 years or more. Data will provide the baseline for long-term monitoring, and be used to address fundamental questions related to global biodiversity patterns, such as latitudinal trends and biodiversity hot spots. It should also prove suitable for testing numerous ecological theories and practical problems.

NaGISA focuses on quantifying benthic biodiversity in two specific nearshore habitats: seagrass beds and rocky shores. These habitats were chosen because of their global distribution and relatively poor state of knowledge and because they are extremely important components of coastal marine ecosystems. Rocky shores and seagrass beds provide essential ecosystem functions and services, such as support of food webs through high productivity and habitat struc-

*Huntsman Marine Science Centre, St. Andrews, NB

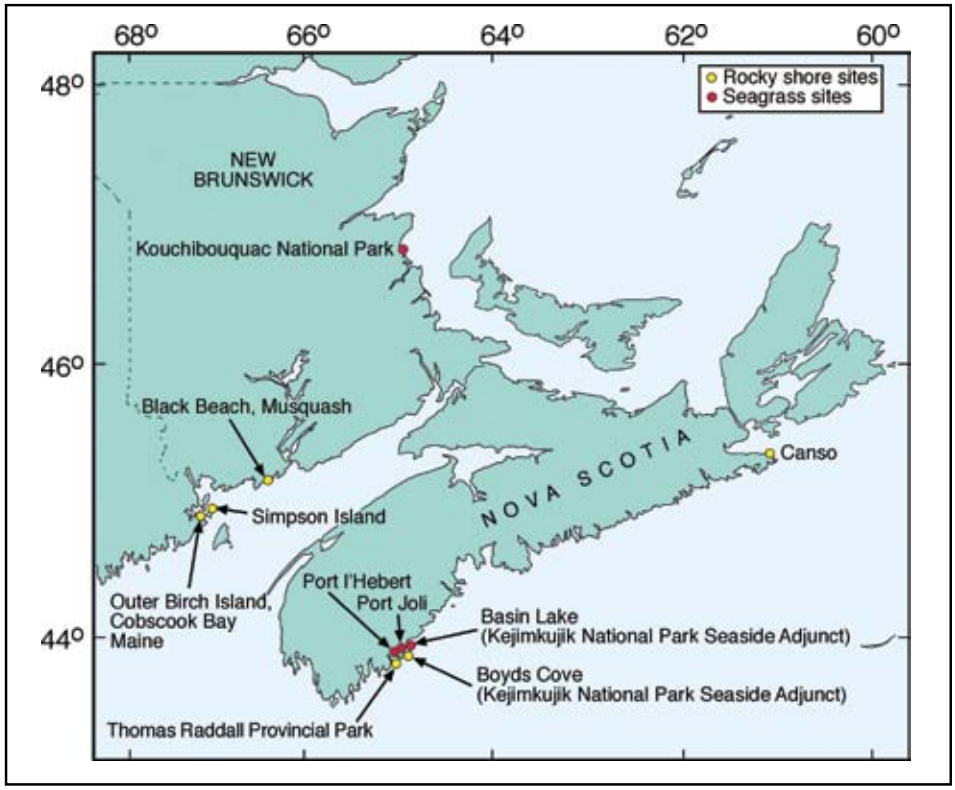
ture, preservation of biodiversity, buffering of coastlines against storm-wave damage, provision of nursery and feeding habitats, and socio-economic benefits. Because of their coastal location, these habitats are particularly vulnerable to anthropogenic[1] and natural stressors, including eutrophication[2], rising sea level, increased storm frequency, and habitat loss. Benthic assemblages are important stress indicators, because benthic fauna are relatively immobile and unable to avoid disturbances. Monitoring by NaGISA in seagrass beds and on rocky shores will be particularly useful in understanding patterns of long-term change related to disturbance.

The NaGISA program is unique in its emphasis on linking the Census of Marine Life's goal of assessing the diversity of life in the ocean to local interests, encouraging international cooperation, and increasing coastal monitoring and research. Many NaGISA sites have allowed for cross-border partnerships through collaborations among government, academia, community groups, and other stakeholders. One such partnership in the Atlantic Ocean region is the collaboration between the Atlantic Ocean office and Suffolk University in Boston. In several regions, NaGISA activities compliment other research initiatives related to biodiversity and coastal ecology research. The information generated by NaGISA will be useful in answering a wide variety of ecological questions.

NaGISA in the Atlantic Ocean Region

The NaGISA program began in 2002, with project teams joining between 2002 and 2008. In 2007, the first NaGISA sites in the Atlantic Ocean region were established by Gerhard Pohle and Lou Van Guelpen through the Huntsman Marine Science Centre. Additional DFO involvement began in 2008, led by Melisa Wong and Angelica Silva at BIO, and Simon Courtenay and Marie-Helene Theriault at the Gulf Fisheries Centre, in collaboration with Peter Lawton at SABS, a DFO laboratory.

Determining sites suitable for long-term monitoring was a challenge. To ensure comparability across all sites, NaGISA aims to monitor relatively pristine areas that are representative of natural biodiversity. Areas near coastal development, high in nutrient enrichment, or susceptible to algae or invertebrate harvesting were avoided. Logistical



Map shows NaGISA sites in the Atlantic Ocean region. Sites outside Passamaquoddy Bay, NB, at Cobscook Bay, Maine, and Simpson and Outer Birch islands are maintained by Gerhard Pohle and Lou Van Guelpen of the Huntsman Marine Science Centre and Tom Trott of Suffolk University in collaboration with Peter Lawton of SABS. Sites at Kouchibouquac National Park and Musquash, NB, are maintained by Simon Courtenay and Marie-Helene Theriault of the Gulf Fisheries Centre. Sites on the Atlantic coast of NS are maintained by Melisa Wong and Angelica Silva of BIO.

NaGISA seagrass site at the Migratory Bird Sanctuary, Port l'Hebert, NS

[1] Derived from human activities

[2] Process when bodies of water are so nutrient-rich that plant life (e.g., algae) proliferates to the point of causing the extinction of other organisms

concerns, such as long-term accessibility and distance from the institutes, were also taken into account. Consideration of these factors resulted in many sites in the Maritimes being established in migratory bird sanctuaries, provincial and national parks, and on islands. The sites in the Atlantic Ocean region range from Northern Nova Scotia to Cobscook Bay, Maine. While most sites in the Atlantic Ocean region are in the northwest Atlantic, the regional office has also established NaGISA sites in Senegal, West Africa, through collaboration with Thomas Trott of Suffolk University.

The NaGISA sites established by Melisa Wong and Angelica Silva of BIO are located on the Atlantic coast of Nova Scotia (NS). This will be the first documented systematic monitoring of nearshore biodiversity in this region. Rocky shores monitored are in Canso, Thomas Raddall Provincial Park, and Kejimkujik National Park Seaside Adjunct. Seagrass sites are all located on the south shore of NS: in Port Joli, Port l'Hebert, and Basin Lake in the Kejimkujik Seaside Adjunct.

Most of these sites are sampled in the late summer. Standardized sampling protocols ensure comparability of data across all regions. The protocols are purposely kept simple and of low cost for easy implementation in developing countries and for accessibility to a wide range of collaborators. In keeping with the spirit of the program, most NaGISA field teams in the Atlantic Ocean region incorporate students, community groups, and volunteers to their teams.

The field work at rocky shores encompasses quadrat and transect sampling in different intertidal and subtidal zones. In the field, percent cover of seaweed species is recorded. Seaweeds and fauna are then collected and taken to the laboratory for species identification, and determination of density and biomass. At seagrass sites, quadrat sampling is used to determine percent cover of seagrass species. Replicate sediment cores are taken and later sorted in the laboratory for seagrass and faunal species. These are identified to the lowest taxonomic resolution possible, and species density and biomass determined. At most NaGISA sites, measurements are made of physical parameters, such as water temperature, salinity, chlorophyll a concentration, and wave exposure.

NaGISA rocky shore field work at Simpsons Island, NB

Data from each NaGISA site will provide estimates of species diversity, richness, density or percent cover, and biomass. Because the first phase of the CoML is ending in 2010, project members have submitted data from 2008 and prior to the NaGISA program. Analyses of biodiversity and species density and biomass across geographic gradients are being conducted by different NaGISA project members according to expertise. The analyses are broken down into major taxonomic groups, including polychaetes, molluscs, decapod crustaceans, echinoderms, macroalgae, and seagrasses. Seagrass infaunal samples are taking longer to sort and identify than anticipated, but when data become available, Melisa Wong (BIO) will provide the analyses and interpretation. All data submitted to NaGISA are incorporated into the Census' Ocean Biogeography Information System (OBIS), an online global atlas of ocean biodiversity (www.iobis.org). NaGISA species' locality data are publicly available as a NaGISA dataset within OBIS.

Many participants of the NaGISA program have extended their research beyond the general mandate of the program. In some cases, the NaGISA sampling has been incorporated into pre-existing coastal marine research programs. For example, Melisa Wong will incorporate NaGISA data into food network models for coastal marine ecosystems and into her seagrass ecology research. Several program members also

Using a sediment corer to sample seagrass and associated invertebrates at Kouchibouquac National Park, NB

Identifying seaweed species in the laboratory

Seagrass (*Zostera marina*) at the NaGISA seagrass site in the Migratory Bird Sanctuary at Port Joli, NS

participate in a subprogram of NaGISA called *History of the Near Shore*, led by Tom Trott of Suffolk University. This NaGISA initiative aims to assess historical records of biodiversity from one Pacific and four Atlantic sites, resample these sites using the NaGISA protocols, and conduct a comparative meta-analysis. Other interesting research projects developed from the NaGISA program include an evaluation of the efficacy of NaGISA protocols compared to other sampling methods, led by Remy Rochette of the University of New Brunswick.

As the first phase of the CoML ends, there is much interest in maintaining the NaGISA program past the original end date of 2010. A CoML committee has been active in developing plans beyond 2010 and discussions of the way forward continue among program participants. While the program focus may change to examine processes and mechanisms underlying observed biodiversity patterns, NaGISA likely will continue for many years to come. Participation in the NaGISA program by DFO Science will have several significant outcomes. Long-term datasets of nearshore benthic biodiversity will be developed and will be among the first in the Atlantic Ocean region. Data will provide information on long-term changes in biodiversity patterns, and enhance many aspects of research in coastal marine systems. Fundamental ecological issues will be addressed, and contribute to the management and conservation of nearshore marine habitats. We look forward to our continued involvement with the NaGISA program, and to its further development and increased scope of research.

BIO's Marine Water Quality Monitoring Laboratory Achieves ISO Accreditation

Christopher Craig

Patti Densmore, Quality Assurance Officer and laboratory manager, tests water quality in the ISO-accredited lab at BIO.

Water quality monitoring has been a core program function of Environment Canada (EC) since the Department's inception in the early 1970s. Most of the Department's activities in this area have focused on the assessment and reporting of environmental monitoring trends to fulfill various federal and international legislative obligations. Environment Canada's Marine Water Quality Monitoring (MWQM) program has had a presence at BIO since 1972. The primary role of the MWQM program is to support EC's mandate under the Canadian Shellfish Sanitation Program. This federal program is delivered jointly by EC, the Canadian Food Inspection Agency, and DFO. The major objective is to protect the public from the consumption of contaminated shellfish by ensuring that bivalve shellfish (oysters, clams, mussels, and scallops) are harvested from waters of acceptable environmental and sanitary quality.

Environment Canada's MWQM laboratory at BIO, recently relocated to the third floor of the new Katherine Ellis Laboratory, performs fecal coliform analysis on marine water samples taken during sanitary and water-quality surveys and provides these results to EC biologists who assess the environmental suitability of classified shellfish-growing areas. This laboratory recently obtained ISO/IEC 17025:2005 laboratory accreditation, an internationally recognized standard against which a laboratory's technical competency is assessed using criteria and procedures specifically designed to ensure laboratories consistently produce reliable and accurate results. The standard covers every aspect of laboratory management from sample preparation and analytical proficiency to record-keeping and reporting of data. ISO/IEC 17025:2005 focuses on the laboratory's Quality Management System and its elements including document control, non-conformances, corrective/preventative actions, equipment, traceability, and measurement of uncertainty.

ISO accreditation is a very challenging standard to achieve and maintain. It does, however, provide international recognition that an accredited laboratory has consistently demonstrated competency

David MacArthur, a biologist in the Marine Water Quality Monitoring program, takes a marine water sample.

and is managed by qualified personnel who have implemented a rigorous quality-control system and can produce reliable, accurate results. The implementation of ISO/IEC 17025:2005 challenges Quality Management Systems laboratory personnel to continually improve their quality and technical competency.

The staff and management of Environment Canada's Marine Water Quality Monitoring program are very proud of their long and continued association with BIO.

Natural Rates of Sediment Containment of PAH, PCB, and Metal Inventories in Sydney Harbour, Nova Scotia

Richard Nelson, Grazyna Folwarczna, Susan Cobanli, Kenneth Lee, and John N. Smith

Sydney Harbour, Nova Scotia, like many urban marine inlets, has long been used as a waste disposal area. In particular, it has been subject to atmospheric and effluent inputs of contaminants, including metals and polycyclic aromatic hydrocarbons (PAHs), from the Sydney steel plant and coke ovens (Figure 1) since 1899. A fraction of coal tar residues discharged from the coking ovens into Coke Ovens Brook, that settled in the tar ponds, subsequently reached the estuary of Sydney Harbour. Since many PAHs and metals are preferentially absorbed onto particles, these contaminants accumulated in the sediments of the estuary.

The tar pond that drains into Muggah Creek is a repository for approximately 3,500 tonnes of PAHs as coal tar, 3.6 tonnes of PCBs (derived from the use of electrical equipment in the steel plant), and heavy metals. Within the estuary, the highest PAH concentrations have been reported for the South Arm, with concentrations decreasing towards the outer harbour. Remediation of the tar ponds using *in situ* stabilization techniques is presently underway, but environmental issues regarding the large contaminant inventories in the sediments remain unresolved. One major issue is the extent to which highly contaminated sediments deposited during periods of peak industrial activities in the past are undergoing natural containment by the present deposition of cleaner sediments. If natural containment is sufficiently rapid and effective, then it may not be necessary to undertake large investments in capital and resources to clean harbour sediments. To provide advice on this issue, a DFO project was initiated to use radionuclide tracers to determine the time scales for the historical accumulation of contaminants in the sediments of Sydney Harbour and to predict future harbour remediation rates through burial by fresh, cleaner sediments.

SEDIMENT TIME HISTORIES

Sediment cores were collected at 38 locations indicated in Figure 1 and analyzed for radionuclides, metals, and organic contaminants. Sedimentation rates and geochronologies were determined from sediment-depth distribution of the radioactive isotopes lead-210 (^{210}Pb) and Cesium-137 (^{137}Cs), and metal and organic contami-

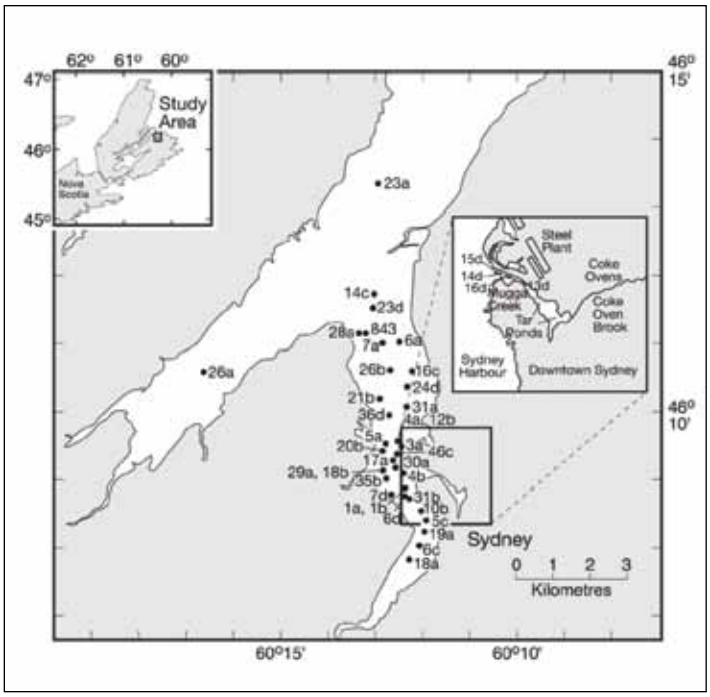


Figure 1. Steel mill and coking plants discharged wastes into the South Arm of Sydney Harbour via Coke Oven Brook, the tar ponds, and Muggah Creek. Sediment cores were collected at stations in Sydney Harbour and Muggah Creek.

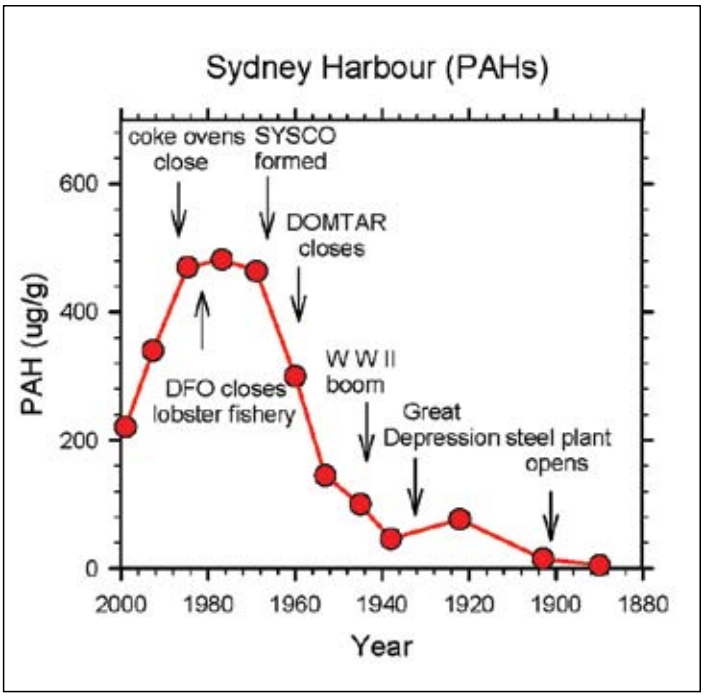


Figure 2. The history of PAH concentrations in a sediment core from Sydney Harbour shows presently declining levels owing to the natural burial of older sediments by less contaminated material.

nant concentrations were plotted versus the date at which they were deposited. The PAH distributions (Figure 2) in a typical core (Figure 1:1a) from the harbour show initially elevated levels in 1900 synchronous with the construction of the DISCO steel plant, which went into production in 1901 fuelled by coke produced in the adjoining coke ovens from the poor-quality Cape Breton coal. Steel production slowed during the Great Depression of the 1930s, but then increased rapidly during the economic boom following World War II, resulting in related changes in PAH sediment concentrations. Closure of the DOMTAR coal tar refining plant in 1962 and the formation of SYSCO in 1968 by the provincial government led to additional discharges of PAHs. Following the 1980 closure of the lobster fishery in the South Arm due to the measurement of elevated PAH concentrations within digestive glands, the coke ovens were shut down in 1988 and SYSCO changed to an electric arc manufacturing process in 1990. Sediments deposited since 1988 have contained reduced levels of PAHs leading to a continual decline in the overall PAH concentrations in the sediments. (SYSCO was closed in 2000.)

HISTORICAL CONTAMINANT MAPS

The spatial history of PAH contamination of Sydney Harbour can be illuminated by the construction of surface PAH concentration maps as shown in Figure 3. These maps clearly illustrate the periods when PAH concentrations in specific regions of the harbour exceeded environmental quality guidelines. For example, the National Oceanographic and Atmospheric Administration's (NOAA) *effects range-low* (ER-L) corresponds to background concentrations below which the presence of contaminants has little chronic or acute effect on benthic organisms and the *effects range-medium* (ER-M) corresponds to levels above which organisms are very likely to be negatively affected by the presence of a contaminant. The ER-L and ER-M for PAHs (4.02 and 44.8 µg/g, [micrograms per gram] respectively) correspond to the blue and yellow contours, respectively, in Figure 3. It can be seen that by 1960, PAH concentrations exceeded the ER-M (yellow contour) in most cores from Sydney Harbour. The recent decline in PAH observed at most locations can also be extrapolated into the future using a simple particle-transport model combined with ^{210}Pb sedimentation rates. Results show that by 2020, PAH concentrations will have been reduced below the ER-M at all locations in Sydney Harbour except Muggah Creek and the South Arm by the simple burial of surface sediments by fresher uncontaminated material.

FUTURE CONTAMINATION OF SYDNEY HARBOUR

Clearly, Sydney Harbour contaminant inventories are undergoing natural containment by the continuous deposition of less contaminated sediments. In the regions closest to Muggah Creek, where sedimentation rates tend to be the highest, the contaminant inventories are presently separated from the sediment surface by about 5-15 cm of less contaminated sediments and, in some cores, the maximum PCB and PAH levels occur at depths of >50 cm. Using the above modeling approach, maps have been constructed showing the year that surface sediment concentrations will fall below the sediment quality criteria (Figure 4). For example, the cyan portion of each

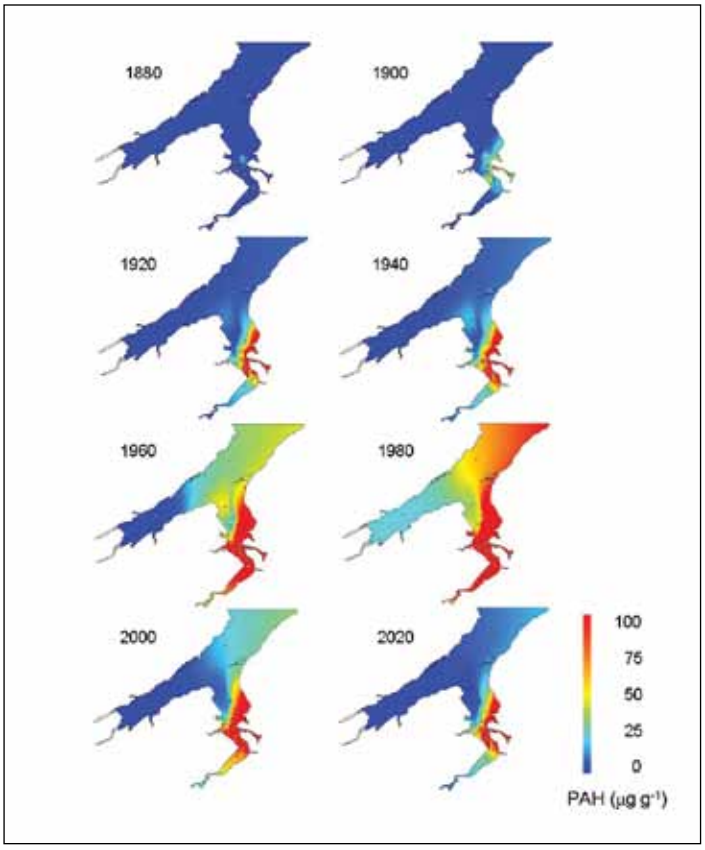


Figure 3. Reconstruction of historical PAH surface concentration maps is based on PAH sediment geochronology, and extrapolation of PAH concentrations to 2020 was estimated using a particle-transport model.

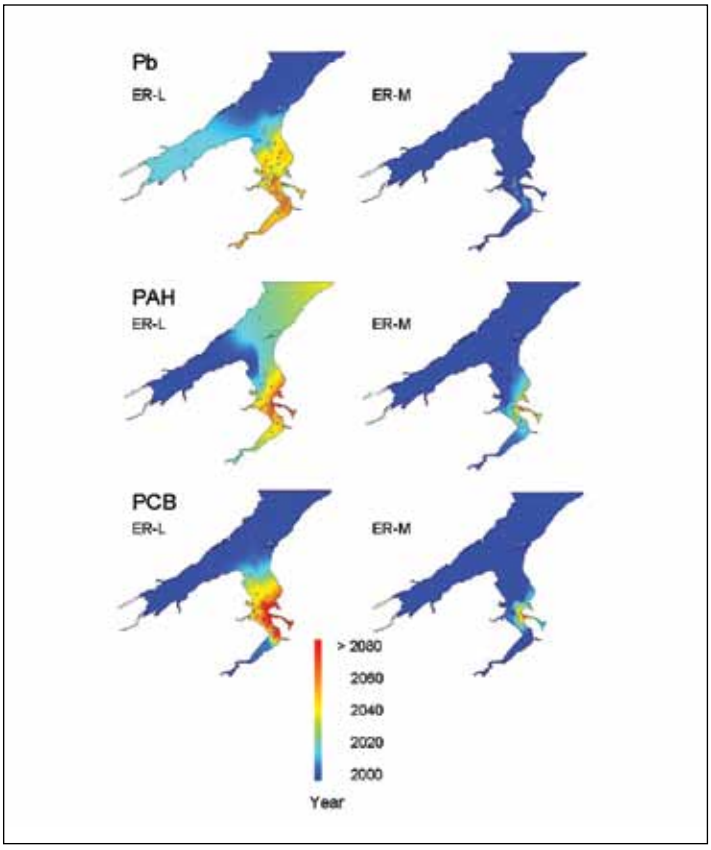


Figure 4. Maps of year in which Pb (top), PAH (middle), and PCB (bottom) concentrations in surface sediments will decrease below the effects ranges, ER-L and ER-M

map indicates a region of the harbour in which the contaminant level will fall below either the ER-L (left) or the ER-M (right) by about the year 2020, as indicated in the colour legend at the bottom of Figure 4. These maps show that Pb levels throughout the entire harbour will have fallen below their ER-M (212 µg/g) and ER-L (46.7 µg/g) by 2020 and 2050, respectively.

PAH concentrations will fall below the ER-M (44.8 µg/g) in the central region of the harbour by 2030, but will continue to remain above the ER-M in Muggah Creek until 2060. PAH levels will only decline below the ER-L (4.02 µg/g) in the central part of the harbour by 2060 and will remain above the ER-L in Muggah Creek until 2090. PCB levels (Figure 4: bottom) also will fall below the ER-M (0.18 µg/g) in the central parts of the harbour and in Muggah Creek by about 2030 and 2060, respectively. These results suggest that Pb contamination of Sydney Harbour sediments does not represent a long-term threat and that natural containment will reduce Pb levels below those predicted to have a significant impact on organisms during the next 10-20 years. PAH and PCB levels will have declined below the ER-M by about 2030 in almost all parts of the harbour. The sole exception is Muggah Creek where PAH and PCB levels will remain above the ER-M until 2060 and therefore represent a long-term, toxic threat to organisms in the absence of direct remediation.

Regional development and anthropogenic remediation issues should be considered in the context of these results. Future dredging of harbour sediments intended to accommodate larger vessels must be evaluated in the context of the magnitude of contaminant resuspension and enhanced bioavailability that will invariably result from this type of operation. Present remediation activities in the tar ponds may also result in future releases of PCBs and PAHs that could contaminate the layer of cleaner surficial sediments that has presently capped the main inventory of contaminants deposited during the 1960s-1980s. One additional caveat is that as the harbour sediments become less contaminated, they may attract a larger and more diverse benthic community similar to that found in the less contaminated, outer reaches of Sydney Harbour. Bioturbation by these infauna could enhance the microbial degradation rates of organic contaminants and return contaminated sediments more efficiently to the sediment surface, thereby altering model predictions. However, the net effect of sediment capping by the deposition of cleaner sediments will be predominantly positive.

Large-scale Ocean Modelling for Operational and Climate Applications

Youyu Lu, Dan Wright, Frederic Dupont, Zeliang Wang, Michael Dunphy, Charles Hannah, and Brenda Topliss

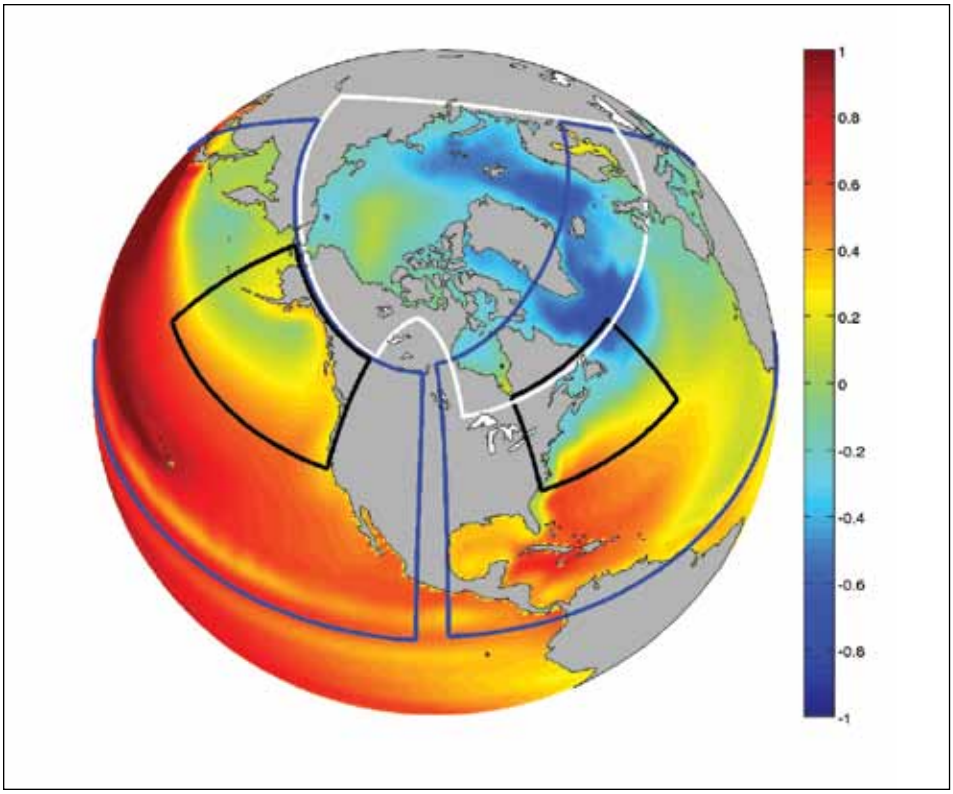


Figure 1. Schematic of the NEMO modelling system: the boxes denote the domains of basin- and regional-scale models. The colour shading shows the distribution of the long-term mean ocean dynamic height (in metres) simulated by the coarse-resolution global model.

Oceans play a pivotal role in weather and climate. Understanding and forecasting ocean variability have important applications, such as improving management of fisheries and environment, optimizing search-and-rescue operations, and developing effective strategies for adapting to climate change. The relevant changes in ocean state (current, temperature, salt, contaminates, carbon dioxide, oxygen, etc.) occur at spatial scales from centimetres to thousands of kilometres and time scales from seconds to thousands of years. Numerical ocean models are now able to simulate many realistic aspects of these changes, thanks to rapid advancements in computing technology and modelling techniques.

During the past decade, deep-ocean modelling research at BIO has made substantial progress in numerous areas. Over the years, we have developed close collaboration with DFO colleagues working on modelling the offshore shelf and inshore regions and with researchers at Dalhousie University interested in assimilating data into realistic models. Recently, the work has benefited from the coordination and

support of DFO's Centre of Excellence COMDA (Centre for Ocean Model Development for Applications), the inter-departmental program CONCEPTS (Canadian Operational Network of Coupled Environmental PredicTion Systems), and the university-based research network GOAPP (Global Ocean-Atmosphere Prediction and Predictability). Partnerships have been developed with other centres at DFO, Environment Canada, universities, and Mercator Operational Oceanography in France. The work focuses on developing a system of ocean models based on a state-of-the-art modelling framework called NEMO (Nucleus for European Modelling of the Ocean). Some key issues that can be addressed using this system (schematically shown in Figure 1) are briefly described below.

GLOBAL COUPLED OCEAN-ATMOSPHERE WEATHER FORECASTING

Global coupled ocean-atmosphere weather forecasting, a core project of CONCEPTS, aims to add an active ocean component to the sophisticated numerical weather forecasting system running operationally at Environment Canada's Canadian Meteorological Centre. The coupled system, when established, not only will allow for operational forecasts of ocean state, but also will improve the accuracy of weather forecasts, as demonstrated by pilot studies. A fine-resolution (1/4°) global ocean and sea-ice model has been developed for this purpose. The model is able to represent the strong and highly variable currents in the ocean, including the Gulf Stream, Kuroshio off Japan, the equatorial currents, and the Antarctic Circumpolar Current (Figure 2). Much work focuses on improving the simulation accuracy through the use of ocean observations, such as from satellites, floats, and moorings, in conjunction with ocean models. The associated mathematical techniques, referred to as data assimilation, are being developed by partners in the GOAPP and CONCEPTS projects.

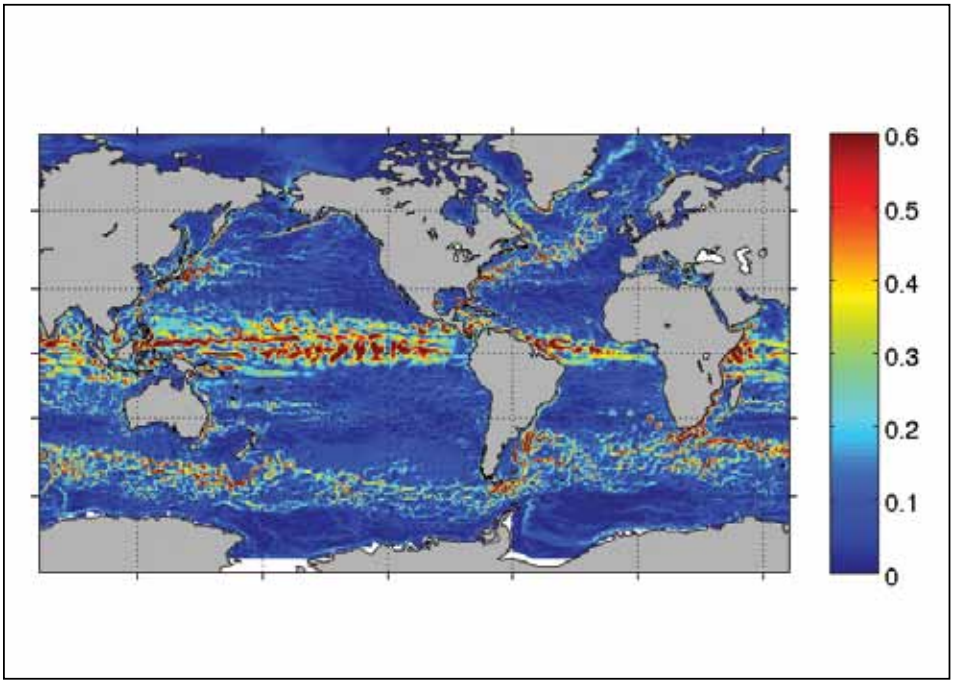


Figure 2. A snapshot of the solution of the fine-resolution global model: colour shading denotes the magnitude of the velocity of the ocean current (in m s^{-1}) at 10-m depth below the ocean surface.

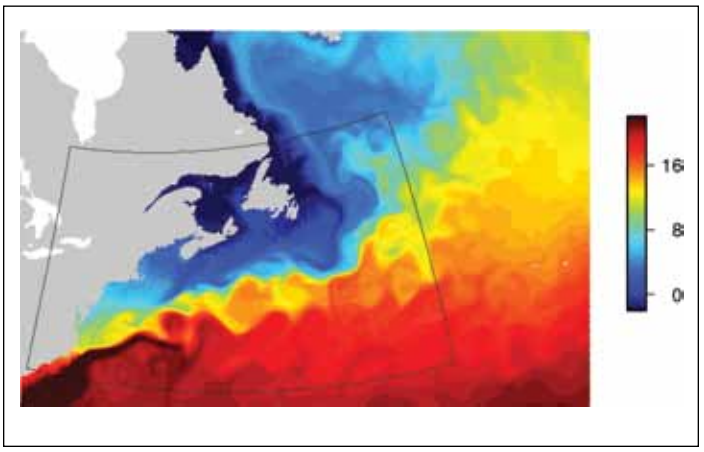


Figure 3. A snapshot of the simulated sea surface temperature (in °C) in the Gulf Stream region: the box represents the boundary of a high-resolution sub-model embedded in the fine-resolution North Atlantic model.

NORTH ATLANTIC MARINE ENVIRONMENTAL CHANGES

BIO maintains observation programs in the North Atlantic to routinely monitor the health of the environment and improve the safety of marine operations, including transportation and offshore oil-and-gas exploration and production. To help fulfill these requirements, models capable of representing details of oceanic variability are needed. For example, in the western North Atlantic the ocean currents are constantly distorted by meso-scale eddies, with typical sizes of tens of kilometres. Because high-resolution models are very computationally demanding, a nesting technique is adopted which allows for the inclusion of regions of enhanced resolution within large-scale models. Figure 3 shows a snapshot of the surface ocean temperature simulated by a high-resolution (1/12°) sub-domain of the Gulf Stream region nested in a 1/4° North Atlantic model. Comparison with satellite remote-sensing data indicates that the statistics of the meso-scale eddies in this region are well represented by the model. In addition to applications involving the space and time scales associated with ocean and atmospheric weather variability, the model is also used to investigate the influence of eddies on slow ocean-climate changes.

ARCTIC OCEAN AND SEA-ICE CHANGES

The Arctic Ocean is becoming a focal point for research because of rapid changes in its environment and increasing industrial activities in this region. To better understand and forecast changes in the Arctic, models dedicated to simulating changes in the whole Arctic with special attention to the coastal waters of the Canadian Arctic are being developed. The pan-Arctic model has a horizontal resolution of 18 km. Figure 4 shows the distribution of thickness and the drift velocity of sea-ice under typical

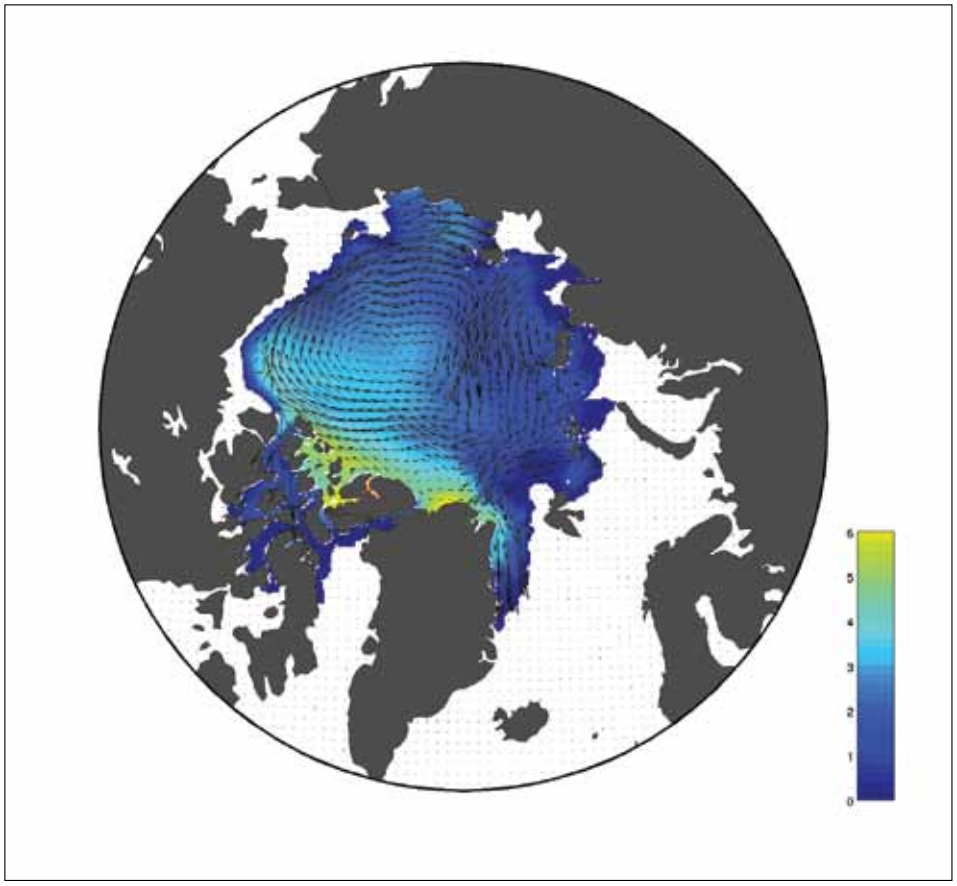


Figure 4. The thickness (colour shading, in metres) and drifting velocity (arrows) of sea-ice in typical summer conditions, simulated by the fine-resolution Arctic model

summer conditions. Model simulations covering multiple decades, forced by realistic atmospheric conditions, are being used to improve understanding of the causes and impacts of the recent changes in sea-ice conditions observed in the Arctic. An embedded high-resolution (4.5-km) sub-model improves the representation of the complicated geometry of the Canadian Arctic Archipelago. DFO maintains a long-term monitoring program in the main passages through the Canadian Arctic Archipelago and the model solutions will be helpful for interpreting the observations and for predicting future changes in this key area.

THE OCEAN'S ROLE IN CLIMATE CHANGE

To study the ocean's role in long-term climate changes, a coarse-resolution (1°) global ocean model has been developed. On the high-performance computers currently available to us, this model can be integrated over a decade in just a few days. While lacking the capability of high-resolution models to describe small-scale structures, the model exhibits considerable skill in simulating large-scale oceanic variations, as confirmed by comparisons with observations of sea-level, hydrographic, and sea-ice variations. The model has been used to study the forcing mechanisms of ocean variations at intra-seasonal, seasonal, inter-annual, and decadal time scales. Figure 5 shows the model-simulated global sea-level trend during 1993-2004, which agrees well with satellite altimeter observations.

The model system and technology described above have a wide range of extended applications. For example, we are conducting a reanalysis of North Atlantic variations during the past decade using the data assimilation technology developed in the GOAPP project. There also are plans for the development of seasonal ocean forecasting products using this model system and Environment Canada's atmospheric forecasting system. The possibility of forecasting ocean temperature distributions with lead times of a few months has significant implications for ecosystem and fisheries management at DFO. Another important area of application is the downscaling of regional climate simulations which require the coupling of atmospheric regional climate models to realistic ocean models.

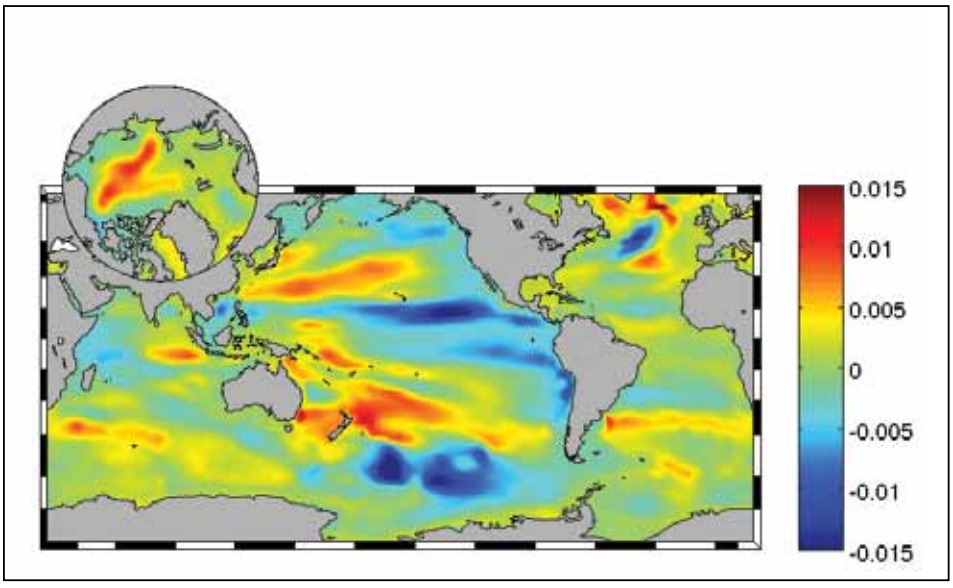


Figure 5. Global sea-level trend during 1993-2004 simulated by the coarse-resolution model: colour shading is in metres per year. Positive and negative numbers denote the rising and falling trends, respectively. Note: a net global averaged sea-level rise, estimated to be 2.8 millimetres per year, is not included in the model solution.

Deep-ocean modelling studies at BIO have benefited greatly from the computing facilities at the Atlantic Computational Excellence Network (ACEnet), at Environment Canada, and at Dalhousie University. The recent purchase of a high-performance computing system by DFO will further enhance this important research and development activity at BIO.

The Laser Tide Gauge: The Canadian Hydrographic Service Atlantic's New GLOSS Water Level System

Phillip MacAulay, Christopher Coolen, and Frederick Carmichael

Tide gauges, some of which have been in place for centuries, are among the world's oldest scientific instruments. Historically, because of the potential naval advantage to be gained from foreknowledge of the height of the tide, tide gauge data and the tidal predictions that can be made from the data have often been closely guarded military secrets. Nowadays, tide gauge data, predictions, and even the prediction tools themselves are freely available on the internet. For example, for access to Canadian tide gauge data: (www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/twl-mne/index-eng.html); for predictions: (www.waterlevels.gc.ca); and for prediction tools: (www.mar.dfompo.gc.ca/science/ocean/coastal_hydrodynamics/WebTide/webtide.html).

Tide gauge instruments may seem old school but the data they continue to provide serve a range of traditional marine and navigational interests as well as a growing number of modern applications. For example, tide gauge data are used by hydrographic organizations like the Canadian Hydrographic Service (CHS) to determine important water level references such as mean water level, tidal range, and chart datum (chart datum is the zero reference used on nautical charts). As important, the CHS uses tide gauge data to remove the influence of the tides from newly collected multi-beam bathymetric sounding data. This new bathymetric data is then used to improve the CHS's suite of nautical charts and associated publications, as part of the CHS's ongoing efforts to ensure safe and navigable Canadian waterways: (www.charts.gc.ca/index-eng.asp).

The historic sea-level rise trends (www.ipcc.ch/publications_and_data/ar4/wg1/en/ch5s5-5-2.html) used as indicators of the effects of global climate change come from analysis of tide gauge data. The International Global Sea Level Observing System (GLOSS): (http://www.gloss-sealevel.org) was organized to coordinate the continued collection and analysis of these data sets. Even the cutting-edge methods for estimation of global sea-level rise based on satellite altimetry depend upon the data from tide gauges with co-located Global Positioning Systems (GPS) for calibration. (http://ibis.grdl.noaa.gov/SAT/SeaLevelRise/LSA_SLR_calibration.php).

The data from tide gauges now also serve emergency measures warning systems. For example, access to tide gauge data in real time allows organizations like Environment Canada's Atlantic Storm Prediction Center (ASPC) (www.atl.ec.gc.ca/weather/aspc.html) and the Alaska Tsunami Warning Center (ATWC) (http://wcatwc.arh.noaa.gov) to monitor water levels during storm-surge and tsunami events.

As a final example, tide gauge data provide the link between the bathymetry of the nautical charting world and the topography of topographical mapping world and are used for effective definition of land-sea boundaries, and in the development of coastal flooding models. Thus, while tide gauges as instruments may seem mundane, the importance of their data and the need to improve its reliability, precision, and accuracy motivate continued efforts to improve tide gauge design.

In Canada, the CHS is responsible for design, maintenance, and operation of Canada's tide gauge networks. As part of a National initiative, CHS Atlantic at BIO has been conducting a program to improve the Atlantic tide gauge network's capabilities, its infrastructure and, ultimately, the quality of its data. One element of these efforts is the Laser Tide Gauge.

The Laser Tide Gauge consists of three independent water level sensors, one of which uses a ranging laser, all packaged in a single insulated, heated, multi-well stilling well system. The reason for using three sensors, each in its own independent stilling well, is to ensure data reliability. Two sensors are necessary for redundancy since tide gauges are often located in remote locations. The third is present principally to adjudicate disagreements between sensors so that if and when problems develop one can reliably tell which sensor is faulty.

A stilling well is a long tube with a small entrance or orifice at

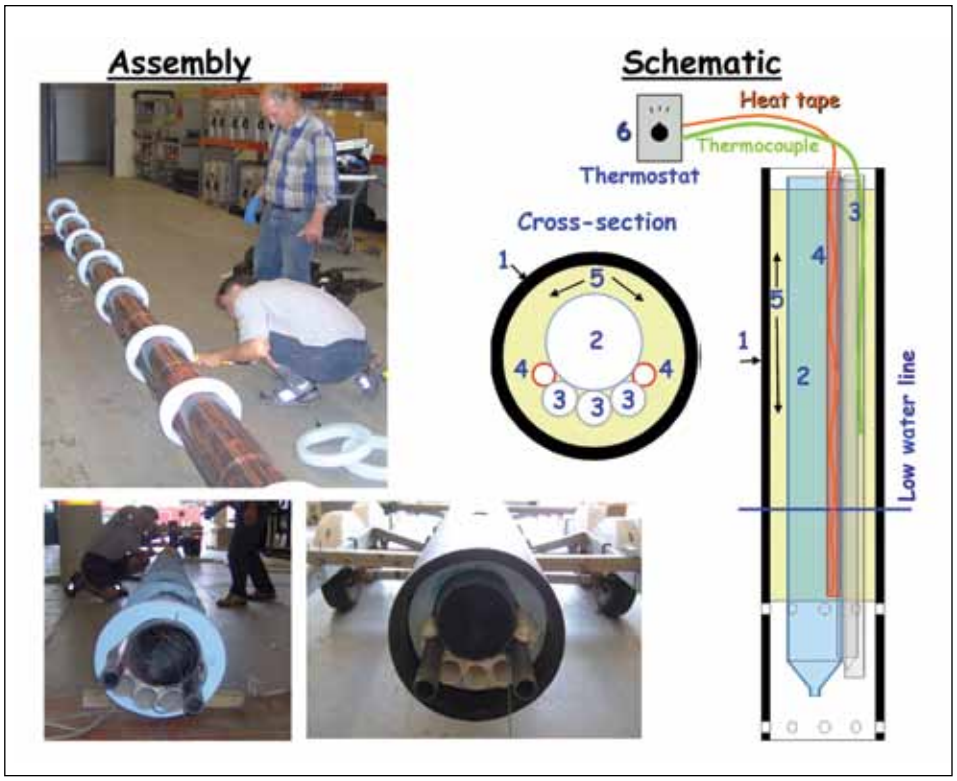


Figure 1. The insulated, heated, multi-well tide gauge system: see text for the explanation.

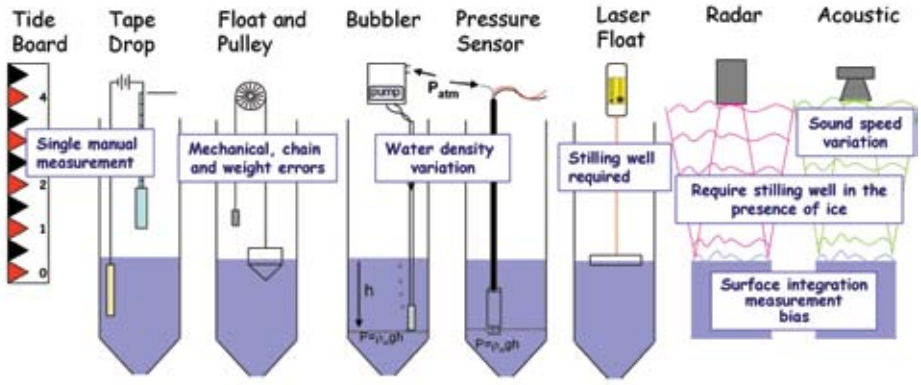


Figure 2. Water level sensor options

the bottom. It has two purposes: it protects the water level sensor, and it acts as a mechanical filter, damping out high-frequency water level fluctuations that might otherwise overly disturb sensitive instrumentation. The ratio between the well and orifice diameter determines the degree of damping. Stilling wells introduce their own maintenance and data quality issues. For example, they can plug up and the density structure of the water column inside the stilling well can, at times, differ from that outside the well, which can lead to small disparities between water levels inside and outside the well. However, these limitations must be weighed against those of the sensors to be used (Figure 2) and of the environment in which they will be deployed (Figure 3).

The significance of the insulated, heated, multi-well stilling well (Figure 1, Assembly) is that it has been designed and constructed at BIO to better and more cost-effectively survive Atlantic Canada's sometimes harsh winters and the sub-Arctic winter conditions of Northern Labrador. It consists of four independent stilling wells, a 6-inch-diameter centre well for the laser sensor (Figure 1, Schematic, items 2), and three smaller 2.5-inch-diameter wells (items 3) for the other sensors (Figure 2), in this case, a tape drop for initial quality control, a bubbler for redundancy, and a pressure sensor installed in a more lightly stilled well for redundancy and ongoing quality control, and to act as a fast-response sensor for tsunami warning purposes. The wells are bundled together with two smaller heating tubes (items 4), and the entire bundle is installed as a unit inside a thick, tough, polyethylene outer casing (items 1). After initial assembly, the interstitial space between the outer casing and the inner well bundle is injected with marine-grade polyurethane insulating foam (items 5).

The two heater tubes house low-wattage, self-regulating heat tapes with thermostatic control (items 6) and once the well is installed these tubes are filled with environmentally friendly anti-freeze to provide a good thermal link between the heat tapes and the heater tubes along their full length. This configuration provides for even heating along the full length of the well. Using this system, well temperatures are maintained at between 4° and 6° C, even when external air temperatures outside the well drop below -40° C.

The ideal water level sensor is one that is simple, accurate, precise, always reliable, and inexpensive to construct, deploy, and maintain. No sensor fully meets all criteria. For example, while the traditional float-and-pulley sensor has been widely used and is fairly inexpensive and theoretically simple, it requires a stilling well, is prone to several modes of mechanical failure, and without special measures cannot generally be expected to be accurate to better than 1-2 cm.

Bubbler and pressure sensors are potentially reliable and do not necessarily require stilling wells; however, they do not make direct measurements of water level. Instead, both rely on foreknowledge of water density and the relationship that pressure at the depth of the sensor is dependent on the height of water above the sensor, and on the water's density and its vertical structure, both of which in regions like Atlantic Canada can change appreciably throughout the year. For this reason, without either repeated recalibration, or additional sensors used to measure water density, both sensors can be inaccurate by up to 3 to 5 cm depending on tidal range.

Radar and acoustic sensors determine water level by either measuring the time it takes for the radar or acoustic waves to travel from the sensor to the water's surface and back, or by comparing the phase between outgoing and reflected waves at the sensor. Both methods rely on knowing the speed of the waves through the air. While this speed is nearly constant for radar waves, the speed of acoustic waves is somewhat more sensitive to temperature and humidity and without special measures acoustic sensors can be inaccurate by up to 3 to 5 cm or more

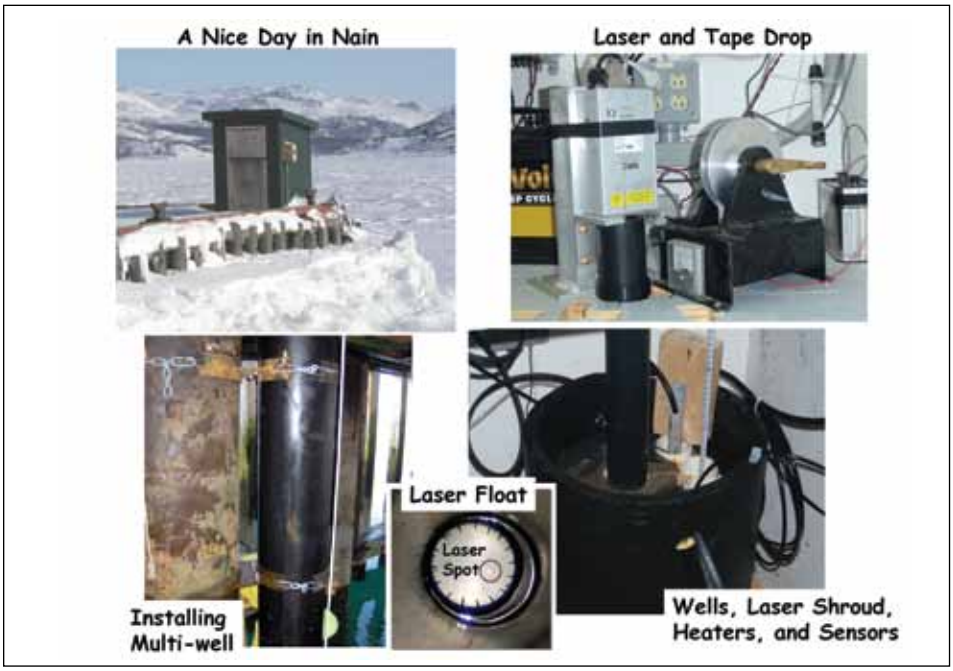


Figure 3. The Nain Installation

depending on the range to the water.

The measurements provided by both acoustic and radar sensors can to some degree depend on the roughness of the water surface and on the presence of anything floating on top. Under good conditions a radar sensor can be accurate to about 1 cm; however, both sensors are relatively expensive and neither will work effectively in the presence of ice without a stilling well.

For many applications, inaccuracies of a few centimetres are acceptable. However, for gauges used to estimate sea level rise rates, i.e., GLOSS gauges, millimetre precision and accuracy are desirable. For this reason, CHS Atlantic chose to explore a different sensor option, to design its own laser-ranging-based sensor system. Laser-ranging devices are now fairly common. Inexpensive examples (a laser tape measure) can be purchased at a hardware store. More sophisticated devices can reliably achieve accuracies of less than 1 mm over fairly long distances. However, most lasers will not reliably reflect off a water surface. Therefore, for reliable operation, a reflector (Figure 3, a laser float) is needed and, thus, a stilling well.

The CHS's laser sensor uses a MRC/Dimetix DSL-B15 laser with 2-mm measurement accuracy (Figure 3). After some experimentation, a reliable means of float placement and retrieval was achieved by embedding rare earth magnets inside a PVC foam-board float and then using a steel disk to place and retrieve the float. Small groves were cut into the edges of the float to speed water shedding following float placement. Finally, a 2-inch removable inner shroud was installed extending downward from the laser far enough into the well so that the laser can only effectively "see" the float and never the sides of the well (this is the smaller black pipe shown extending below the laser and into the 6-inch centre well in Figure 3). This eliminates the occasional measurement spikes (one or two per day) due to reflection off the sides of the well that were observed during testing.

By comparison with direct measurement by tape drop and after compensating for the height that the laser float protrudes above the water surface (about 1.4 cm), the laser's 2-mm accuracy has been verified for this application. The laser system is fairly inexpensive, making it one of the cheaper sensor options. There have been no sensor failures to date. The laser makes an absolute distance measurement, requiring no field calibration. If a failure does occur, a new unit can simply be swapped in, turned on, and should immediately supply high-accuracy data.

Three laser systems, one at each of Atlantic Canada's GLOSS tide gauge sites, have been in operation for more than a year with few problems. The data from the Nain site with its new multi-well system are the best ever collected from this GLOSS station. Because the new multi-well is robust it has over-wintered with no issues, in conditions that have in the past crushed older wells. The well insulation and efficient heating system have reduced energy costs sufficiently to pay for the new well in one to two years. The laser system is proving to be so effective that plans are being made to install similar systems at non-GLOSS sites, simply for reliability. Its design addresses several limitations of existing water level systems and sensors; it was well received at the 2009 Paris GLOSS meeting; and it is potentially the first operational laser-based tide gauge in the world.

Seabed Stability Observations with a Seafloor Lander at the Outer Halibut Channel

*Michael Li, Angus Robertson, Blair Greenan, and Robert Prescott**

Oil and gas exploration and production in the Canadian offshore require geoscience knowledge of the distribution and stability of seafloor sediment. On behalf of the Government of Canada, NRCan's Geological Survey of Canada (GSC) (Atlantic) conducts research in this area through seabed mapping, sampling, and sediment-transport measuring with seafloor instruments. Instrumented seabed landers (Figure 1) provide direct observations and measurements of near-bed hydrodynamic processes, magnitude and frequency of sediment transport and seabed erosion, and the formation and instability of bedforms on the seafloor. Through collaboration with DFO Science and the Canadian Coast Guard (CCG), GSC Atlantic recently successfully deployed the seafloor-instrumented lander RALPH in 275 m of water in a canyon at the outer Halibut Channel on the western Newfoundland margin (Figure 2). The suite of sensors mounted on RALPH recorded valuable information on seabed stability that will contribute to facilitating offshore hydrocarbon developments.

What is RALPH and how is it used in marine geoscience research? RALPH is an autonomous seabed lander developed and operated at the GSC Atlantic. It is a group of interfaced underwater sensors, mounted on a large robust frame with mooring assembly, used to record near-bed hydrodynamic conditions and seabed responses on the continental shelf slope, as well as in coastal waters. RALPH is deployed to the seafloor and left to record a variety of parameters, typically for a month at a time. The system is then recovered and the recorded data are downloaded and analyzed by GSC Atlantic scientists and technical staff to study near-bed wave and current forcing, the seabed response, and sediment transport processes.

The sensors on RALPH can record waves, steady currents, suspended sediment concentration, bedforms (e.g., ripples), and sediment responses near the seabed (Figure 3). Some of the latest additions include acoustic Doppler current profilers (ADCP) for high-resolution velocity profile measurements, and a high-definition video camcorder that takes short video clips and high-resolution stills in time-lapse fashion. GSC Atlantic staff can examine the imagery to quickly identify what is on the seabed and how it responds to the flows, and even to monitor biological activities and responses. When RALPH is fully equipped, it can support up to 23 sensors and seven computers. Because RALPH performs tasks underwater in remote locations, all of the electronics are pressure-housed to withstand

*of Prescott and Zou Consulting

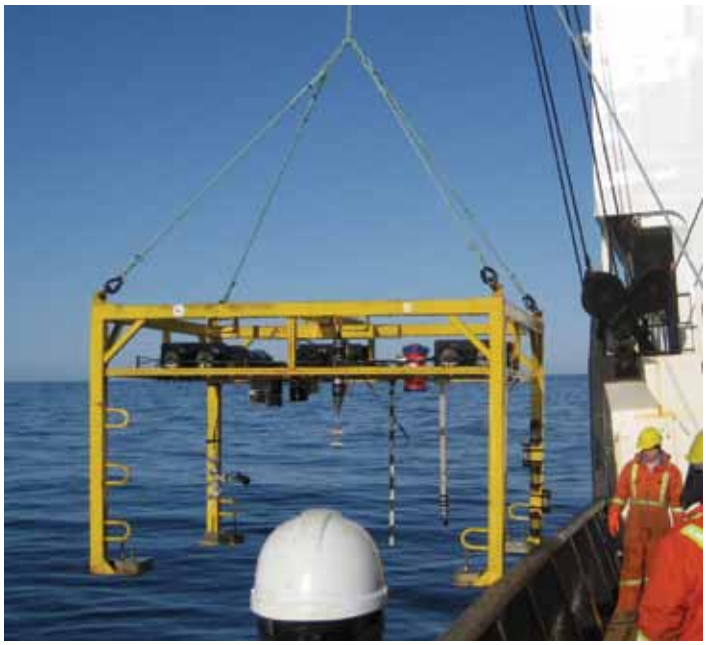


Figure 1. GSC Atlantic's instrumented seabed lander, RALPH, is recovered in the Halibut Channel from the CCGS *Ann Harvey*.

water ingress, and many are networked together for timing control. The system is powered by batteries and logs data using data-loggers mounted on the frame.

The deployment and recovery of RALPH is a complex process as it frequently involves stormy winter conditions, integration of information on surficial geology, oceanography and fishing activity in the deployment area, and interaction among scientists, technical staff, and CCG ship's staff. Also, deployments and recoveries are dependent on access to suitably sized marine vessels and acoustic release moorings. The support of DFO technical staff at BIO and the CCG was instrumental in the success of the lander deployment and recovery for the Halibut Channel experiment.

Continued upgrades of the GSC Atlantic's landers have been important in maintaining the GSC's leading-edge research in sediment transport and seabed stability, at national and international levels. Since the early 1990s, the landers have been deployed more than 30 times in the coastal and shelf waters of Sable Island Bank, Scotian Slope, Northeast Channel, Grand Banks, Bay of Fundy, Northumberland Strait, nearshore Prince Edward Island, the Arctic, and New Zealand. Its design has been copied in New Zealand, the United Kingdom, and China. Analyses of the collected lander data have contributed to various engineering and resource development issues such as siting and operation of offshore platforms, route assessment for subsea gas pipelines, assessment and monitoring of offshore dredge spoil sites, and coastal erosion caused by nearshore sediment transport processes. These lander data have also been used to verify hydrodynamic and sediment transport models.

There have been significant gas discoveries in the deep water off eastern Canada. Slope-crossing pipelines along canyons are likely means to transport these discoveries to land and markets. Seabed instability on the canyon floors is a constraint for these pipelines. The objective of the latest lander deployment at the Halibut Channel was to assess the near-bed flow process and sediment mobility as constraints for slope-crossing pipelines. Principal sensors used for this field experiment included two electron-magnetic current meters and a travel-time acoustic current meter for velocity measurements, a downward-looking ADCP for near-bed velocity profile data, six Optical Backscatter Sensors and one Acoustic Backscatter Sensor for suspended sediment concentration measurements, and a digital video camera for monitoring seabed responses. DFO colleagues at BIO collaborated in the experiment by contributing acoustic release moorings and an acoustic Doppler current profiler for flow velocity measurements in the water column. A CTD (conductivity-temperature-depth) cast was undertaken to obtain temperature and salinity profiles at the deployment site. Most sensors performed well in this experiment and recorded several energetic events potentially caused by tidal and wind-driven currents during storms. The current speed and direction data recorded by the up-looking ADCP (Figure 4) demonstrate that nearbed flow velocity reached as high as 1 – 1.4 m/s with a dominant down-canyon (southeast) direction. Video data showed several sediment-advection, bedload-transport, and sedimentation events that are associated with these high-velocity events. In the coming months, GSC Atlantic and DFO staff will collectively analyze the dataset to assess the near-bed current and sediment mobility processes and evaluate their impli-

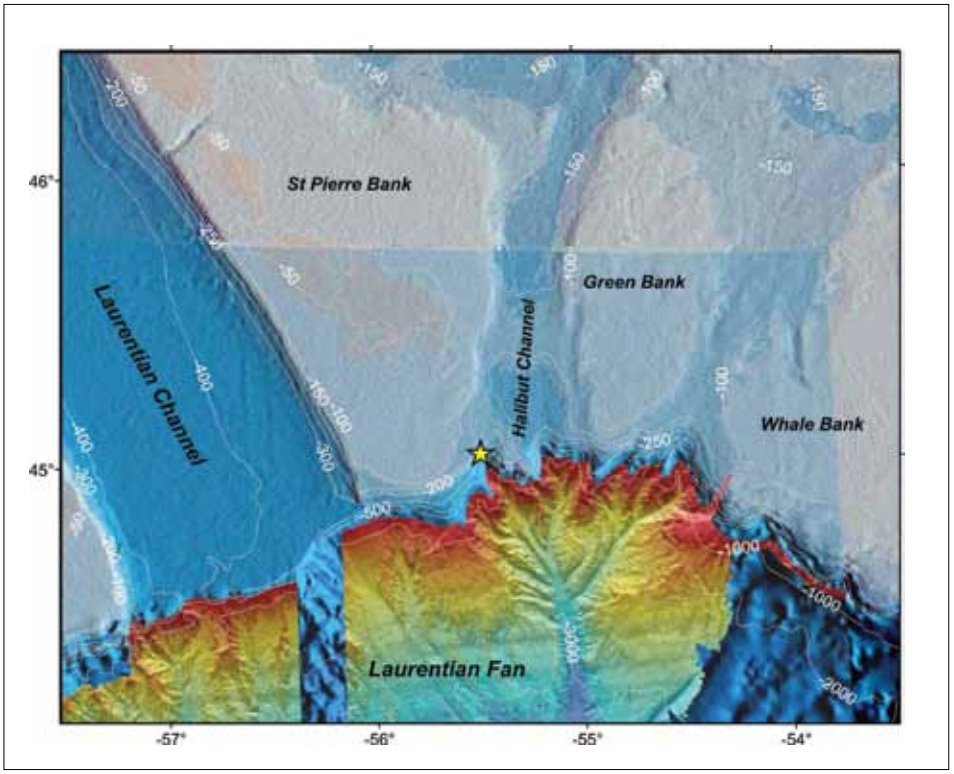


Figure 2. The star indicates the location of the 2008 deployment of the instrumented seabed lander, RALPH, in a canyon at the outer Halibut Channel on western Newfoundland margin. Depth contours are in metres. The colour bathymetry on the slope and in basin shows canyon morphology and depth range from 800 metres (red) to 3,500 metres (light blue). Graphic is courtesy of Ned King.

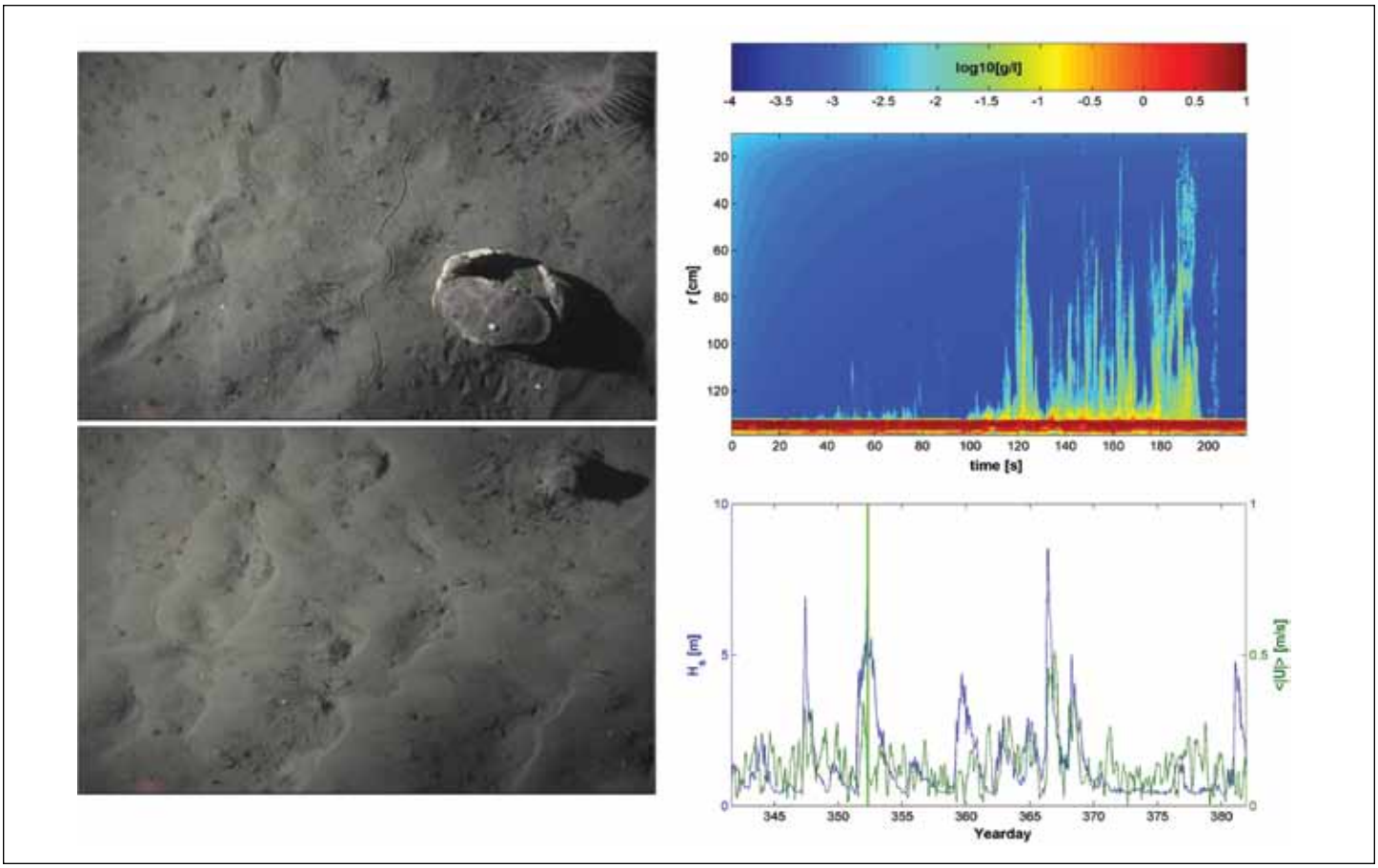


Figure 3. Shown are examples of seabed images (left), wave height and current data (lower right), and time series of suspended sediment concentration profiles (upper right) recorded by Acoustic Backscatter Sensors (ABS) collected by a recent RALPH deployment. In the upper right image, **r** is the distance from ABS to seabed and colour legend shows log10 of suspended sediment concentration in grams/litre (g/l). **Hs** is significant wave height and **|U|** is magnitude of mean current.

cation to slope-crossing pipelines.

The GSC Atlantic has just started the Offshore Geoscience Program. One of the planned activities in this program will be the deployment of our lander in the Bay of Fundy to study sediment transport under the strong tidal currents and how this affects the tidal energy development there. For further information on the research activities of GSC Atlantic, visit its web site (http://gsc.nrcan.gc.ca/org/atlantic/index_e.php).

Acknowledgement: *The authors would like to thank Edward King and David Piper for the background geological information that led to the selection of the deployment site; Bruce Wile and David Morse for co-ordinating field support and logistics of opportune CCG ships; Murray Scotney for technical support; and John Loder and Tim Milligan for supporting DFO collaboration in this field experiment.*

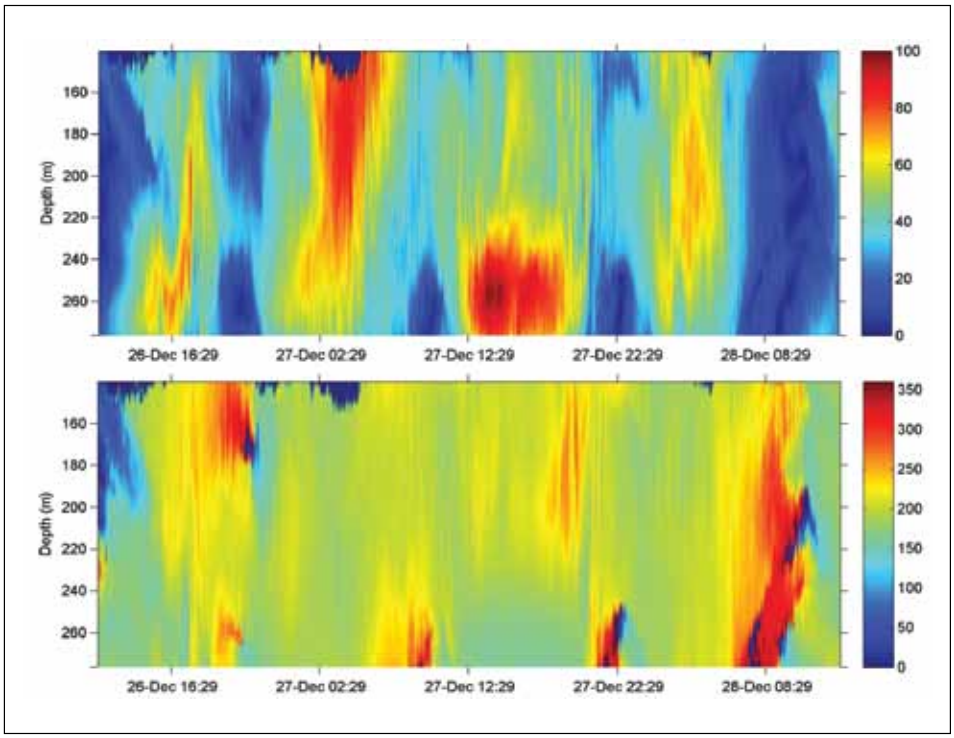


Figure 4. Vertical profiles of current speed (upper panel; cm/s) and direction (lower panel; degree true north) for the two-day period, December 26-28, recorded by the up-looking ADCP from the 2008 lander deployment at the outer Halibut Channel. Vertical axes are depth in metres.

Geological Field Work on Magnificent Bylot Island

Hans Wielens, Gordon Oakey, Jim Haggart, and Lisel Currie

Figure 1. A panoramic view of the Bylot Island landscape

As part of NRCan's Geomapping for Energy and Minerals (GEM) Program, Bylot Island, which is adjacent to the northeast tip of Baffin Island in Canada's Arctic (Figure 2), was visited in 2009 by Geological Survey of Canada scientists to study rock formations in relation to petroleum systems. Five conditions must be met before a petroleum accumulation can develop. There must be a reservoir (sandstone), a seal (shale), mature source rock (shale), a trap, and the trap must be present before the source rock generates petroleum.

Figure 2. Landsat image of Bylot Island: blue is glaciers; browns and greens are land; red is bare rock.

During the 1990s, oil of Cretaceous age (100 to 65 million years ago) was found on Greenland and major gas and some oil were found in the Labrador Sea. Satellite radar images show what appear to be oil slicks where the gas and oil were found. Further north, in Scott Inlet near the northern part of Baffin Island, using the submersible Pisces IV, an oil seep was found in 1985 in deep water. The seep was sampled and was determined to be Late Cretaceous oil. A surface slick was found in this same area in 1976. If petroleum is present there, is it possible that there are accumulations in Lancaster Sound and Baffin Bay? On Bylot Island, field work in the 1960s showed Upper Cretaceous and Tertiary (about 100 to possibly 55 million years ago) sediments, but at that time petroleum systems were not being sought. If it could be shown that source rock, a reservoir, and a seal of the petroleum system are all present on land, then it is likely that these features would be present offshore. Such a determination would significantly reduce offshore exploration risk. The other two conditions necessary to ensure petroleum accumulation can only be determined at each location.

The intent was to study the sediments and establish whether the three petroleum system conditions—reservoir, source rock, and a seal—were present vertically in the Cretaceous-age rocks and over a wide area. If so, samples would be taken to measure and get proof. Bylot Island consists of a high-grade metamorphic, 2.5 billion-year-

[1] The branch of stratigraphy that focuses on correlating and assigning relative ages of rock strata using the fossil assemblages contained within them.

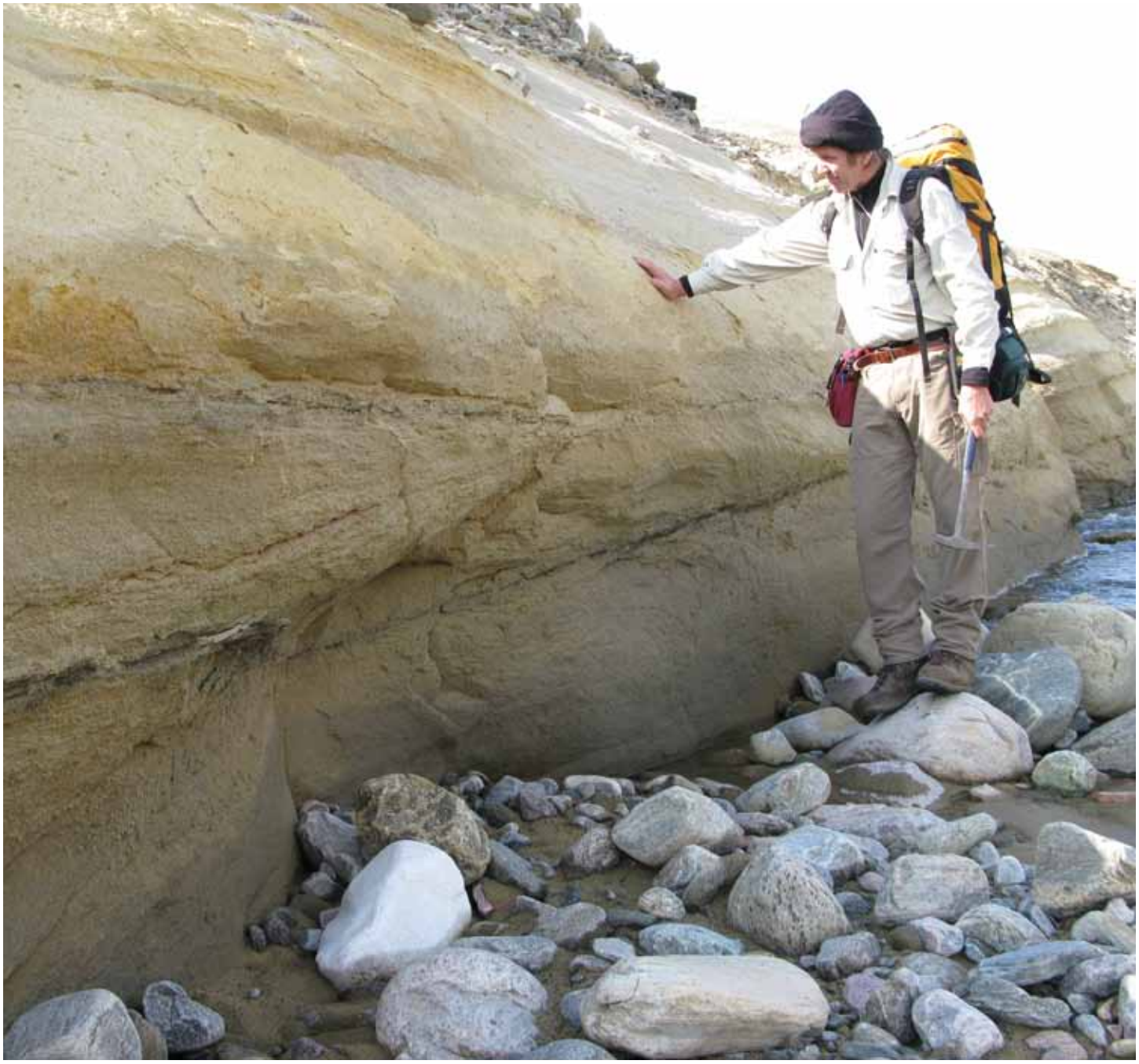


Figure 3. Jim Haggart looks at a thick sandstone, with part of it deposited by a river channel.

old, Precambrian core quite visible as mountains, and younger sediments that cover part of the island in the south, west, and north as a hilly landscape. A ten-day reconnaissance trip carried out during the last two weeks of July 2009 was very successful.

Three geologists travelled to Bylot Island: one each to study the petroleum system, biostratigraphy and fossils, and the tectonic movements of the whole system. They were accompanied by a much-appreciated Inuit Bear Guide who saw the bears long before the scientific party members.

All over the area, thick shale sections and thick beds of lightly consolidated sandstones were visible (Figure 3). In the latter, the white-yellow colour and soft-curved appearance showed that they were almost pure quartz, with little, if any, clay. Iron minerals appeared to glue the grains together. Much of the sandstone could easily be ground into single grains by hand, indicating that a reservoir is certainly present. These characteristics were evident throughout the area. The shales appeared to be pure, not shaley sand, and many were dark-coloured to black. Those could be source rocks, especially because they showed a white efflorescence or yellow sulphur on them. The efflorescence was visible in many locations (Figure 4), making black shale look from a distance like white sandstones. These shale packages were over 10 metres thick. Surprising is that very similar sand and shale sections are present in Tertiary rocks, and in the uppermost Tertiary bed was found a thick shale, or seal. That those youngest rocks were there was known, but not that they are so similar to the older ones; this extends the range

Figure 4. Black shales with white efflorescence on top of white sandstone: the steepest rocks near the bottom of the creek are the sandstones, but the more gently sloping white rocks above the overlying black shale turned out to be black shales also. That black is shown on the left side with a white gypsum efflorescence, often seen on good oil-source rocks.

where a good petroleum system can be present.

Measurements of the shales show that excellent source rocks are present, in both Cretaceous and Tertiary rocks that are capable of generating oil and gas. Of the reservoir samples, only a few could be measured, because most did not survive the voyage to the laboratory intact, despite careful wrapping and handling. Of those that could be measured, one was tight and the others showed good reservoirs.

The reconnaissance field work showed that, as required for a petroleum system, excellent source rock, reservoirs, and sealing rocks are present, and their lateral extent and persistence on land indicate that their presence offshore is quite likely. In fact, what was found far exceeded expectations. To get a better understanding of the configuration of the rock types and thicknesses, in 2010 an extensive aeromagnetic survey is planned for the offshore area. This will be augmented on a cruise aboard the German ship *Polar Stern* to collect seismic refraction and reflection data. Bylot Island will be revisited to answer some of the questions about its younger geology.

Bylot Island

During their geomapping field work, the authors were excited to experience the spectacular scenery and intriguing features of Bylot Island. Bylot Island is part of Sirmilik National Park which is located at the northern tip of Baffin Island and encompasses 22,252 square kilometres of Eastern Arctic Lowlands and Northern Davis Region of mountains, glaciers, fiords, and the Penny Ice Cap. Bylot Island, one of four separate parcels of the park, is a sanctuary for migratory birds: murres, kittiwakes, and the Greater Snow Goose are among the variety of songbirds, shorebirds, and waterfowl. The terrain is a mixture of mountains, hills, icefields, snowfields, and glaciers.

The authors suspect this stone circle (below) to be a Viking monument, similar to those found in Denmark. Archaeological work in the area uncovered threads spun from the fur of hares, a Viking practice (the indigenous Inuit did not do this kind of spinning).

Erosion has shaped a variety of hoodoos, formed due to local consolidation of the sandstones by iron compounds. A soft rain of sand grains was experienced while standing under some, showing how fast these hoodoos erode; yet, within them are large, hard concretions. Climbing through the Enchanted Valley, the authors thought its name apt; the scenery is incredible.

The glaciers on Bylot Island are striking. Virtually all are at their end-moraines, the ground-up rocks deposited farthest out by the snout of the glacier, and crevasses are present only over "steps" in the underlying bedrock. Melt-water runs off mostly over the top. All of this indicates they are in compression and growing. The glaciers form on the 2.5-billion-year-old Precambrian rocks and erode them at a high rate. The reddish rocks are 1.5-billion-year-old Precambrian quartzites that likely provided, in part, the material for the much younger sandstones.

Hoodoos

Glaciers

Polar bears were, of course, present. Andrew, the Inuit bear guide provided by Parks Canada, spotted these two animals in the seawater well before the authors did. Andrew advised them to return another time to this spot occupied by the mother and her cub. The bears feed on the seals that use ice floes around the island as resting spots.
Despite this far northern habitat, the flowers were beautiful and tenacious, clinging to almost bare rock or growing in dry loose sand. Pollination is done by butterflies.

Viking circle

Snowgeese and ducks – photos courtesy of Lisel Currie

Polar bears

All photographs in this article were taken by Hans Wielens, except those otherwise credited.

Characterization and Dispersion of Produced Water from the Venture and Thebaud Offshore Platforms on the Scotian Shelf

Susan Cobanli, Brian Robinson, Haibo Niu, Peter Thamer, Rod Doane, and Kenneth Lee

In every oil and natural gas reservoir in the world, water is trapped in the pores and fractures of rocks that are sandwiched between impermeable layers within the earth's crust. This formation water is derived from ancient sea water or fresh water, and is as old as the fossil fuels in the reservoir, typically millions of years in age. Furthermore, fresh water, brine, or sea water, as well as treatment chemicals, might be injected into the reservoir to displace hydrocarbons from the formation, to increase pressure within the reservoir, and to improve production performance. Recovered along with oil and/or natural gas from the reservoir, these liquids are known as produced water.

Chemists Peter Thamer and Brian Robinson prepare equipment for sampling the water column around the Venture platform.

Produced water represents the largest volume of waste material in offshore oil and gas production operations. For the protection of the marine environment, regulatory guidelines within Canada limit the concentration of total petroleum hydrocarbons (TPH) that may be discharged into the ocean within the produced-water stream. However, environmental concerns remain, due to the presence of potential contaminants (e.g., organic compounds, heavy metals, naturally occurring radioactive compounds, treatment chemicals, elevated nutrient concentrations, etc.) and the detection of sub-lethal biological effects observed within organisms exposed to produced water in experimental studies.

To assess the risk of produced-water discharge in the Atlantic Region, scientists at DFO's Centre for Offshore Oil, Gas and Energy Research (COOGER) have been working on a multi-year research program funded in part by the Program of Energy Research and Development. In the summer of 2009, with the cooperation of ExxonMobil Canada, COOGER scientists conducted a week-long mission to the Scotian Shelf, onboard ExxonMobil's offshore supply vessel MV *Ocean Tern*, to sample produced-water effluents from the Thebaud and Venture natural gas fields near Sable Island. Representative samples of treated produced water with TPH levels reduced to regulatory compliance levels for discharge at sea, and water samples from locations and depths surrounding the production facilities, were recovered for chemical and toxicological analyses. The study provided an assessment of fate, transport, and potential effects of produced water discharged at sea. In addition, the results of chemical and biological studies are to be used for the development of environmental effects monitoring protocols and the validation of numerical plume dispersion models for risk assessment.

A Niskin bottle is sub-sampled by NSERC Visiting Scientist Dr. Haibo Niu onboard the MV *Ocean Tern*.

Chemist Peter Thamer (left) and biologist Susan Cobanli conduct chemical and microbiological analysis of produced water from within a portable laboratory onboard the MV *Ocean Tern.*

PRODUCED-WATER CHARACTERIZATION

Chemical analyses of produced water from the Venture and Thebaud platforms indicated that concentrations of phenols and BTEX (benzene, toluene, ethylbenzene, and xylene) dominate the total organics in both produced waters, with phenol concentrations greater in Thebaud produced water than in Venture (Figure 1). The concentration of hydrocarbons including saturated hydrocarbons (alkanes) and polycyclic aromatic hydrocarbons (PAH) contributed to <1% of the total organics in produced water.

Results from the analysis of inorganics, nutrients, and salinity demonstrate that produced-water discharge from the Venture platform is more saline than Thebaud and has higher concentrations of nutrients (ammonia, silicate) and metals such as barium, strontium, and iron (Table 1). At the Venture site, the delineation of the produced-water plume was made by collecting seawater samples at three depths (2 m, 10 m, and near-bottom) over 26 locations, within 500 metres from the platform.

Table 1. Summary of produced-water salinity, nutrient, and metal analysis

	VENTURE	THEBAUD
Salinity (ppt)	203.5	27.6
Silicate (µM)	374.3	80.7
Nitrate (µM)	1.3	0.8
Ammonia (µM)	22518	2737
Nitrite (µM)	1.7	0.8
ELEMENT CONC	**(µg/L)**	**Conc(µg/L)**
Aluminum	100	22
Antimony	< 2	< 2
Arsenic	< 50	< 50
Barium	1240000	146000
Beryllium	1.2	0.2
Bismuth	< 0.5	< 0.5
Boron	29000	2800
Cadmium	2.4	0.02
Calcium	21800000	2760000
Chromium	< 10	< 10
Cobalt	< 10	< 10
Copper	< 10	< 10
Iron	137000	23100
Lanthanum	16	2
Lead	27	4.8
Lithium	36000	1900
Magnesium	1380000	185000
Manganese	24100	2930
Molybdenum	1.0	1.9
Nickel	< 20	< 20
Phosphorus	70	< 50
Potassium	1110000	87000
Rubidium	4400	310
Selenium	< 50	< 50
Silicon	25600	2430
Silver	0.6	< 0.2
Sodium	49500000	7310000
Strontium	2410000	255000
Sulfur	460	300
Tellurium	< 2	< 2
Thallium	140	15
Thorium	< 0.2	< 0.2
Tin	< 0.5	< 0.5
Titanium	< 1	< 1
Uranium	< 0.005	0.012
Vanadium	< 5	< 5
Zinc	2400	120

BIOLOGICAL EFFECTS

Microbes respond very quickly to their surrounding environment and are responsible for primary ecosystem processes including the production of biomass, nutrient regeneration, and the biodegradation/biotransformation of contaminants. The potential impact of discharged produced water was assessed by monitoring changes in the rate of bacterial growth in the waters surrounding the Venture platform.

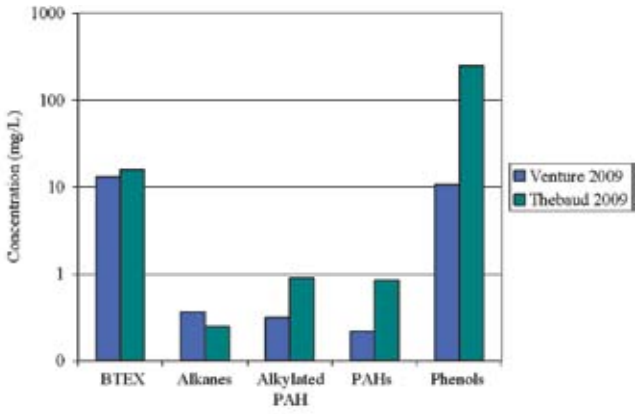


Figure 1. Concentration of organics in Thebaud and Venture produced water (shown on a logarithmic scale)

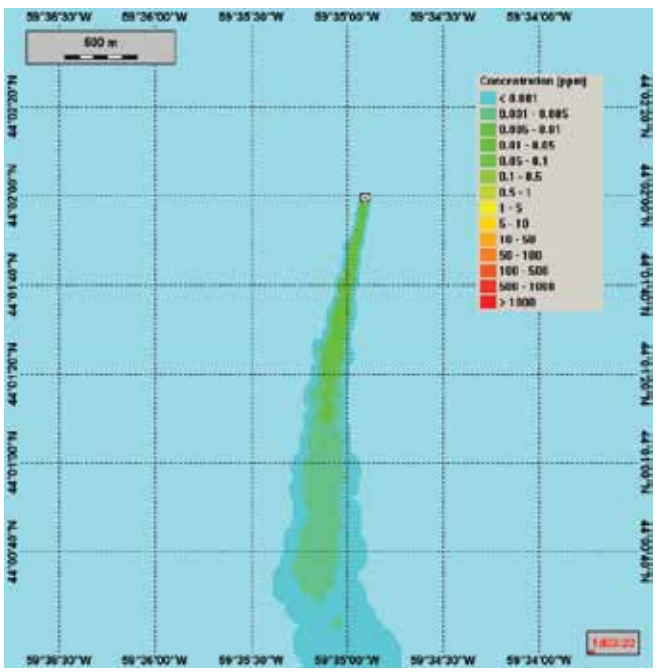
Following release of the water into the open ocean, the high temperature (56°C) decreases and the anaerobic produced water is diluted rapidly. Previous studies have demonstrated that natural chemical reactions may alter the concentration and composition of residual components of the produced water following its discharge into aerobic surface waters. To simulate field conditions, a subset of samples were aerated for 46 hours prior to chemical (Table 2) and microbiological analyses. Laboratory experiments with dilutions of seawater and produced water (0.25% - 20%) from the discharge stream showed that concentrations of produced water above 2.5% in both unaerated and aerated samples induced detrimental effects in both cases. Furthermore, results from an identical series of diluted seawater samples corrected for the influence of elevated salinity concentrations (>200ppt) by the addition of NaCl confirmed that salinity alone accounted for a fraction of the toxic responses observed.

Table 2: Changes in Venture produced water chemistry, pre- and post-aeration

CONSTITUENT ng/mL	PRE-AERATION	POST-AERATION
BTEX	12,952	<1
Alkanes	321.9	339.9
Methylated PAH's	289.1	11.8
PAH's	207.6	2.2
Phenols	10,624	8,397

MODELLING OF DISPERSION

To understand the dispersion and potential environmental impacts of produced water discharged from the Venture platform, COOGER applied the DREAM (Dose-related Risk and Effect Assessment Model) model (Figure 2). Capable of tracking 15 groups of chemicals simultaneously, with the input of 3-dimensional current data generated from an ocean circulation model for the Scotian Shelf, the DREAM model predicted a rapid sinking of the produced-water plume to the seafloor immediately after release, due to the water's high density. Because the discharge volume is very small (94-137 m3/day compared to as much as 15 to 20 thousand m3/day from the Terra Nova and Hibernia fields offshore Newfoundland and Labrador), a very high dilution ratio is achieved within a few hundred metres of the platform. For example, for an initial total pollutant concentration of ~535 ppm found in the raw produced water, the model predicted that the concentration would be reduced to less than .001 ppm within 100 metres from the point of discharge. By comparison of the predicted environmental concentration (PEC) with the predicted no-effect concentration (PNEC) of contaminants, it was deemed that the level of environmental risk was very low (i.e., probability of damage greater than 5% (PEC/PNEC=1) was constrained within 0.00125 km^3). To validate the accuracy of the model, the predicted environmental concentrations for three tracers (iron, ammonia, and naphthalene) were compared with measurements from 26 stations at three depths. Good agreement (uncertainty <20%) between the predicted and measured concentrations was found.



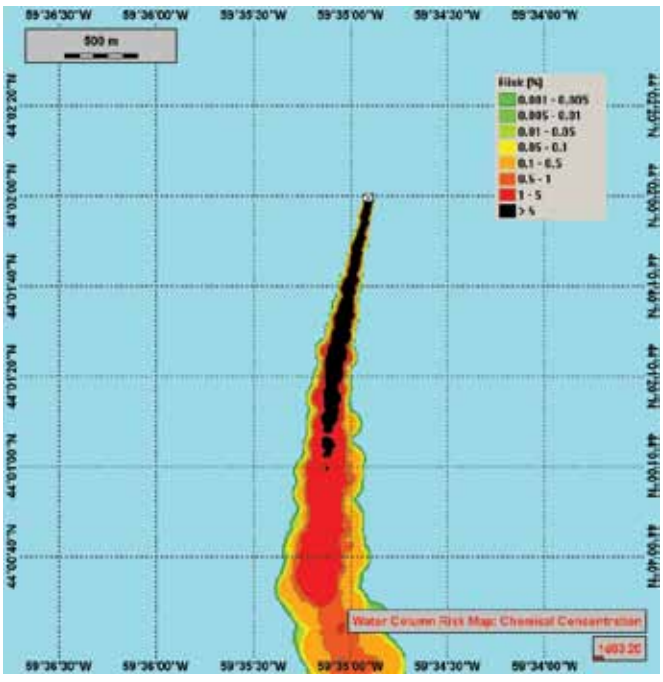


Figure 2. Environmental concentration and risks predicted by the DREAM model

CONCLUSIONS

This collaborative study with the offshore oil industry has demonstrated the feasibility of the DREAM model for the prediction of potential impacts associated with the discharge of produced water. The preliminary results from this modeling effort will lead to improvements in the accuracy of the model and the design of future monitoring protocols. The results of the biological studies have improved our knowledge of the specific components within produced water that elicit the strongest toxic responses. This information will be used for the design of future environmental effects monitoring protocols and the development of operational mitigation/remediation strategies on offshore platforms.

Mapping Placentia Bay

John Shaw and D. Patrick Potter

NRCan's Geoscience for Ocean Management (GOM) Program (2003-2009) delivered geoscience knowledge to inform decisions leading to integrated management of Canada's offshore (under-ocean) lands. Canada's Ocean Action Plan has identified five regions as priorities for integrated management planning. Under the GOM program the Geological Survey of Canada (GSC) and the Canadian Hydrographic Service (CHS) mapped a number of those regions using multibeam sonar systems. Subsequent ground-truthing surveys enabled the production of 1:50,000 scale maps of seafloor topography, backscatter (sediment texture), and surficial geology.

Placentia Bay, encompassing 3,600 square kilometres on the southeast coast of Newfoundland, and the Grand Banks constitute one of the five priority areas. Surveys of Placentia Bay were undertaken from 2004 to 2006 using Kongsberg sounders aboard the CCGS *Creed*, the CCGS *Matthew* and several hydrographic launches. The CCGS *Hudson* was used for sampling and geophysical surveys in 2006, and GSC staff had access also to sample and geophysical data previously collected. The 1:50,000 scale seafloor topography maps were published in 2009 (Potter and Shaw, 2009a, b, c, d, e) and the backscatter maps will be published in 2010. The area mapped is shown in Figure 1.

1: 50,000 SCALE MAP SHEETS

Two map sheets from the series are shown here as Figures 2 and 3. Figure 2 depicts the Argentia region, and contains insets of Argentia Harbour that enable the detailed seafloor morphology to be viewed in higher resolution.

THE RECORD OF GLACIATION IN PLACENTIA BAY

One of the more remarkable aspects captured in the new maps of Placentia Bay is how strongly the seafloor bears the imprint of the last ice age (Figure 4). During the last glacial maximum (about 20,000 years ago), glacier ice streaming out of Placentia Bay sculpted the seafloor into ridges of glacial material (A) identical to the drumlins seen onshore in Atlantic Canada. This imprinting is particularly prominent in southwest Placentia Bay, just off the coast of the Burin Peninsula. Toward the south (B), the ridges become more elongated, providing evidence for the acceleration of glacier ice into a fast-flowing ice stream that flowed southward towards Halibut Channel on the Grand Banks. The seafloor texture in this area is varied, and includes bedrock (E) and the bouldery gravel of drumlins. Toward the bottom right of the image, the glacial ridges are blanketed by glacial mud (C) that still carries the imprint of iceberg furrows formed 14,000 years ago—modern icebergs are rare visitors to Placentia Bay. In the extreme bottom right the smooth seafloor consists of thick recently deposited mud (D).

THE MEGAFLUTE CONUNDRUM

The seafloor on the southeast side of Placentia Bay, just off the coast of the Avalon Peninsula, has puzzled GSC researchers for many years. A vast system of flutes (trenches) is incised into the muddy seafloor in

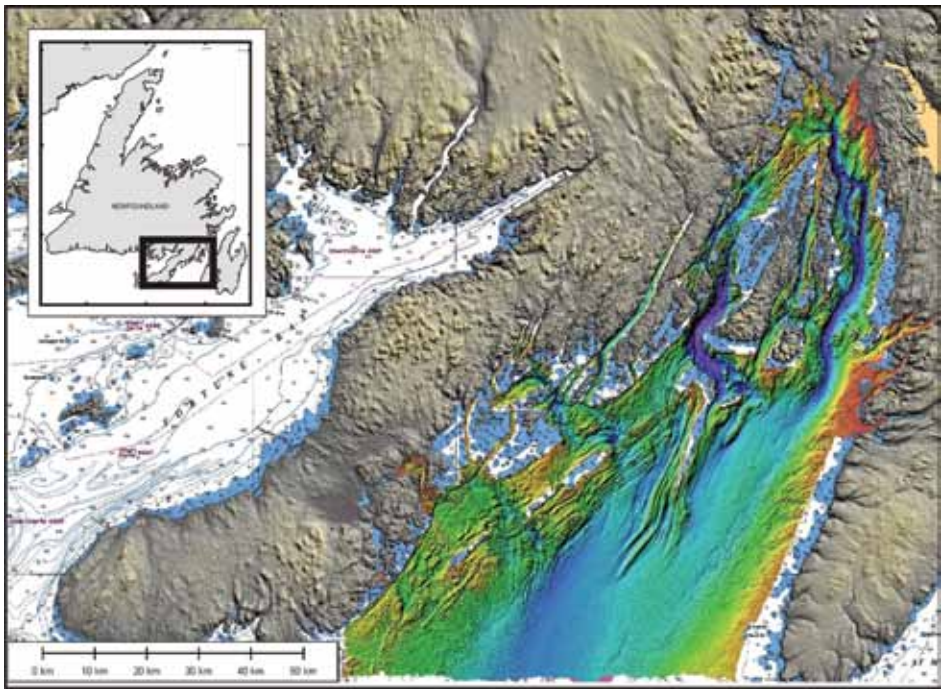


Figure 1. Shaded seafloor relief map of Placentia Bay: this area is shown in greater resolution on the series of five 1:50,000 scale maps published by NRCan and jointly authored by NRCan and the CHS. The area mapped is bounded by the Burin Peninsula in the west and the Avalon Peninsula in the east. The deepest areas, shown in violet, are the channels in the north of the bay, namely Eastern Channel (right) and Western Channel which attains a depth of about 450 m.

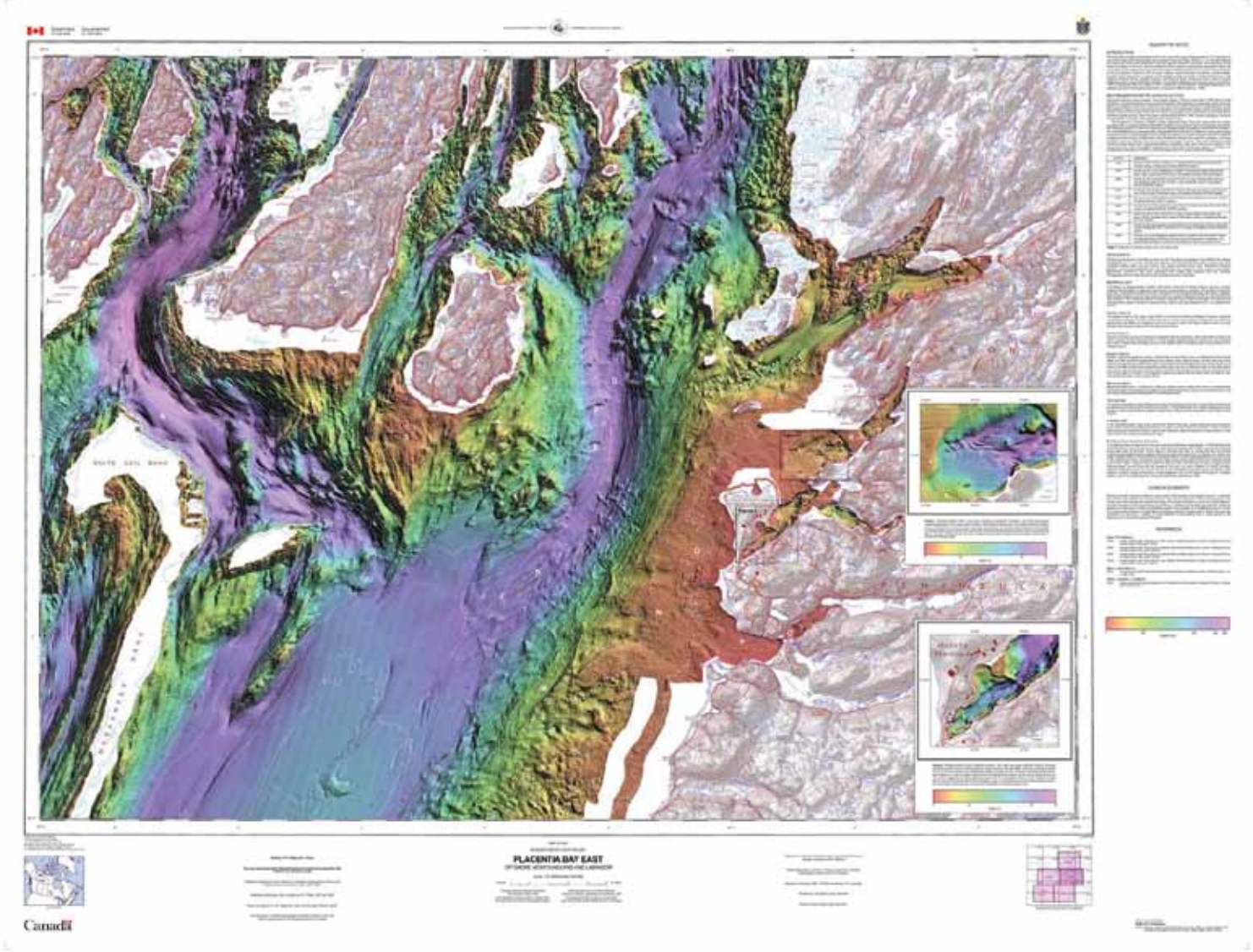


Figure 2. Shaded seafloor relief map of the Argentia region (Potter and Shaw, map 2009b): the extensive shallow areas off the coast of the Avalon Peninsula (red) were dry land during the postglacial lowering of the sea level, about 9,000 years ago.

water depths of approximately 200 m. The trenches are found in a zone about 4 km wide that extends about 100 km in a northeasterly direction. The new multibeam sonar surveys show that the trenches are circular to oval in shape, and range in length from hundreds of metres to many kilometres. They are characterized by steep sidewalls up to 8 m high, and are incised into soft, postglacial mud, exposing older and more resistant glacial mud at the seafloor. To the east of the flutes, all the postglacial mud has been stripped away, releasing vast volumes of mud from the seafloor (about 4 km^3 by one previous estimate).

When were the flutes formed? Some have proposed that erosion of the seafloor was caused by a single event, namely, the 1929 tsunami which killed 27 people on the Burin Peninsula. This is unlikely, as the instantaneous mobilization of so much mud would have been noticed in the bay. However, researchers are no closer to understanding the origin of the fluted seafloor. Modeling of the Labrador Current by Dr. Guchi Han at DFO (St. John's, Newfoundland and Labrador) clearly shows the branch of the current that flows strongly up the east side of the bay, corresponding exactly with the fluted zone. It is thus possible that the fluting is associated with the onset of this strong current.

HUMAN IMPACTS ON THE SEAFLOOR

Human impact in Placentia Bay increased in the 20th Century. A notable event, which, however, left no mark on the seafloor was the Red Herring disaster in 1969. Large-scale fish mortalities were attributed to the escape of elemental phosphorus into Placentia Bay from the phosphorus reduction plant at Long Harbour. This event triggered extensive studies by DFO scientists. During World War II, intensive activity near the United States Naval Station Argentia left a legacy of dredged areas and spoil heaps, both of which are imaged on the new map series. Surveys in the Argentia area in the mid-1990s focused on the base's deep-water dumpsite (Figure 3). At a depth of 450 m, objects identified using side-scan sonar were beneath the resolution of the multibeam sonar data.

The new mapping has provided intriguing evidence of more recent human intervention. In the 1990s, a fleet of large deep-sea trawlers was towed out of Marystown and scuttled in about 200 metres of water in Placentia Bay. These 80-m-long vessels appear on both the multibeam bathymetry and backscatter maps. A side-scan sonar survey in 2006 showed that most of them are sitting upright on the seafloor (Figure 6), with masts and funnels still in position.

Figure 3. Backscatter map (Potter and Shaw, "A": 2153) of the same area depicted on Figure 2. High backscatter (dark blue) is indicative of a range of hard bottoms, including bedrock, bouldery gravel, fine muddy gravel, and muddy coarse sand. The location of the former deep-water dumpsite mentioned in the text is circled.

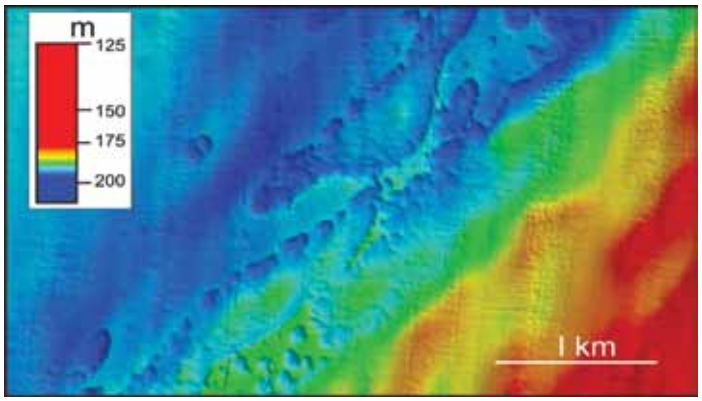


Figure 5. Megaflutes in Placentia Bay: in the west the seafloor is smooth, except for scattered pockmarks. The fluted zone contains flutes of various types, and includes residual islands of uneroded mud. In the east (red area) all the postglacial mud has been stripped from the seafloor. The steep walls of the flutes are 2-3 m high in this area.

FUTURE WORK

The mapping was completed under the auspices of NRCan's Geoscience for Ocean Management Program, which has now ended. Placentia Bay forms part of the Placentia Bay–Grand Banks Large Ocean Management Area (LOMA), and is the only substantial piece of the LOMA to have been mapped. In coming years it is hoped that the new data will be used to plan activities in the LOMA. In particular, the creation of a seascape map, i.e., a map which delineates a series of units with unique associations of morphology, sea-floor texture, and biota, is planned. A second goal is to investigate the link between the seafloor terrains that have been mapped and the three cod-spawning areas that have been described in Placentia Bay.

ACKNOWLEDGEMENTS

The mapping was made possible through collaboration with the Canadian Hydrographic Service, and particular recognition is due to Gerard Costello and Michael Lamplugh of the CHS Atlantic at BIO and Charles Stirling of the CHS at St. John's. As joint authors with NRCan, the CHS logo appears on all map sheets. Cartography was by Patsy Melbourne of NRCan.

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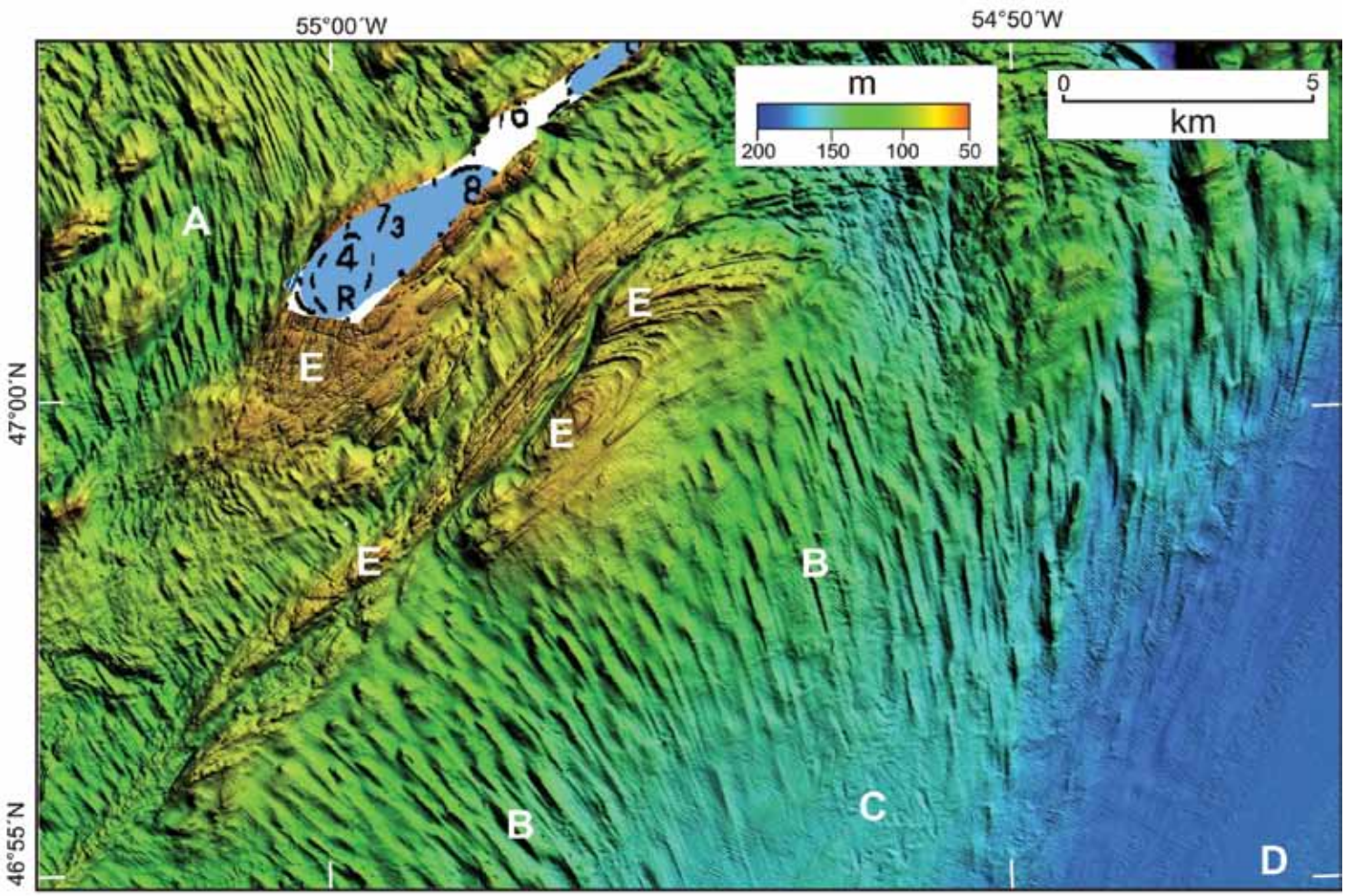

Figure 4. Glacial landforms are evident in southwest Placentia Bay. Large areas of exposed bedrock also exist. See text for explanation.

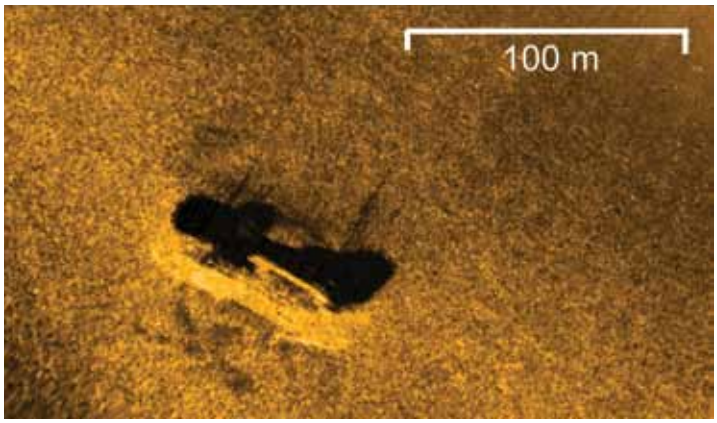

Figure 6. This side-scan sonar image shows an 80-m-long trawler scuttled in the 1990s. The vessel sits upright on the floor of Placentia Bay, in a water depth of 200 m. The dark acoustic shadow on the muddy seafloor shows the vessel's masts. Five such vessels are clearly visible on the seafloor relief map of southwest Placentia Bay (Potter and Shaw, map 2009d).

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A Highlight of 2009 for the TRINITY Route Survey Office

LCdr Scott Moody

The ships of Standing Naval Mine Counter Measures Group One in close formation outside Halifax Harbour

A highlight for staff of the Route Survey Office (RSO) is going to sea to collect and process side-scan data. In 2009, the mission changed slightly: instead of the normal collecting, processing, and displaying of data, we were looking for practice mines (inert) on the seafloor. Normally, data collection is in support of mine counter-measures operations but this time the role was mine hunting.

On August 29, a group of small ships arrived in Halifax, escorted into the Naval Dockyard by HMC Ships *Shawinigan* and *Goose Bay*, two Maritime Coastal Defence Vessels. This elite group of ships composes the Standing Naval Mine Counter-Measures Group One. This was their first visit to Halifax since 1998 and was the first time that Canadian warships joined the group.

HMCS *Goose Bay* was loaded with extra boats, diving gear (including an emergency recompression chamber), and a clearance diving team, while *Shawinigan* took on board a Klein 5500 side-scan sonar system and a processing team from the TRINITY RSO. The Canadian Navy's experts in side-scan sonar operations, processing, and interpretation are with the RSO at BIO.

The team from TRINITY RSO often joins the Coastal Defence Vessels for short periods to assist with side-scan sonar operations. The Vessels are often employed as mine hunters and survey the seafloor for mine-like objects and for changes in areas where there were previous surveys. The process is relatively simple though time-consuming: survey and collect the data for a given area, review the data and contacts, measure the contacts, and produce a list of contacts that require further investigation by a remotely operated vehicle or a clearance diver.

The high-resolution Klein 5500 system allows the operators to see a lot of small shapes that require review and classification prior to their being sent to the Mine Counter Measures Tasking Authority which assigns a suitable ship to identify the highest-priority contacts. If a mine is located it is dealt with in an appropriate manner. The mine could possibly be removed from the sea floor and taken ashore by the divers, using lifting bags and small boats, so that it can be exploded; or, it may be neutralized in place through the use of explosive charges.

The Standing Naval Mine Counter Measures Group One is one of two Mine Counter Measures Groups in NATO. Group Two operates primarily in the Mediterranean while Group One is responsible for the North Atlantic and into the Baltic Sea. When in the Baltic, the Group searches for real mines left over from both world wars, when more than one million mines were laid in that small area. The Group's time here in Canada and in the United States was spent practising mine hunting and operating in unfamiliar waters.

The Canadian sea floor proved to be extremely challenging due to the variety of bottom types and the high number of mine-like rocks that clutter the bottom and slow the hunting. After a week of finding a lot of mine-like rocks along Nova Scotia's South Shore, the Group headed to New York for a port visit. A second, very large, exercise in the Virginia Exercise Areas off Norfolk followed, where the relatively sandy gravel bottom made mine hunting much easier. From Norfolk the ships visited Charleston, South Carolina, before heading east across the Atlantic once more. After Norfolk, HMC Ships *Goose Bay* and *Shawinigan*, with Route Survey personnel still embarked, headed back to Halifax.

It was a true highlight for TRINITY RSO personnel to be part of this elite group of NATO Standing Naval Forces ships: Standing Naval Mine Counter Measures Group One.

OCEANS AND AQUATIC MANAGEMENT

Integrated Oceans and Coastal Management: Continued Collaboration in the Maritimes Region

Jazmine Hayden

Canada's Oceans Act, established in 1997, promotes an integrated approach to oceans and coastal management, encouraging government-wide collaboration and coordination and respect for jurisdictional authorities. In DFO's Maritimes Region, the Oceans and Coastal Management Division (OCMD) of the Oceans, Habitat and Species at Risk Branch is working with many partners to manage our oceans and our coastal interests. This article provides details on many collaborative initiatives in which OCMD employees participate and, in many cases, lead.

COLLABORATIVE GOVERNMENT FRAMEWORKS

A key area for improvement identified in *Canada's Oceans Strategy* is the need for better government coordination. More than two dozen federal departments have some form of legislative responsibility for aspects of integrated coastal and oceans management (ICOM). Provincial authority extends into many coastal and offshore management areas as well, necessitating effective government coordination and communication.

Regional Committee on Coastal and Ocean Management

The Regional Committee on Coastal and Ocean Management (RCCOM) in the Maritime Provinces is the senior executive forum for federal and provincial governments to collectively provide oversight, coordination, and direction for the planning and management processes related to ICOM. The OCMD engages in regular federal-provincial collaboration via the RCCOM Coordinating Committee (CC). The RCCOM CC discusses regional ICOM matters to:

- advance the joint work plan, covering state of the coast and ocean reporting, and marine and coastal spatial planning
- support ongoing ICOM activities in the three Maritime Provinces.

Gulf of Maine-Bay of Fundy Strategic Framework for Integrated Management

A framework is being developed by OCMD staff to set integrated management and ecosystem objectives for the Gulf of Maine-Bay of Fundy region, and to provide options for advancing integrated management (IM) in the absence of a formal Large Ocean Management Area. This framework also will provide important guidance and options for DFO's regional coastal management work. The next step is consultations on the draft framework within DFO and with key government partners, before work begins with external partners, in the community. The community engagement components of the framework have implications for DFO's work throughout the region.

OCMD Program Areas, DFO Maritimes

Coastal and Oceans Management Memorandum of Understanding

An ICOM Memorandum of Understanding (MOU) between the federal government and the Province of Nova Scotia is in development to:

- advance the NS Coastal Management Framework
- support IM activities and joint conservation/Marine Protected Area (MPA) planning
- share information.

The completion for the Canada-Nova Scotia MOU is anticipated in the fiscal year 2010/11. A similar MOU is being considered with New Brunswick (NB) and Prince Edward Island.

FIRST NATIONS AND ABORIGINAL COMMUNITIES

To strengthen participation and involvement, the OCMD collaborates with various First Nations and other Aboriginal organizations on the following initiatives:

- Eastern Scotian Shelf Integrated Management (ESSIM) Initiative
- Bras d'Or Lakes Collaborative Environmental Planning Initiative (Bras d'Or CEPI)
- Southwest New Brunswick (SWNB) Marine Resources Planning Initiative.

Unama'ki Institute of Natural Resources-Fisheries and Oceans Canada MOU

The OCMD coordinates with other DFO branches in the development and implementation of the Unama'ki Institute of Natural Resources-Fisheries and Oceans Canada MOU. The OCMD is collaborating in the renewal of an MOU to collaborate with the five Unama'ki First Nations communities in Cape Breton and support the Bras d'Or Lakes Collaborative Environmental Planning Initiative (Bras d'Or CEPI).

Maliseet Nation Aboriginal Traditional Knowledge Protocol

In collaboration with partners, such as the Maliseet Nation Conservation Council, Indian and Northern Affairs Canada, and Parks Canada Agency, the OCMD is supporting the development of a Maliseet Nation Aboriginal Traditional Knowledge protocol. This protocol will provide methods for six Maliseet Nations in Southwest New Brunswick to share their traditional knowledge with government and for government to make more informed decisions about marine resources and space planning.

Bras d'Or Lakes Collaborative Environmental Planning Initiative

The OCMD provides key direction and support to this unique collaborative initiative as our primary coastal management effort in Nova Scotia. Efforts to date in the Bras d'Or include:

- developing a governance process through which federal, provincial, municipal, and First Nation governments can collaborate with industry, academics, community members, and non-government organizations toward the development of an overall management plan for the lake and watershed lands
- conducting a regulatory, policy, and program review of government departments with responsibilities for the major environmental issues within the Bras d'Or
- developing a framework for the management plan that includes planning at the scale of the entire watershed and at each individual sub-watershed
- developing and implementing a sub-watershed management plan for the Denys Basin area of the Bras d'Or
- advancing the adoption of land use development standards by the four municipal governments in the Bras d'Or aimed at better protecting the lakes from development and protecting property from the effects of sea-level rise and climate change
- developing an indicator-based State of the Bras d'Or report card, indicating the general health of the Bras d'Or ecosystem.

REGIONAL PARTNERSHIPS

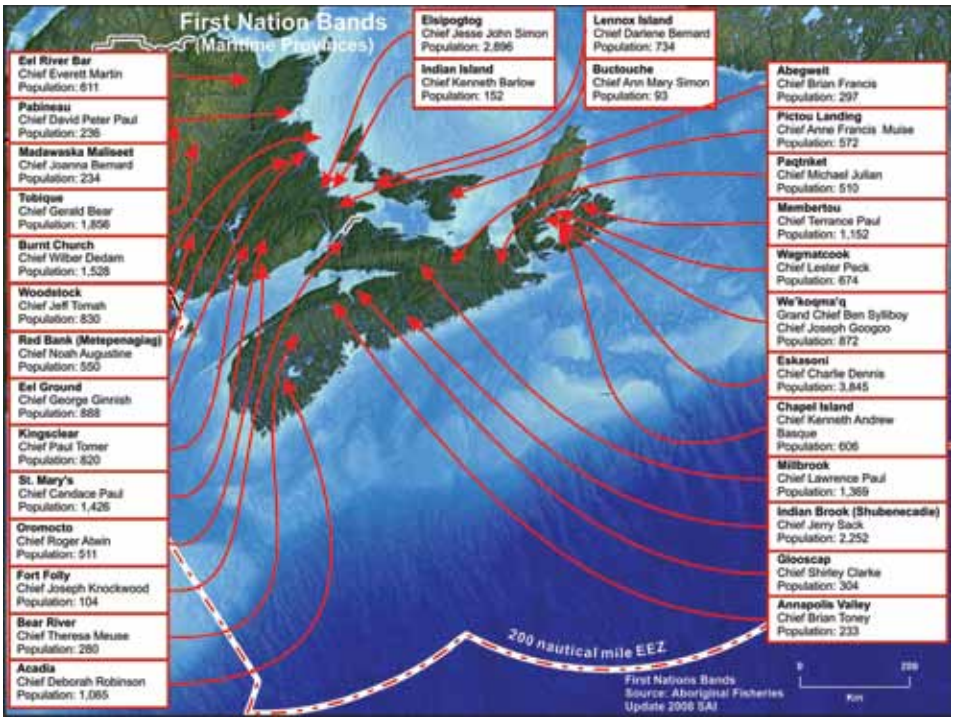
Perhaps the main overarching objective of non-government partners in coastal and oceans management is to create more effective opportunities to plan and manage human activities. The following examples illustrate partnership approaches to integrated coastal and oceans management collaboration:

Atlantic Coastal Zone Information Steering Committee

The Atlantic Coastal Zone Information Steering Committee (ACZISC) provides leadership and facilitation to promote the common goals of its partners in support of improved coastal and oceans management in the Atlantic Provinces. The ACZISC has two collaborative sub-committees:

1. Integrated Coastal and Oceans Management Working Group

The OCMD collaborates with coastal and oceans managers across the Atlantic Provinces via this ICOM Working Group to:



First Nations bands in the Maritime Provinces

- discuss policy initiatives
- make more informed decisions about management activities in the region
- develop best practices for ICOM professionals.

2. Coastal and Oceans Information Network Atlantic

Coastal and Oceans Information Network Atlantic (COINAtlantic) is a data and mapping utility to support decision-making by coastal and ocean managers and users of coastal and ocean space and resources. The web-accessible COINAtlantic utility makes it possible to search many partner data sets and to display the layers of data on maps. The COINAtlantic Management Committee is currently focused on enhancing the usability of these web-mapping services.

Musquash Estuary Advisory Committee

Employees of the OCMD are responsible for managing the Musquash Estuary Marine Protected Area (MPA). The governance structure for the MPA requires an advisory committee of representatives from federal and provincial governments, aboriginal organizations, non-government organizations, and academic institutions. The committee reviews and provides input to the development of a management and monitoring plan. The OCMD and advisory committee members also work to increase awareness of the MPA. Communications activities, such as sign installations and brochure and website development, are currently underway.

Eastern Scotian Shelf Integrated Management Stakeholder Advisory Council

The ESSIM Initiative started as a pilot project in 1999 and by 2005 had grown to include a Stakeholder Advisory Council (SAC), representing the interests of all levels of government and the coastal and oceans sectors, such as oil and gas, fisheries, First Nations, and non-government organizations. Action planning is currently underway to address Integrated Management and Ecosystem Approaches to Management priorities, with a focus on marine spatial planning, state of the environment reporting, and a regional framework for commercial fisheries.

The Gully Advisory Committee

Similar to the Musquash MPA (above), the CMD works with the Gully Advisory Committee (GAC) to manage The Gully MPA—a deep submarine canyon on the Scotian Shelf near Sable Island. The GAC consists of representatives from industry, academia, other federal and provincial government bodies, and environmental non-government organizations. Each member contributes skills, knowledge, and experience related to the ecology, management, conservation, and uses of this important conservation area. The GAC played an important advisory role during the assessment and establishment process for the MPA and now serves as a forum to exchange information and views among user groups and other key partners. The OCMD continues to consult the GAC for advice on the implementation of policies and regulations, management strategies, operational procedures, activity approvals, education and outreach opportunities, and research directions.

Southwest New Brunswick Marine Resources Planning

A steering committee of knowledgeable local partners (supported by DFO and the Province of New Brunswick) produced recommendations for the development and implementation of an IM plan to manage resources and space in the SWNB portion of the Bay of Fundy. This initiative will be used as a pilot for future planning initiatives in NB and the Gulf of Maine. A joint federal-provincial response to the recommendations was endorsed by the RCCOM on November 24, 2009, including recommended next steps. Immediately, a letter, signed by the Deputy Minister of the NB Department of Fisheries and Aquaculture and the Regional Director General of DFO, Maritimes Region, was sent to the steering committee. Overall, the committee is pleased with the recommended next steps, and is looking forward to working collaboratively on the next phase of the initiative.

INTERNATIONAL PARTNERSHIPS

The OCMD maintains strong participation in Canada-United States oceans and coastal discussions in the Gulf of Maine via the Gulf of Maine Council on the Marine Environment and relationships between DFO and the National Oceanic and Atmospheric Administration in the United States.

Gulf of Maine Council on the Marine Environment

The Gulf of Maine Council on the Marine Environment is a partnership of government and non-government organizations. The Council aims to maintain and enhance environmental quality in the Gulf of Maine to support sustainable resource use for existing and future generations.

State of the Environment Reporting

The main purposes of state-of-the-environment reporting (SOER) are to foster the use of science in policy and decision making, and to report to the public and partners on the condition of the environment. SOER in the Maritimes Region is in the planning phase and we are working with our regional and international partners to provide SOER online.

The OCMD is partnering with the Gulf of Maine Council on the Marine Environment to develop SOER for the Gulf of Maine in 2010. Within DFO, the OCMD collaborates with the Science Branch and the Centre of Expertise on State of the Oceans Reporting for large ocean management areas to collectively report on the state of coastal and oceans activities.

CONTACT US

For more information on the above collaborative partnerships, please contact: Jazmine Hayden (jazmine.hayden@dfo-mpo.gc.ca).

Species at Risk Recovery, Planning, and Implementation in the Maritimes Region

Allison Tweedie and Species at Risk Management Division Staff

The North Atlantic right whale – photo courtesy of Lei Harris

The Species at Risk Management Division (SARMD) for DFO's Maritimes Region provides program management, advice, and assistance to other sectors in the implementation of Species at Risk activities. As mandated by the *Species at Risk Act* (SARA), SARMD is responsible for the assessment and listing of species, development of recovery strategies, action plans, and management plans, and for the implementation of those documents through funding initiatives in partnership with universities, environmental organizations, and other government departments. The increase in the endangered North Atlantic right whale population, identification of its critical habitat, and the results of partnering initiatives like the Habitat Stewardship Program illustrate the good work being supported by SARMD.

GOOD NEWS FOR RIGHT WHALES

The North Atlantic right whale (Figure 1), one of Canada's best known marine species at risk, feeds seasonally in waters off eastern Canada and the northeastern United States. The species' small population size, vulnerability to ship and fishery interactions, and low birth rate have presented

Figure 1. The North Atlantic right whale was photographed during DFO field work in the Bay of Fundy – photo courtesy of Lei Harris.

considerable challenges to its recovery. However, 2009 brought some good news to the North Atlantic right whale conservation and research community. The 39 new calves, born in warm waters off Florida during the winter months, was the highest number in recent years. This suggests that the species is capable of reaching a reproductive rate that may allow for recovery. The number of catalogued (known) whales in the population also climbed to 438 individuals by 2009, the highest population count since research on the species started 30 years ago. There is no definitive explanation for the increased calving; however, researchers believe that an abundance of prey in the species' preferred feeding areas and directed conservation efforts in Canada and the United States are responsible.

LOCATING THEIR HOME: EXAMINING CRITICAL HABITAT

Under SARA, SARMD is responsible for developing recovery strategies within one year of a species being added to the Schedule 1 of SARA as *endangered* and two years if listed as *threatened* or *extirpated*. Recovery strategies are planning documents that identify what needs to be done to stop or reverse the decline of a species and they provide a basis for the development of an action plan. Recently, DFO has an added legal obligation that all recovery strategies must identify the species' critical habitat to the extent possible, based on the best available information. Under SARA, critical habitat is defined as the habitat essential for the survival or recovery of the species.

Identifying critical habitats for marine species can be a challenging task, as many of these species are highly migratory and difficult to monitor. For some marine species, their feeding and breeding areas can be thousands of kilometres apart. As well, many marine species move in and out of Canadian waters. Nonetheless, in the past year, progress has been made in identifying critical habitat for some species.

In the case of the right whale, the recovery strategy was finalized in June 2009. This document received input from the Right Whale Recovery Team, which included regional DFO staff and a diverse collection of stakeholders, including scientists, environmental organizations, and industries such as oil-and-gas, shipping, and fishing.

The identification of critical habitat for the right whale was made possible through dedicated research projects including aerial and ship surveys and the analysis of the distribution of right whale prey. Through this research, DFO was able to identify Roseway Basin and Grand Manan Basin as critical habitat. With the completion of the recovery strategy, SARMD will now focus on an action plan which will guide the implementation of the recovery strategy.

The critical habitats of other species also were identified this year. The recovery strategy for the Scotian Shelf population of the northern bottlenose whale is scheduled to be finalized in 2010 and posted on the SARA Public Registry. The proposed strategy, which was posted for public consultation in 2009, identifies critical habitat for the whale in three deep-water canyons on the Scotian Slope: The Gully, Haldimand Canyon, and Shortland Canyon (Figure 2). Specifically, the critical habitats are located in waters more than 500 metres deep where the whale is known to dive to feed on squid.

The recovery strategy for the leatherback turtle was prepared before the obligation to include critical habitat. Therefore, leatherback critical habitat in Canadian waters will be identified in the species' action plan. Like right whales, leatherbacks are highly migratory and feed in Canadian waters seasonally before returning to tropical and subtropical waters. Individual turtles may spend more than five months in Canadian waters. Researchers have equipped leatherbacks with satellite tags that help track their movements, including when they begin to migrate from Canadian waters. The data will be used to identify critical habitat which, in turn, will help direct protection and recovery efforts.

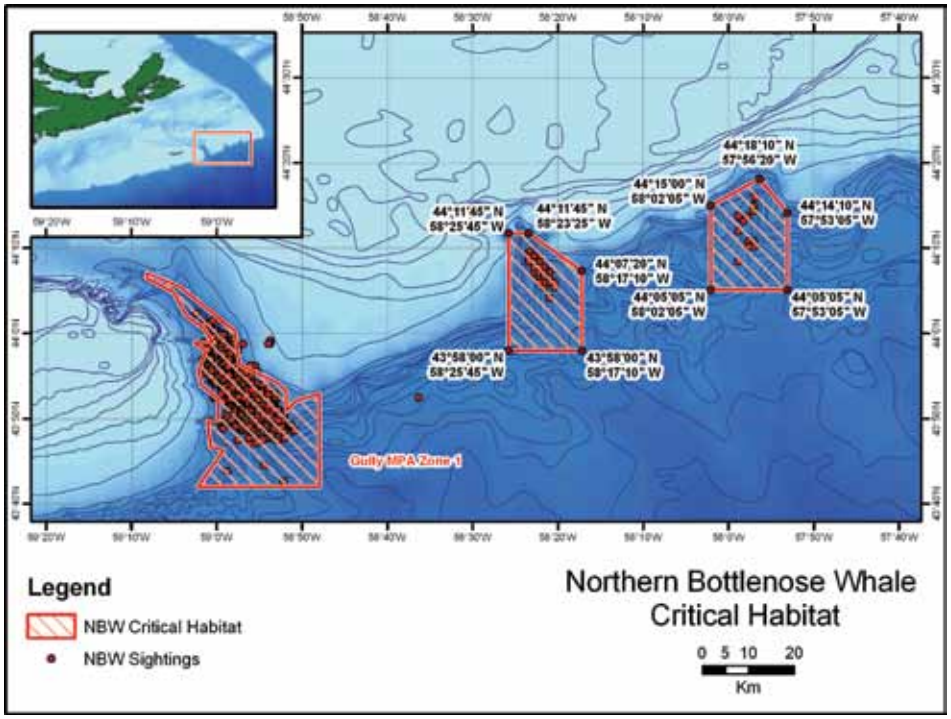


Figure 2. Critical habitat of the northern bottlenose whale: The Gully MPA Zone 1 coordinates are available at: (http://gazette.gc.ca/archives/p2/2004/2004-05-19/html/sor-dors112-eng.html).

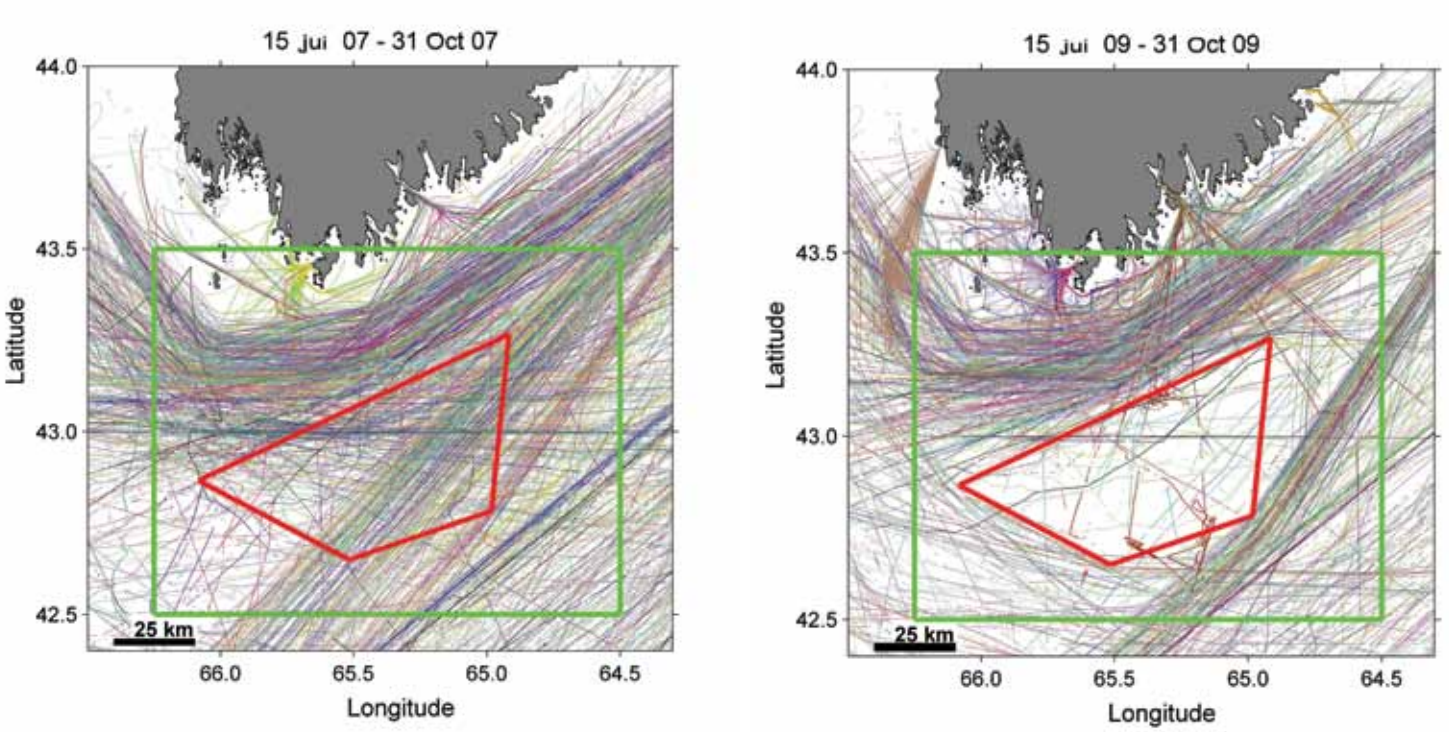


Figure 3. Maps of the Roseway Basin region off southwest Nova Scotia show the Area To Be Avoided (ATBA: red line) and individual vessel tracks prior to ATBA implementation (2007: left panel), and during the second year of implementation (2009: right panel). From: Vanderlaan, A.S.M. and C.T. Taggart. 2009. Efficacy of a voluntary area to be avoided to reduce risk of lethal vessel strikes to endangered whales. Conservation Biology. 23(6): 1467-1474.

WORKING WITH STAKEHOLDERS THROUGH THE HABITAT STEWARDSHIP PROGRAM

DFO collaborates with Environment Canada to administer the Habitat Stewardship Program (HSP). The HSP provides funding for "stewards" (Canadians from all walks of life) to engage in conservation actions to benefit wildlife. HSP projects involve activities that protect or conserve habitat for species at risk on private, provincial Crown, and Aboriginal lands, and in aquatic and marine areas, across Canada.

In 2009, one HSP-funded initiative to help prevent right whale entanglement in fishing gear was led by World Wildlife Fund (WWF) Canada. The WWF consulted with fishing associations from Nova Scotia and New Brunswick to develop a list of standard practices that fish harvesters can adopt to reduce the risk of whale entanglements. One such measure involves shortening buoy lines connected to lobster traps that sit on the ocean floor. When traps are moved from deep water to shallower water, the amount of line floating at the surface can increase, thus increasing the entanglement risk for whales. The new, promoted practice of coiling slack line at the surface reduces this threat. Considering that fish harvesters developed these voluntary rules, they are more likely to adhere to them.

Ship strikes are the leading cause of human-induced right whale mortality. In 2009, Angelia Vanderlaan (now a Post-doctoral Fellow with DFO at the St. Andrews Biological Station), working with Dr. Christopher Taggart and his research team at Dalhousie University, published research describing efforts to mitigate vessel-whale interactions in right whale critical habitat. In partnership with groups including DFO and Transport Canada, the research completed by Taggart's group helped convince the International Maritime Organization (IMO) to designate a voluntary Area To Be Avoided (ATBA) in the Roseway Basin region. The ATBA was precedent-setting, the first in the world specifically designed to reduce the likelihood of vessels striking an endangered whale species. The IMO sent notices to mariners advising them of the importance of this area to right whales and requested they voluntarily avoid the Basin region. With help from Bell-Aliant and their cell towers, Taggart's group recorded vessel traffic in the Basin region before and after the ATBA was established (Figure 3). Their results clearly showed that during the first year of the ATBA implementation, 71% of the vessels in the region chose to avoid the Roseway Basin; this voluntary compliance reduced the likelihood of lethal vessel strikes by 82%. During the second year of implementation, the compliance by the shipping industry reached a stable 80% which reduced the risk to the whales by 93%. The most encouraging part of this story is that it shows the promise of using voluntary initiatives to influence species recovery.

DFO personnel have also implemented right whale recovery initiatives. To help reduce right whale mortality from accidental entanglement in fishing gear, DFO has consulted large-whale disentanglement experts to develop specific training for fishery officers. A successful disentanglement can require more than one attempt, so it is critical to track an entangled whale's position in the open ocean. Satellite and radio-tracking buoys, which can be attached to the entangled gear, were purchased by DFO for this purpose.

LOOKING TO THE FUTURE

Fostering recovery of species like the right whale and others demands a collaborative effort, and the above examples attest to the hard work of many. These advances in the recovery of the species can be attributed to partnerships among DFO, many levels of government, scientists, environmental organizations, and industry members. It is anticipated by SARMD that 2010 will be a busy year, with positive results for not only right whales, but for other SARA-listed species.

Protecting Habitat Together: Tatamagouche Workshop Promotes Collaborative Action

*E. Anita Hamilton, with the Steering Committee for the ENGO-CNGO-DFO Habitat Workshop**

Fisheries and Oceans Canada / Pêches et Océans Canada

On November 5-6, 2009, 42 representatives from environmental and conservation non-governmental organizations (ENGOs and CNGOs), the New Brunswick government, and members of the Habitat Management Program (HMP) of DFO met at the Tatamagouche Centre to discuss the challenges and opportunities in achieving fish habitat protection.

DFO is entrusted with the conservation and protection of fish and fish habitat through provisions of *Canada's Fisheries Act*. This mandate is linked to governmental responsibilities including, but not limited to, water quality, biodiversity protection, climate change, sustainable fisheries, and management of fish habitat. A key activity of the HMP is "partner, stakeholder, aboriginal and public engagement" with a desired outcome that "opportunities exist for individuals and organizations to be engaged and work collaboratively to protect and conserve fish habitat".

In 2006, following a national workshop coordinated by the Canadian Environmental Network (RCEN) and DFO, the ENGO-DFO National Fish Habitat Coordinating Committee** (NFHCC) was formed to provide a vehicle for increased communication around the issue of fish habitat protection. The RCEN selected delegates from four ENGOs and representatives from DFO to sit on the NFHCC. This Committee recommended regional workshops to enhance relationships and communication between regional DFO fish habitat management programs and environmental and conservation groups.

Two national workshops have been held, one in October 2006 and another in November 2007. The purpose of these workshops was to create a forum for the discussion of habitat issues in Canada, to educate NGOs about the HMP, and to solicit advice from NGOs on practical ways to improve the protection of fish and fish habitat in Canada. The workshop in Tatamagouche was unique in that two DFO Regions—Maritimes and Gulf—participated, in order to invite NGOs from the three Maritime Provinces. Attendees included representatives from ENGOs and CNGOs involved in fish habitat protection activities, five delegates from First Nations, representation from the Nova Scotia government, and HMP personnel from the National Capital, Gulf, and Maritimes regions.

The workshop began with presentations from DFO and the RCEN on their mandates and the rationale for the workshop. Representatives from the Kennebecasis Watershed Restoration Committee and the Nova Scotia Adopt-A-Stream Program presented two case studies, which laid the foundation for facilitated discussions about the issues, challenges, and opportunities for fish habitat protection in the Maritime Provinces.

The primary issues for fish habitat management were identified as:

- barriers (e.g., causeways, poorly installed culverts, dams) to the passage of fish in watercourses and estuaries
- organic contamination (e.g., sewage) caused by the release of toxins and organics into the water
- the cumulative impacts of human development (e.g., wharf and highway construction, subdivision development).

The primary challenges are:

- the capacity of NGOs to secure long-term funding in support of their initiatives
- understanding jurisdictional mandates and how they link to habitat protection
- educating the public and industry on the importance of fish habitat
- addressing knowledge gaps.

This workshop opened the door to explore opportunities to improve the state of fish habitat in the Maritime Provinces. Participants recognized that part of that exercise is to improve communication between DFO and environmental and stewardship organizations. DFO cannot protect, conserve, and restore aquatic habitats alone. This responsibility needs

Participants in session at the Protecting Habitat Together workshop in Tatamagouche. Photo courtesy of Susanna Fuller

The Tatamagouche Centre, Tatamagouche, Nova Scotia, was the scene of the habitat workshop. Photo courtesy of the Tatamagouche Centre

Break-out session at the Tatamagouche workshop

to be shared with other government organizations, NGOs, communities, and individuals. There has to be better understanding of the issues and activities underway and those being planned by organizations, in order to optimize collaborative opportunities and integration of restoration activities within larger management plans. Stakeholders must be aware of the mandates of governments and be fully engaged in the review and development of policies that influence government.

There is an immediate need to explore ways to improve collaboration and to identify opportunities for cooperative action. To that end, the group agreed to:

- publish a report of the workshop and make it available to the general public
- explore potential opportunities for undertaking a mapping exercise that will identify aquatic habitat issues of concern.

The workshop report will be available by April.

*ENGO-CNGO-DFO Habitat Workshop Steering Committee:

Steering Committee co-chairs: Susanna Fuller (Canadian Environmental Network) and Bill Ritchie (DFO)
Steering committee members: Shannon Arnold (Ecology Action Centre), Anita Hamilton (DFO, Maritimes Region), Bob Rutherford (Nova Scotia Salmon Association), Fernand Savoie (DFO Gulf Region), Andy Sharpe (Clean Annapolis River Project), and Amy Weston (Adopt-A-Stream Program).

**ENGO-DFO National Fish Habitat Coordinating Committee

Susanna D. Fuller (Ecology Action Centre)
Olga Schwartzkopf (The Soil and Water Conservation Society – BC Chapter)
Anne-Marie Turgeon (Nature-Quebec)
John Werring (David Suzuki Foundation), ENGO Co-chair
Alternate: Cliff Wallis (Alberta Wilderness Association)

TECHNICAL SUPPORT

Research Voyages in 2009

Donald Belliveau

Researchers at BIO utilize the following research vessels based at the Institute and operated by the Canadian Coast Guard (CCG), Maritimes Region:

CCGS *Alfred Needler*, a 50-m offshore fisheries research trawler;
CCGS *Hudson*, a 90-m offshore research and survey vessel;
CCGS *Matthew*, a 50-m coastal research and survey vessel.

In addition, BIO scientists conduct field programs on CCG research vessels from other DFO regions, vessels of opportunity (e.g., CCG buoy tenders and icebreakers, commercial fishing ships, and survey ships), and research vessels of other countries. The CCGS *Creed*, based in the Quebec Region, was used by NRCan's Geological Survey of Canada (GSC) for multibeam survey work in the Gulf of St. Lawrence. Researchers from NRCan and hydrographers from the Canadian Hydrographic Service (CHS) participated in surveys from the *Louis S. St-Laurent* in support of Canada's United Nations Convention on the Law of the Sea (UNCLOS) program. The CHS also had a hydrographer aboard the Swedish Icebreaker *Oden* which was conducting a joint Canada-Denmark UNCLOS survey over the Lomonosov Ridge. The North Pole was visited on that voyage. BIO researchers participated in the joint Canada-Spain program, NEREIDA, aboard Spanish research vessels off the Flemish Cap, to investigate the Northwest Atlantic Fisheries Organization (NAFO) fishing areas off Canada's east coast. Surveys normally conducted on the CCGS *J.L. Hart*, a 20-m inshore research vessel, were conducted on a series of charter vessels in 2009 because the *Hart* was removed from service and the replacement vessel was not yet available.

The CCGS *Alfred Needler*'s principal role is in stock assessment surveys. The *Needler* was used for the annual winter survey on Georges Bank and the Scotian Shelf. Continuing problems with the trawl winch and engines resulted in only 35% of the survey stations being sampled. Coverage was limited to portions of Georges Bank and the (NAFO) Area 4W. In April, the *Needler* sailed to St. John's, Newfoundland and Labrador (NL), and worked for two-and-a-half months on the NL Region spring survey. The vessel returned to BIO for the annual July Scotian Shelf survey, which was completed with more sites fished than in the previous two years. After a maintenance break, the *Needler* was used to study the deep-water species in The Gully Marine Protected Area (MPA), before returning to the NL Region to conduct an annual scallop survey. The vessel was then used in the research of the distribution of Atlantic Salmon between Labrador and Greenland, as part of an international study. The *Needler* stayed in the NL Region to participate in the fall survey and returned to BIO in mid-December.

The CCGS *Hudson* started her year in early April. The first cruise was for the Maritimes Region annual spring Atlantic Zone Monitoring Program (AZMP). This cruise collects data on water properties, temperature, salinity, nutrients, dissolved oxygen, and plankton biomass for the annual *State of the Ocean Report* and for focused research projects. The second cruise serviced moorings in Orphan Knoll and the Laurentian Fan off Newfoundland. The vessel then sailed to the Labrador Sea to service oceanographic moorings and collect conductivity, temperature, and depth data in oceanographic survey operations, as part of Canada's contribution to global climate studies. The *Hudson* returned to the Labrador Sea in June for NRCan to conduct refractions studies using ocean-bottom seismometers. On this highly successful cruise, five lines over tectonic plates were collected to supplement existing data. In July, as the Canadian contribution to NEREIDA, the *Hudson* conducted drop-camera and video studies of sponge concentrations on the slopes of the Flemish Cap, in support of NAFO conservation measures. The same cruise returned to the Stone Fence Coral Conservation area where, after a five-year closure to fishing, a recovery of corals was noted. Finally, the first video and camera surveys were conducted around St Anns and Missaine banks, which are candidate areas for an MPA. In August, the *Hudson* worked in the Gulf of Maine Discovery Corridor conducting video surveys and benthic ecological studies as part of the Canadian Healthy Oceans Network (CHONe) program. CHONe is a strategic network focused on biodiversity science for the sustainability of Canada's three oceans, and includes researchers from 15 universities across Canada, DFO, and seven other government laboratories. This cruise hosted research teams from two Atlantic universities, including four CHONe graduate students. The

In 2009 the CCGS *Matthew* and her two launches conducted a hydrographic survey operating out of Summerside, Prince Edward Island. The multibeam seabed survey was in support of DFO Gulf Region's Ecosystem Research Initiative. This initiative included mapping Northumberland Strait on both sides of the Confederation Bridge. Pictured here is the *Matthew*'s multibeam-equipped survey launch *Plover* in the foreground and in the background the CCGS *Opilio* conducting a benthic sampling survey. Photo courtesy of Mike Lamplugh

2009 cruise obtained additional marine geological information and benthic habitat characterization that will be used to target 2010 studies that will include use of the deep-water Remotely Operated Vessel ROPOS for high-resolution imaging and sample collections. NRCan used the ship in September for geophysical research in the Bay of Fundy and off the Grand Banks. The Bay of Fundy work was undertaken to supplement a mapping series of geological structures. They conducted sidescan surveys, piston coring, bottom photography, grab sampling, and seismics for geophysical research. The Maritimes Region's fall AZMP cruise was conducted in October. From late October to mid-November, oceanographers from the Institut Maurice Lamontagne in the Quebec Region conducted their fall AZMP/Ice Forecast cruise in the Gulf of St. Lawrence. From late November to mid-December, the *Hudson* was used to conduct the fall AZMP cruise of the Northwest Atlantic Fisheries Centre in St. John's, NL. The season concluded on December 10 when the ship entered her refit period with a drydocking in St. John's.

The CCGS *Matthew* is primarily a hydrographic vessel which can carry two hydrographic launches and conduct surveys with its high-resolution Kongsberg EM710 multibeam sonar system. After local equipment trials in May, the *Matthew* conducted surveys in the Northumberland Strait and then in unsurveyed waters around Penguin Island off the south coast of Newfoundland. This was the second year of a multi-year survey in the area. Enroute to this unsurveyed area, the *Matthew* conducted reconnaissance surveys on the northwest coast of Cape Breton Island, looking for submarine geothermal vents, and continued a survey from 2008 looking for the HMCS *Shawinigan* which was torpedoed in November, 1944, off Port Aux Basques. In June, the *Matthew* moved to the north coast of Newfoundland to continue

surveys in Bonavista Bay and around Fogo Island. During this period, the *Matthew* investigated an underwater landslide/slump area off the northern coast of Newfoundland. The *Matthew* headed for the Labrador coast in July. NRCan conducted the fourth year of on-going studies on iceberg scours on Makkovik Bank. The vessel spent from mid-August to mid-September surveying to expand the safe shipping channels in the Voisey's Bay area, then from early October until early November, conducted a joint CHS-NRCan survey in the Bay of Fundy. On November 4, the *Matthew* returned to BIO for the winter.

Replacement of our ageing scientific research fleet is a high priority. Plans are underway to replace the *J.L. Hart*; preliminary design work was started in 2006. Delivery is expected in 2011. Two replacement trawlers, one for each of the east and west coasts, were announced in the spring 2005 federal budget; a third was added in 2007. The vessels are anticipated to be delivered in 2013-2014. The replacement for the *Hudson* is moving ahead; the design contract should be let in 2010, with delivery of the ship in 2013.

The Dartmouth Technical Workshop Supports BIO Science

Milo Ewing and Paul McKiel

Senior Technologist, Milo Ewing, performs annual maintenance on the harbour surveillance radar system.

The Dartmouth Technical Workshop (DTW), located at BIO in the Vulcan building, is one of several Electronics and Systems Maintenance (E&SM) workshops within the DFO Maritimes Region. The DTW is part of the Canadian Coast Guard (CCG)'s Integrated Technical Services (ITS) Directorate, under the Superintendent of Electronics and Informatics.

The DTW has been at BIO since April 2003. Previously, it was located at the Dartmouth Coast Guard Base, where it was known as the Ships Electronic Workshop (SEW) Dartmouth. The DTW was formed from the amalgamation of SEW Dartmouth and the former Halifax Coast Guard radio workshop at Ketch Harbour. This newly formed group and the Dartmouth-based marine navaids technicians were relocated to the BIO campus as an initial move toward relocating the CCG to BIO from the Dartmouth Coast Guard base. The marine aids techni-

cians have since returned to the Dartmouth Coast Guard base, under the Marine Civil Infrastructure group, with ITS.

The DTW comprises a Supervisor of Technical maintenance, two senior electronics technologists—one for land-based and one for shore-based systems—and 20 working-level electronics technologists. With the implementation of the Coast Guard regional reorganization, the group will eventually comprise two area supervisors, and approximately 15 working-level electronics technologists.

The role of the DTW is to provide technical support to Coast Guard's electronics and informatics systems, both on ships and at the Coast Guard radio centres in the Maritimes Region, and to the associated remotely controlled equipment sites. This is a 24-hour, 7-day operational environment, with weekends covered by a rotational standby schedule.

The DTW supports a wide variety of systems, including land- and ship-based radar; gyrocompasses; electronics chart systems; VHF, MF/HF,* and air-ground radio communication systems; ships' internal communications; satellite-based communications systems; and Marine Communication and Traffic Services centres' systems. Increasingly, computer- and network-based systems are being installed at Coast Guard sites, and the technicians have had to develop the expertise to maintain these systems.

In recent years, the ITS directorate has undergone a re-organization, which has resulted in the loss of a specialized workshop that was responsible for all electronic system installations for Coast Guard, in the Maritimes Region. As a result, the installation portion of that work has become the responsibility of the DTW and its sister workshops throughout the region.

DTW staff have been involved with a variety of high-profile voyages over the years: the CCG *Louis S. St-Laurent*'s trip to the North Pole in 1994, the SHEBA project in the Arctic Ocean (1997-1998), the Polar Institute trip (Tundra 99) in 1999, several UNCLOS missions, the Oceanstec trade mission in 1998, and the Hurricane Katrina relief mission on the CCG *Sir William Alexander*. They have also responded during emergencies such as the Swissair disaster and Hurricane Juan.

The DTW operates in an exciting and dynamic environment, with no two days being the same. The work is always demanding, and the DTW has proven to be a rewarding career for those who have passed through its doors. The future holds many challenges, both in the technical and human resource fields, but the DTW is up to that challenge.

Chad Maskine works on the NAVALINK system for helicopter operation; Kevin McGuigan, the ship's navigation officer, is in the background.

Heather Kinrade at work in the forward oceanographic lab aboard CCGS *Louis S. St-Laurent*

*Very High Frequency; Medium Frequency/High Frequency

CELEBRATIONS

Celebrating the 40th Anniversary of the *Hudson 70* Expedition

Charles Schafer, Claudia Currie, and David Frobel

Peter Wadhams, who was part of the *Hudson* 70 expedition, instigated the anniversary celebration at BIO. Now a professor in the Department of Applied Maths and Theoretical Physics at Cambridge University, he is seen here in the Beaufort Sea north of Alaska, March 15, 2007. The HMS *Tireless* is surfacing beside APLIS-2007 ice camp after carrying out an ice thickness survey under the camp.

When the CCS *Hudson* sailed into Halifax Harbour on October 16, 1970, it became the first marine research vessel to circumnavigate the Americas on a single voyage. The 40th anniversary celebration of the *Hudson 70* expedition was held at BIO, November 17-18. On November 17, the public was invited to visit the CCGS *Hudson* to view a series of displays depicting the voyage; the exhibits were set up in the main laboratory, the plotting area, and on the ship's afterdeck. A ceremony to recognize the participants and their accomplishments on the expedition followed. More than 50 of the original scientific staff and ship's crew were piped into the auditorium; they had travelled from

The *Hudson 70* commemorative coin

Dr. Bernie Pelletier (center), Chief Scientist on the Beaufort leg of the *Hudson* voyage, receives his commemorative gifts from, left to right: Gary Sidock (Director-General, Fleet, CCG), Stephen Locke (Director, GSC Atlantic, NRCan), and Michael Sinclair (Director, Maritimes Region, DFO Science).

Hudson 70 participant, Roger Smith (left), and Richard Smith, former captain of the CCGS *Hudson*, discuss the vessel at the Coast Guard display.

Time capsules with *Hudson 70* memorabilia

across Canada, Florida, and the United Kingdom to attend. Opening remarks were given by Roger Smith, who, as a young man, took leave from his graduate studies at Queen's University to be part of the voyage. Roger then introduced three speakers representing the Canadian Coast Guard, NRCan, and DFO, who gave their perspectives on the significance of the expedition.

Those short presentations were followed by Ed Murray (NRCan, retired) who provided details about two time capsules prepared for the 40th anniversary ceremony. One of the capsules will be taken in 2010 to Resolute on Cornwallis Island in Nunavut and buried at the site of the *Hudson 70* plaque erected there in 1970. The other will be kept in the

BIO library, to be opened upon the 100th anniversary of BIO, in 2062. Ed also told about two time capsules left by Tom Foote in the Antarctic in 1970. The capsules contained information about the expedition and were left behind for future visitors to discover.

Ed's talk was followed by a presentation of commemorative items to each of the *Hudson 70* participants, including a coin engraved with a map of the expedition and a pen crafted from a section of the *Hudson*'s teak starboard railing.

Following the presentations, everyone was treated to a song, *The Mighty Hudson*, written by Philip Spencer (NRCan) and sung by Patrick Potter (NRCan). After the ceremony, celebrants, with their friends and families, went aboard the *Hudson* for lunch and to view the displays.

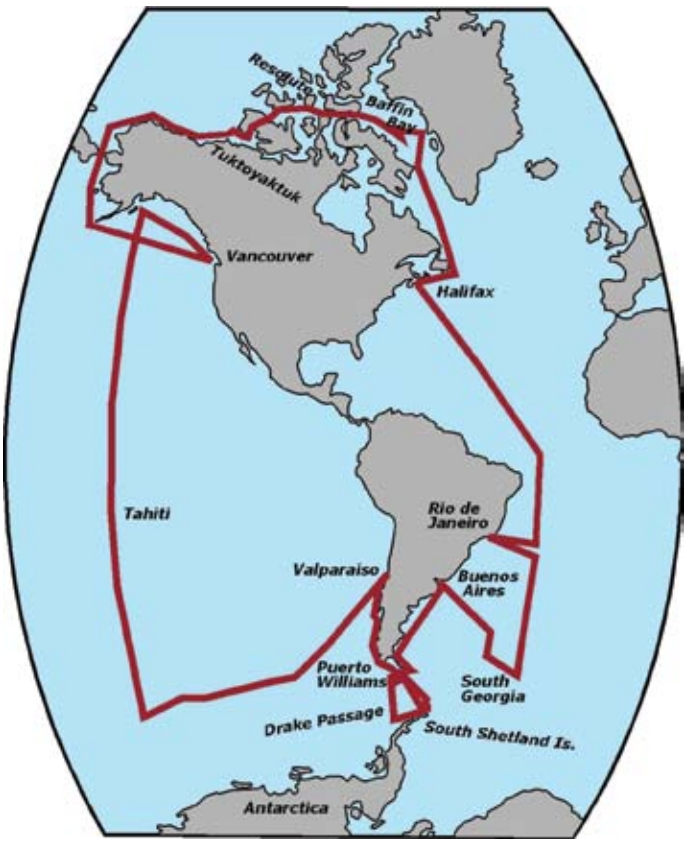
On November 18, four scientists who participated in the expedition gave presentations on their experiences and scientific projects carried out during the voyage. Professor Peter Wadhams of Cambridge University, who sailed on every leg of the voyage as a young graduate, also gave a presentation. By the end of the two-day event, many old friendships had been renewed and everyone seemed to have a new understanding of what had been accomplished both scientifically and logistically by this unique Canadian marine research effort.

Hudson 70 – What Was Accomplished

Charles Schafer, Claudia Currie, and David Frobel

After a year of hectic preparation and with the support and enthusiasm of Canada's Minister of Energy, Mines and Resources (Joe Greene), the CSS *Hudson* sailed south from Halifax on November 19, 1969, and returned on October 16, 1970, to become the first marine research vessel to circumnavigate the Americas on a single voyage.

The *Hudson* sailed more than 100,000 kilometres and, including all legs of the voyage, carried 122 scientific staff from several countries. She returned home with an impressive collection of samples and observations that would become the focus of scientific investigations for decades to come. Much of the credit for this unprecedented Canadian accomplishment goes to the crew of the *Hudson*, especially to captains David Butler and Fred Mauger, and to three BIO staff who came up with the idea a few years before: Dr. Cedric Mann, Dr.



Map shows the route of the CSS *Hudson*'s 1970 circumnavigation of the Americas.

Lowering plankton nets to sample drifting organisms in the marine water column

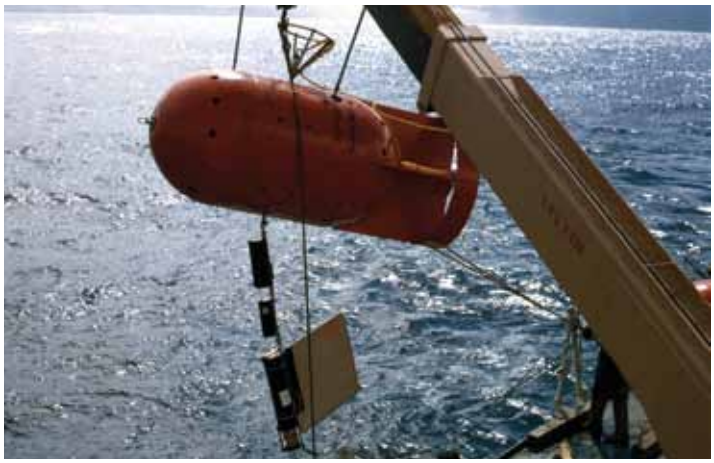
A dredge haul from the seabed surface is brought on board for analysis.

Recovering a bottle of sea water from a known depth for chemical analysis

William Ford, and Captain Walter Kettle.

The first leg of the *Hudson*'s voyage of discovery took the expedition to the south, toward the sub-Antarctic Island of South Georgia. Along the way, acousticians, biologists, chemists, geologists, and physical oceanographers carried out studies that targeted the distribution of a variety of physical oceanographic parameters and biological species on an ocean-wide scale. Plankton hauls were made, acoustic characteristics of the deep-scattering layer were mapped, and mid-water trawls to sample fish populations were done. Seawater samples were collected for chemical analysis, and for the determination of particle content and a suite of standard oceanographic parameters such as temperature and salinity.

From the South Georgia Island area, the *Hudson* sailed west toward Buenos Aires and then proceeded south along the coast to carry out surveys between South America and Antarctica. Four buoys, each carrying an array of three current meters and three temperature recorders attached to their mooring lines at different water-depth intervals, were moored at predetermined locations across Drake Passage.



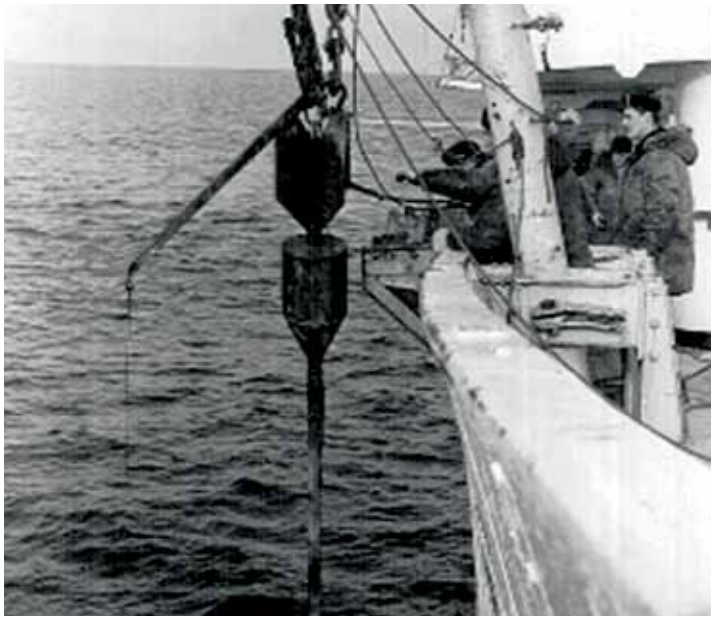
Deployment of current meter array in Drake Passage

Data recorded during the 11-day deployment represented the first comprehensive current speed measurements ever made across this important connection between the Earth's two major oceans, the Atlantic and the Pacific. While the CSS *Hudson*'s crew were deploying the four oceanographic moorings, a launch party dropped off at Puerto Williams on the southern coast of Chile collected samples of marine invertebrates and inter-tidal algae in the coastal channels of Tierra del Fuego.

From Puerto Williams, the *Hudson* sailed to Punta Arenas where a team of Chilean scientists came aboard to collaborate with their Canadian counterparts in a study of the physical oceanography, chemistry, and biological life of the largely unexplored marine habitats of the Chilean fjords. Thirty-three fjords were surveyed, several using one of the *Hudson*'s lifeboats. The conclusion of the Chilean fjords survey brought the ship to Valparaiso, Chile, on April 15, and then toward the 150-degree meridian west, where measurements aimed at sampling the Earth's magnetic and gravity fields along a mid-ocean transect were initiated and would continue all the way along the meridian to latitude 55 degrees north.

The *Hudson* arrived in Vancouver in early June after completing a four-week geophysical survey off the coast of British Columbia. On August 14, she departed Victoria, heading north to the western Arctic on the final two legs of the voyage that would traverse the northwest Pacific Ocean, the Chukchi and Beaufort seas, the Northwest Passage, and Baffin Bay before steaming back to

Bosun, Joe Avery (left) and chief scientist, Bernie Pelletier, erect a plaque near Resolute, Cornwallis Island, Nunavut.



Crew deploys a corer to investigate sedimentation history in the Beaufort Sea.

Halifax. *Hudson 70*'s exploration of the Canadian Arctic offshore was completed in two legs. Both had a strong emphasis on marine geology and geophysical surveying of the seafloor. Sidescan sonar and reflection seismic profiling to water depths of 60 metres revealed deep and intensive ice scouring of the sea floor, and the existence of dozens of underwater ice-cored mounds (pingos) as much as 100 kilometres from shore.

On September 30, the *Hudson* left Resolute Bay, Nunavut, to begin the final leg of its circumnavigation of the Americas. At this time, the ship was coordinating its survey program with the CSS *Baffin* and the U.S. Coast Guard cutter *Edisto*. *Edisto*'s mission was to serve as the "shooting ship" for a series of refraction seismic experiments in which the necessary sound waves would be generated by detonating explosives. Upon concluding the refraction seismic survey in Baffin Bay, the *Hudson* started the long trip home and arrived in Halifax on October 16.

Following welcoming celebrations, scientists and BIO technical staff began analyzing samples and data recordings collected during the voyage. Publications based on these observations continued to appear for more than 21 years after the event, with at least one Arctic environmental atlas still to come. During the fifteen years following the expedition, scientific findings and preliminary results of a diverse suite of marine science investigations were published in peer-reviewed journals, government publications, and as graduate-student theses. The expedition provided a once-in-a-lifetime opportunity for marine researchers from across Canada to come together in a common venture to extend their investigations to relatively inaccessible areas of the oceans. It took place at a time when assessment of the marine environment on a global scale was becoming increasingly important to governments and individual environmentalists.

Authors' note: the information for this article was extracted from a series of articles and a book published several years after the completion of the expedition, and from the *Hudson 70* cruise report.

Senior officers and scientists celebrate the successful completion of the Northwest Passage.

Celebrating the return of the CSS *Hudson* after its historic, 11-month circumnavigation of the Americas

Darwin 2009 Celebrations

Mike Sinclair and William Li

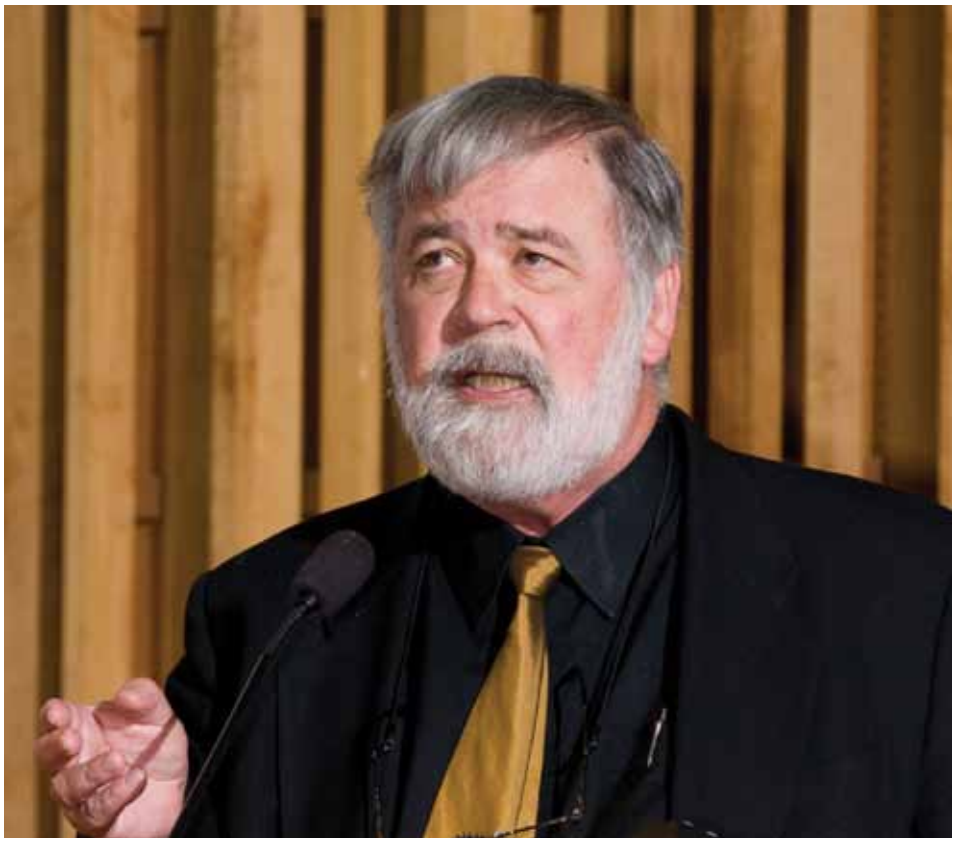
In collaboration with Dalhousie University and the Nova Scotian Institute of Science, BIO celebrated throughout 2009 the bicentenary of Charles Darwin's birth and the 150th anniversary of his book, *On the Origin of Species*.

Two of the events were held at BIO. On May 5, we were fortunate to have Symphony Nova Scotia, led by Resident Conductor Martin MacDonald, perform a selection of classical music that made connections with Darwin's home life at Down House in Kent and his adventures on the voyage of the *Beagle*. Later, Ford Doolittle, a professor at Dalhousie University, introduced Niles Eldredge of the American Museum of Natural History in New York. Dr. Eldredge gave a marvellous lecture, *Darwin: Discovering the Tree of Life*, which traced Darwin's exploratory and intellectual journeys that led to perhaps the most important scientific idea of the last 150 years, the Theory of Evolution.

The second event held was on November 20. To set the scene, Peter Thamer of DFO's Ecosytem Research Division played a piano piece by Mozart, one of Darwin's favourite composers. Then Marlon Lewis, also a professor at Dalhousie University, introduced Paul Falkowski, a former recipient of the Huntsman Medal and a professor at Rutgers University. In his spellbinding lecture, *The Evolution of the Electronic Blueprint of Life on Earth*, Dr. Falkowski showed interconnections between Earth's biogeochemical processes and the evolution of catalyzed chemical reactions that are housed in living organisms.

BIO staff participated in two workshops on evolution. On October 23 at the annual conference of the Nova Scotia Association of Science Teachers, held at Halifax West High School, Sonya Dehler, Rob Fensome, Patrick O'Reilly, and Graham Williams gave presentations throughout the day. Also, Graham Williams held a half-day workshop for student teachers at Mount St. Vincent University on November 20.

The mixture of music, lectures, and workshops resulted in a very special year for all those interested in Darwin, both as a generous and warm-hearted family man and because of his extraordinary body of intellectual work.



Dr. Niles Eldredge

Dr. Paul Falkowski

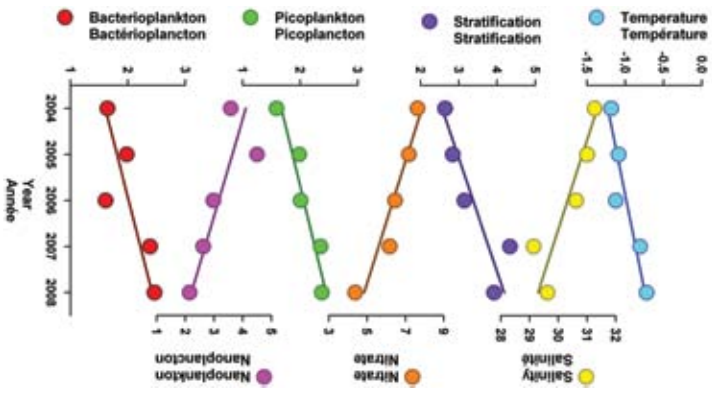
RETROSPECTIVE 2009

Highlights and Emerging Issues

Smallest Algae Thrive as the Arctic Ocean Freshens

William Li

As climate changes and the upper Arctic Ocean receives more heat and fresh water, it becomes more difficult for mixing processes to deliver nutrients for phytoplankton growth from depth to the surface. Small cells will presumably do better than large cells because they are more effective in acquiring nutrients and less susceptible to gravitational settling. Since 2004, DFO researchers in the Maritimes and Pacific regions have discerned an increase in the smallest algae and bacteria along with a concomitant decrease in somewhat larger algae in the Canada Basin of the Arctic Ocean. A long-term trend cannot be established without a much longer observational time series because of inter-annual variability. However, if current changes persist, an altered food web might be a plausible outcome because small algae are eaten only by other micro-organisms, and not directly by larger animals.

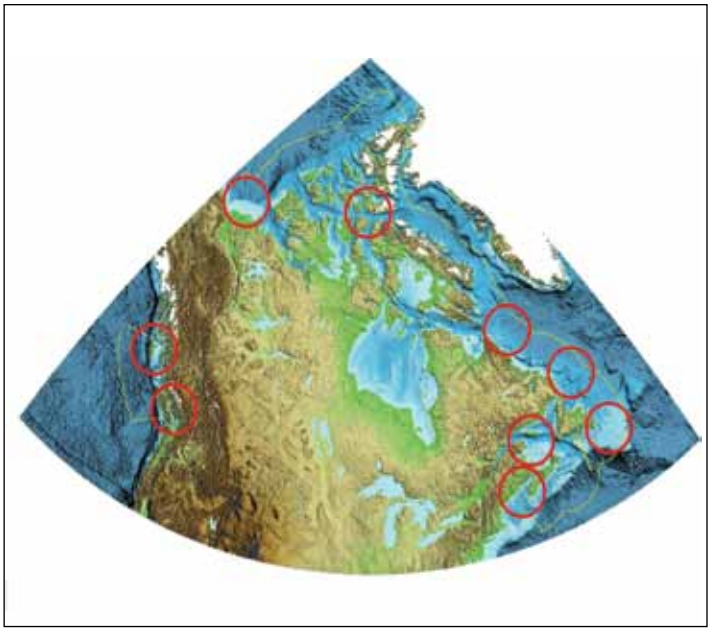


In the Arctic Ocean from 2004 to 2008, water temperature increased and salt content decreased, causing a stronger vertical separation of the water column. This led to a reduced concentration of nutrients in the upper ocean that favoured an increase of small cells (picoplankton, bacterioplankton) and a decrease of large cells (nonoplankton).

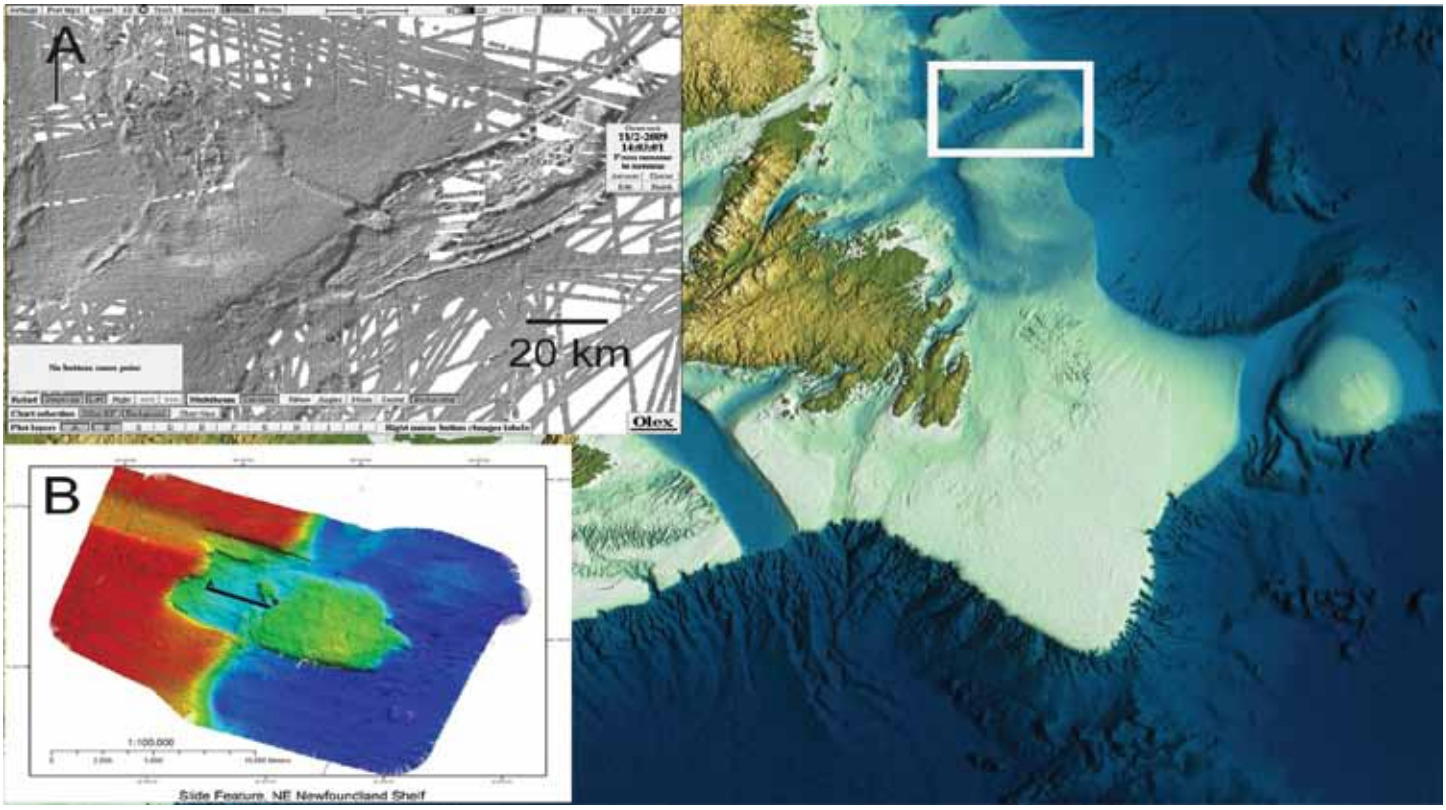
A New Marine Program at the GSC Atlantic

John Shaw

NRCan's successful Geoscience for Ocean Management Program (2003-2009) delivered geoscience knowledge to make informed decisions regarding Canada's offshore lands. The program resulted in extensive seabed mapping in priority areas identified in Canada's Oceans Action Plan. The long-term goal of the successor program—the Offshore Geoscience Program (2009–2014)—is to facilitate economic development via assessment of hydrocarbon resources, identification of development constraints, and provision of geoscience information to other government departments. GSC Atlantic participates in this program along with GSC staff in British Columbia and Quebec.



Areas of activity under the new Offshore Geoscience Program



The base map shows the location of the slide complex (white box) in Notre Dame Channel. Inset map A shows the main portion of the complex, including the 150-m-high failure slope, and grooves made on the sea floor by far-travelled blocks of bedrock. Inset map B shows a higher-resolution, depth-colour-coded, multi-beam image of the 150-m-high rectangular block that is also visible on inset A.

The new project suite includes:

1) basin analysis and resource geoscience (assessment of hydrocarbon resources off Atlantic Canada);
2) geoscience for East Coast offshore development (mapping and sediment transport modeling off Newfoundland and Labrador);
3) Arctic economic development (providing geoscience information to facilitate sustainable development of coastal and marine resources);
4 offshore renewable energy (tidal energy in the Bay of Fundy, wind farm development in British Columbia);
5) ocean management geoscience (provision of information to other agencies); and
6) data and technology services (in support of the other projects).

Discovery of a Vast Submarine Slide on the Newfoundland Continental Shelf

John Shaw, David J.W. Piper, David C. Mosher, Robert C. Courtney, and Michael Lamplugh

Shaded-relief images of the continental shelves of Atlantic Canada, based on compilations of echo-sounder data from research vessels, show deep troughs separated by offshore banks. Higher-resolution Olex ocean-mapping imagery, based on data from fishing vessels, has revealed a large submarine slide complex on the flanks of Notre Dame Channel, consisting of a failure escarpment 150 m high and 120 km long, and a jumble of large bedrock blocks on the sea floor, some of which have travelled nearly 40 km (figure inset A). In the summer of 2009 the Canadian Hydrographic Service surveyed one of the smaller failure blocks (figure inset B) and also a second failed block, 120 km to the southwest. These slides appear to be aligned along a possible seafloor fault that extends southwest toward Newfoundland.

This discovery is of great interest because it was generally believed that large failures were confined to the upper continental slope and to fjords. A slide of this magnitude is capable of creating a highly destructive tsunami, so it is now a matter of some urgency for NRCan staff to ascertain the age of this slide, and determine its cause.

BIO Outreach

Thomas W. Sephton

Anna Dorey of DFO's Population Ecology Division shows Grade 9 students the key features to identify local shark species.

The BIO Outreach Program is a joint effort among all science departments based at the Institute and is managed by DFO Science. Ocean education in its broadest sense is considered essential and staff endeavour to translate BIO research, monitoring, advisory activities, and data management to a level that is easily comprehended by the public. To keep pace with other public education venues in the area, efforts were initiated in 2009 to improve our BIO Ocean Education Centre displays using the latest advancements in touch-screen technology. The historical archives from the *Hudson'70* voyage of discovery were used as the test subject, with excellent results and feedback. The BIO website was totally re-vamped and successfully put back on-line by mid-summer. BIO participated in the annual, national *Take Your (Grade 9) Kid to Work Day* on November 4, when 16 local students toured the Institute to learn more about marine science and the qualifications needed to work here. They were introduced to a number of subjects including sediment cores, LED electronics, gold mine tailings, sharks, and rare deep-water fish species. It was a fun and informative day for these budding marine scientists who visited the Institute.

The BIO Outreach Tour Guide program was once again a successful venture, reaching thousands of local and international visitors. As in previous years, the majority of visitors were aged 6-12, accompanied by their teachers, day camp leaders, and grand-parents. More than 5,000 people were booked for tours given by the two student tour guides. Special tours were arranged for VIP groups that included representatives from the Department of Foreign Affairs and International Trade, Industry Canada (Science and Technology Branch), the Spanish Steering Committee for the Canary Island Oceanic Platform Project, and Dalhousie University's Research Services and Ocean Governance, Policy, Law, and Management course.

Education Outreach at the Geological Survey of Canada (Atlantic)

Jennifer Bates, Sonya Dehler, Gordon Fader, Rob Fensome, Dave Frobel, Nelly Koziel, Bill MacMillan, Bob Miller, Michael Parsons, Patrick Potter, John Shimeld, Bob Taylor, Dustin Whalen, and Graham Williams

The Geological Survey of Canada (GSC) (Atlantic) participated in a number of Canada's activities associated with the United Nations International Year of Planet Earth (IYPE). GSC Atlantic staff are playing key roles in *Four Billion Years and Counting: Canada's Geological Heritage* which will be a cornerstone of Canada's contribution to the celebration of the IYPE. The development of this landmark publication on the geology of Canada represents tremendous efforts by more than 100 contributors and seven editors. The book, to be co-published by the Canadian Federation of Earth Sciences and a commercial publisher, comprises three major sections: Foundations, Evolution of Canada, and Wealth and Health. It will be attractively illustrated, with photographs, paintings, and schematics. The publication of the French version will soon follow that of the English. The book project website is: (www.earthsciencescanada.com/4by).

GSC Atlantic also contributed to the WHERE challenge which educates high school students about non-renewable Earth resources (www.earthsciencescanada.com/where/)

and to the Careers website, which informs about careers in the earth sciences (www.earthsciencescanada.com/careers).

Throughout the year, many GSC Atlantic staff gave invited talks at schools, universities, and libraries, and judged at science fairs. Much of this participation was co-ordinated by the Atlantic Science Links Association at Dalhousie University.

The cliffs of Joggins, a UNESCO World Heritage Site, have been of interest since the days of Sir William Dawson and Sir Charles Lyell (the mid-1800s). Most recently, the 2010 EdGEO participants were introduced to this outstanding example of the Pennsylvanian Coal Age by Dr. John Calder of the Nova Scotia Department of Natural Resources.

A spectacular day at Five Islands afforded the EdGEO workshop participants a lunch-and-learn opportunity. The coastal section reveals the Triassic/Jurassic boundary that represents a major mass extinction event.

The GSC Atlantic works in partnership with the Atlantic Geoscience Society through its EdGEO, Video, and Education committees to provide popular education programs and activities. Membership of these committees includes provincial geological surveys, museums, science centres, universities, and schools.

EdGEO is a national program that supports local workshops on earth science for Canadian teachers. The Nova Scotia EdGEO Workshop Committee has organized workshops throughout Nova Scotia since 1994. The Committee strives to deliver a year-round program that includes its annual field-based workshop in August plus hands-on sessions throughout the year at a variety of education venues such as the Association of Science Teachers' annual conference in Halifax. Teachers now have more professional development opportunities while committee members have more chances to present the wide variety of geoscience topics of interest to educators.

The 16th annual summer workshop was held August 17-18 in the Parrsboro-Joggins area where world-class geological sites abound. Twenty-four educators attended. Days were split between hands-on activities and field trips. The Fundy Geological Museum and the Joggins Fossil Centre graciously offered their facilities. For the first time, the activities and field trips were video-captured with the expectation of posting to the education website, EarthNet.

The workshop program continues to receive enthusiastic responses from the participants, such as:

"I feel that this was a great opportunity … I know that I am much better prepared to present the Grade 4 Rock & Mineral Unit – We will ROCK!!"

Financial support for the August workshop was generously provided by the National EdGEO Committee. In-kind support was generously provided by the GSC Atlantic, Parrsboro Geological Museum, Joggins Fossil Centre, Saint Marys University, Nova Scotia Department of Natural Resources (NSDNR), Nova Scotia Museum of Natural History (NSMNH), Nova Scotia Community College (NSCC), various Nova Scotia schools and boards, and the Atlantic Science Links Association.

The success of the Nova Scotia EdGEO Workshop Program depends upon the knowledge, experience, enthusiasm, and dedication of its committee. Presenters and committee members represent both the geoscience and education communities, including the NSDNR, the NSCC, the NSMNH, Dalhousie University, the NS Association of Science Teachers, several private and public schools and school boards in the province, and GSC Atlantic staff.

Feltzers Rock Layers, winner of the best Atlantic Canada Geological Photograph award in the AGS-PGNS competition – photo courtesy of Ken Renton

Lava and Ocean, winner of the best geological photograph overall award in the AGS-PGNS competition. The photo shows lava flowing into the ocean near Kalapana on the Big Island of Hawaii, United States, on February 27, 2009. Photo is courtesy of Laszlo Podor.

The 9th season of the talk series, *Beyond "The Last Billion Years"*, was cancelled due to the temporary closure of its venue, the NSMNH. However, speakers are being lined up for the 2010 season, when the popular talks will resume.

GSC Atlantic staff continued their membership on the AGS Video Committee. During the 27 years of its existence, this committee has developed a number of quality videos and accompanying guides. The DVD, *Halifax Harbour: A Geological Journey*, is for sale at the BIO Gift Shop. Interest remains in the development of an on-line teachers' guide for the Halifax Harbour video. Production of a video on the Bay of Fundy region with partners, the Fundy Geological Museum, Joggins Fossil Institute, and Cape Chignecto Provincial Park has been moving forward slowly, due to funding issues.

In 2009, the AGS continued its collaboration with the Photographic Guild of Nova Scotia (PGNS). The AGS-PGNS Geophoto meeting brought together photographers and geologists to exchange their expertise. At the annual AGS-sponsored competition at PGNS, Laszlo Podor received the AGS award for best geological photograph overall: *Lava and Ocean* while Ken Renton received the *The Last Billion Years* Award for best Atlantic Canada geological photograph: *Feltzers Rock Layers* (Meguma Terrane rocks in the Lunenburg area of Nova Scotia). The AGS is permitted to use the entered photographs for education purposes.

Workshops and Special Meetings

BIO hosted the 43rd annual **Congress of the Canadian Meteorological and Oceanographic Society** May 31-June 4 at the World Trade and Convention Centre in Halifax. The organization of this conference was made possible through the volunteer efforts of numerous BIO employees. About 550 delegates attended the Congress, including 50 teachers who participated in a very successful education day. As part of the event, Peter Bowyer of the Canadian Hurricane Centre gave a public talk attended by more than 200 people, at the Maritime Museum of the Atlantic on the Halifax waterfront. Peter's talk

included a history of recent hurricanes and remnants which have hit Atlantic Canada. During the conference, the DFO Timothy Parsons Medal for excellence in ocean sciences was awarded to Dr. Richard Thomson of Pacific Region. He received the award for his extensive contributions to multidisciplinary ocean research over more than 35 years of service with DFO.

The **Workshop on Arctic Freshwater Systems of the Mackenzie Delta** was held at BIO June 18-19. The meeting brought together fifteen experts. The objective was to achieve better simulations of the interactions between the Mackenzie River and the waters of the Delta, and related nearshore and coastal areas. While we don't have detailed knowledge of the Mackenzie River discharge into the delta and nearshore/coastal region, we do have the opportunity to solve this problem. A variable (or dynamic) slope model for the channel network that will need to use accurate bathymetry in the outer delta and water-level boundary conditions is being developed. When completed, this model will provide analyses of feasible scenarios for tides and storm surges, to study marine storms and their storm surges.

The meeting, **United Kingdom-Canada Perturbation Experiments on Biological Response to Ocean Acidification**, was held July 29-30 at BIO. Thirteen scientists from BIO, the St. Andrews Biological Station, and from the United Kingdom's Centre for Environment, Fisheries & Aquaculture Science and the University of Plymouth participated in this meeting. The purpose was to discuss and coordinate studies on ocean acidification for commercial fish and shellfish in the United Kingdom and Canada. Results were presented from laboratory experiments which enable assessment of ocean-acidification impacts and related climate change on marine productivity, together with modelling studies in higher trophic levels and field observations. The existing knowledge gap, targeted species, and the feasibility and priority of experiments were identified. The meeting was chaired by Kumiko Azetsu-Scott of the Ocean Sciences Division and was partially supported by the International Governance Strategy Program in DFO.

On November 2-3, BIO staff led and participated in the **Offshore Environmental Factors (OEF) and Marine Transporation Safety (MTS) workshop** held in St. John's, Newfoundland and Labrador. These are programs of the Program on Energy, Research and Development's Frontier Oil and Gas Portfolio. The workshop was led by DFO's Peter Smith (OEF) and the National Research Council's Bob Frederking (MTS). Its purpose was:

1. to communicate research and development results directly to those with a particular interest in offshore oil and gas, mainly on Canada's east coast, but also in the Arctic, and
2. for project and program leaders to receive feedback from stakeholders and colleagues.

Eighty people attended the workshop, including about 30 project team leaders (11 from BIO) and 50 stakeholders representing the east coast and Arctic oil and gas industries. A series of presentations by project leaders was followed by open discussion and feedback. By all accounts, the meeting was a great success and spawned several new ideas and industry-government collaborations.

On November 16-18, NRCan's UNCLOS office at BIO hosted the workshop, **Scientific Issues on the ALPHA-MENDELEEV RIDGE**. This international workshop is held every year and hosted alternately by Russia (2007), Denmark (2008), and Canada. This year there were eight participants from Denmark, nine from Russia, two from the United States, and ten from Canada. The reason for the workshops is to provide updates on the ongoing programs to collect scientific information in the Arctic Ocean for the purpose of defining the outer limits of the continental shelves. The workshop comprised five technical sessions and a general session to discuss options for further collaboration among the participating countries.

Seminars 2009

Over the course of the year, BIO welcomed scientists from around the world to present seminars and to lecture at the Institute.

BIO SEMINAR SERIES

The BIO Seminar Series (BIOSS) provides an institute-wide forum for presentations covering topics of physical, chemical, biological, and fisheries oceanography; marine geophysics; and geology, hydrography, marine ecology, and ocean engineering.

On January 14, BIOSS hosted a mini-symposium: ***Storms and Storm Impacts***. Speakers included **Peter Bowyer** (Canadian Hurricane Centre), **John Charles** (Halifax Regional Municipality), **Don Forbes** (Bedford Institute of Oceanography), and **Keith Thompson** (Dalhousie University). Mr. Bowyer presented a summary of lessons learned in the forecasting of hurricanes in the Canadian Maritimes region. Mr. Charles demonstrated tools and methods being used for municipal planning related to rising water levels and storm surges. Dr. Forbes showed the impacts which severe storms have on Atlantic Canadian coastlines through flooding and erosion. Dr. Thompson presented research in modeling and prediction of storm surges in this region.

On October 16, **Dr. John Harrison** (an academic from the United Kingdom) presented a talk titled ***Out of Whose Womb: Shackleton and the* Endurance**. This presentation captured the imagination of the audience with the story of Ernest Shackleton's amazing journey to Antarctica in 1914-1917.

On November 18, **Dr. Peter Wadhams** (Cambridge University, United Kingdom) presented a talk, ***The Great Ocean of Truth - The* Hudson 70 *Voyage around the Americas and What it Achieved***. This seminar was held as part of the *Hudson 70* celebration at BIO, which is described elsewhere in this review.

CENTRE FOR MARINE BIODIVERSITY SEMINARS

The Centre for Marine Biodiversity (CMB) invites scientists whose research in fisheries, marine ecology, physical oceanography, and related sciences will enhance our knowledge toward the protection of marine biodiversity. In 2009 the CMB hosted the following talks:

An Integrated Approach to Assessment of Seabed Habitat and Biodiversity in Support of Trawl Management on the Continental Shelf of the Great Barrier Reef

Mapping Seabed Habitats and Biodiversity on the Continental Shelf of the Great Barrier Reef
Dr. Roland Pitcher, Principal Research Scientist, CSIRO Marine and Atmospheric Research, Cleveland, Queensland, Australia

GSC ATLANTIC SCIENCE HOUR

The GSC Atlantic Science Hour talk series was initiated in the fall of 2009 following an amalgamation of Science Hour and Mud Club. A working committee organizes weekly one-hour presentations on current geoscience research and technology. Invitations to present are extended to staff and students at the GSC Atlantic, local and regional universities, government departments and agencies, and to visiting speakers, as below:

Geologic History, East Coast Jurassic: A Tale of Rifting, Spreading, Shifting Deltas, Reefs, and Salt Tectonics
Dr. John Harper, Director, Geological Survey of Canada (Calgary), Alberta, Canada

An Introduction to Shale Gas: The Fuel of the 21st Century
Tom Martel, Chief Geologist, Corridor Resources Inc, Halifax, Nova Scotia, Canada

HARVEST FISHERIES SEMINAR SERIES

The Harvest Fisheries Seminar Series began in 2002. DFO's Population Ecology Division hosts this series, whose primary purpose is to provide an opportunity to exchange ideas and to hear about research within BIO and at other institutions. Staff who will be speaking outside BIO are encouraged to also give their presentations at the Institute. As well, the program features visiting researchers and speakers from local universities.

Evaluating the Knowledge Base for Expanding Low Trophic-level Fisheries in Atlantic Canada
Sean Anderson, Department of Biology, Dalhousie University, Halifax, Nova Scotia, Canada

An Introduction to a Pirate's Favourite Statistical Package (Tailored for Beginners)
Bob Farmer, Ph.D Candidate, Department of Biology, Dalhousie University

Quantifying Size-dependent Predation and Selectivity on Squid
Michelle Staudinger, Department of Natural Resources Conservation, University of Massachusetts, Amherst, Massachusetts, United States

How to Build and Use Individual-based Models (IBMs) as Hypothesis Testing Tools
Anna Neuheimer, Postdoctoral Fellow, Engineering Mathematics and Internetworking, Dalhousie University

Coastal Management: Bridging the Land-Water Divide
Marc Ouellette, Acting Coordinator for the Coastal Management Centre of Expertise, DFO Gulf Region, Moncton, New Brunswick, Canada

Fisheries Co-management in the Western Arctic
Amy Thompson, Executive Director, Gwich'in Renewable Resources Board, Inuvik, Northwest Territories, Canada

NRCAN GEOLOGICAL SURVEY OF CANADA (ATLANTIC) SPECIAL SEMINARS

Expanded Local and Laurentide Ice in the Western Queen Elizabeth Islands during the LGM, Deglaciation, and Sea-level Change
Chantel Nixon, Department of Earth and Planetary Sciences, University of Alberta, Edmonton, Alberta, Canada

Mud Volcanism over Plio-quaternary Timescales on the Calabrian Accretionary Prism, Central Mediterranean Sea
Daniel Praeg, Istituto Nazionale di Oceanografia e di Geofisica Sperimentale, Trieste, Italy

Reconstructing the Instability of the Laurentide Ice Sheet during the Last Four Glacial Cycles: A Multi-proxy Approach
Harunur Rashid, Byrd Polar Research Center, The Ohio State University, Columbus, Ohio, United States

Dinoflagellate Cysts and Holocene Paleoceanography of the North Atlantic: New Insights and Challenges
Sandrine Solignac Department of Earth Sciences, Aarhus University, Aarhus, Denmark

OCEANS AND ECOSYSTEM SCIENCE SEMINAR SERIES

The Oceans and Ecosystem Science Seminar Series talks are given weekly and cover topics in physical, chemical, and biological oceanography. The series, run jointly by DFO's Ocean Sciences and Ecosystem Research divisions, provided a forum for both BIO researchers and the following visiting scientists in 2009:

A Toy Model of Internal Waves
Dan Kelley, Department of Oceanography, Dalhousie University

Climate Change: A Collision of Science, Politics, Economics and Ethics
Ken Denman (Canadian Meteorological and Oceanographic Society Tour Speaker), Institute of Ocean Sciences, Victoria, British Columbia, Canada

CSI Coastal Scene Investigation: Using Clues from Halifax Harbour Transexual Snails and Sydney Tar Pond Fish to Solve Ecotoxicological Puzzles
Shannon Bard, Department of Biology, Dalhousie University

New Capabilities and Opportunities for Marine Remote Sensing
Paul Adlakha, C-Core (a global corporation providing innovative engineering solutions), St. John's, Newfoundland and Labrador, Canada

Biogeochemistry of CO_2 System and Net Community Production during Mesoscale Cyclonic Eddies in the Lee of Hawaii
Feizhou Chen, Department of Oceanography, Dalhousie University

Whales as Ocean Road-kill: Quantifying Deaths, Busy Intersections, the Consequence of Speeding, and the Avoidance of Right Whale Playgrounds
Angelia S.M. Vanderlaan and **Christopher T. Taggart**, Department of Oceanography, Dalhousie University

Bio-inspired Electro-active Polymer Jellyfish for Undersea Acoustic Surveillance

Dennis Jones, Defence Research and Development Canada Atlantic, Dartmouth, Nova Scotia, Canada

Cross-frontal Exchange and Mixing at the Shelf-break Front
Dave Hebert, School of Oceanography, University of Rhode Island, Narragansett, Rhode Island, United States

Shallow Water Dynamics and Its Effect on Wave Propagation, Turbulence, and Transport Processes
Daniela Di Iorio, Department of Marine Sciences, University of Georgia, Athens, Georgia, United States

Sea-ice Cover Anomaly and Geochemical Tracers in the Arctic Basin Associated with the Dipole Mode of Sea-level Pressure
Moto Ikeda, Faculty of Environmental Earth Science, Hokkaido University, Hokkaido, Japan

Modelling Study of the Influence of Physical Processes on Coastal Ecosystems
Hao Wei, Ocean University of China, Qingdao, China

The RAPID Climate Change Program in the North Atlantic
Miguel Maqueda, Proudman Oceanographic Laboratory, Liverpool, United Kingdom

Secular and Seasonal Changes of Ocean Tides: Model Results and Observations
Malte Mueller, Hamburg University, Germany and University of Victoria, Victoria, British Columbia, Canada

A Maximum Entropy Approach to Global Water Mass Analysis
François Primeau, Earth System Science School of Physical Sciences, University of California, Irvine, California, United States

Model Study of the Interannual Variability in the Sub-polar North Atlantic Ocean
Entcho Demirov, Department of Physics and Physical Oceanography, Memorial University, St. John's, Newfoundland and Labrador

Special Events

Our Oceans, Our Responsibility: Celebrating World Oceans Day

BIO staff participated in a sunny public event at the Halifax Waterfront on Friday, June 5. Locally, Oceans Day celebrations have been held since the idea was conceived at the 1992 United Nations Conference on Environment and Development in Rio de Janeiro. This year, festivities around the world held even greater meaning as it was the first year that June 8 was designated by the United Nations as World Oceans Day (www.un.org/Depts/los/reference_files/worldoceansday.htm).

At BIO on June 8, the Oceans, Habitat and Species at Risk Branch hosted the annual Oceans Day Meet-and-Greet. A special cake-and-coffee gathering brought together BIO and other local DFO staff. They were eagerly joined by guests from the International Ocean Institute at Dalhousie University who participated in a day-long educational visit to BIO, which has become an annual event. Many

Fish-on-Ice: Dollie Campbell, Brian Jones, and Megan Wilson show visitors some strange fishes from the deep at their popular Oceans Day display.

Soulafa Al Abbasi, International Oceans Institute Course Coordinator, (2nd row, left), Dr. Noel Brown, Course Director (front, right), and Dr. Peter Wells, Senior Research Fellow (back, 2nd from right) lead the 2009 participants on a tour of BIO.

The Waterworld Gallery

Grade 11 students also attended and were presented with *Outstanding Oceans 11 Student Awards* from the Fishermen and Scientists Research Society.

Fun interactive displays, presentations, lectures, tours, and food – how do you celebrate World Oceans Day?

Check the list of events each year:

(www.dfo-mpo.gc.ca/oceans/events-evenements/oceansday-journeedesoceans/list-liste-eng.htm#events-evenements).

In conjunction with Oceans Day and as part of Environment Week activities, **Bob McDonald**, host of CBC's *Quirks and Quarks*, gave **a presentation** at BIO titled ***Surviving the Third Millennium***. The discussion addressed our ability to engineer our way through another thousand years of civilization while facing challenges such as climate change, water supply, droughts on the prairies, floods on the coasts, energy shortage, and the

The Waterworld Gallery

growing population.

The **BIO Waterworld Gallery** officially opened to very good reviews on December 8 on the first- and second-floor landings of the Ellis building. The gallery contains many beautiful photographs based on the theme of water in every aspect of human life and ecosystems. Most of the photographs were taken by Bob Semple, who retired in 2009 from DFO's Population Ecology Division. The gallery will continue to develop with photos submitted by BIO staff and alumni.

Visitors

Neil Bellefontaine, former Regional Director-General of DFO Maritimes Region, now instructs at the **World Maritime University** in Sweden. This is a global centre for advanced education and research for the benefit of the international maritime community. As part of the program, in May a group of **students in the Marine Environment and Ocean Management program**, led by Mr. Bellefontaine, visited BIO. They spent one and a-half days at BIO, where they received a comprehensive overview of the variety of research activities carried on here and also toured several of the labs.

Professor François Primeau of the University of California at Irvine visited BIO October 25-31, to collaborate with Kumiko Azetsu-Scott of DFO's Ocean Sciences Division on ventilation processes and uptake of anthropogenic CO_2 in the North Atlantic. While here, he met with other scientists at BIO and gave the seminar *A Maximum Entropy Approach to Global Water Mass Analysis*.

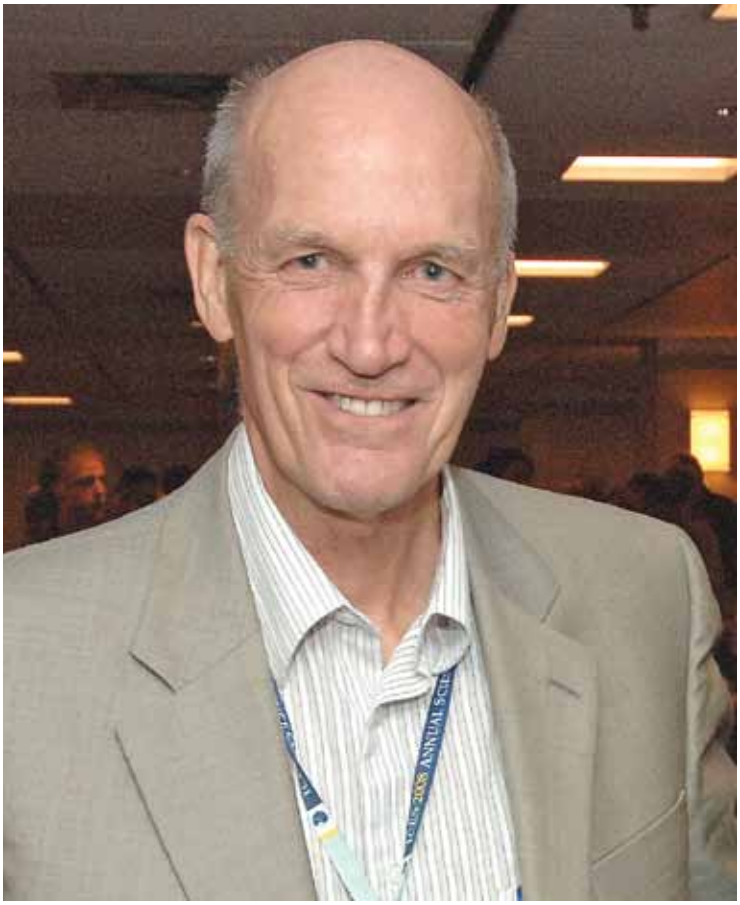
During the week of October 26, **a delegation of Spanish oceanographers, industry representatives, and government officials** visited three Canadian federal laboratories (Northwest Atlantic Fisheries Centre, St. John's, Newfoundland and Labrador; Institute of Ocean Sciences, Sidney, British Columbia; and BIO). Their primary goal was to explore potential collaborations in ocean observing with Canadian academic and science institutions, in connection with their new initiative, the Canary Islands Oceanography Platform. The Spanish oceanographers also expressed interest in working with DFO on broader science issues, such as climate change impacts, effectiveness of Marine Protected Areas, Arctic science, and data management. The BIO discussions were very positive, and the Spanish oceanographers gained much knowledge and made contacts with ocean science experts. While it is too early to enter formal arrangements with the Spanish delegates, it was agreed to pursue mutual interests in areas such as technology exchange, data management, and polar research.

GSC Atlantic staff welcomed several scientists during 2009. **Dr. Richard Laroque** of the Institut Maurice-Lamontagne, Mont-Joli, Quebec, worked with Vladimir Kostylev on habitat mapping in the St. Lawrence River. **Dr. Steven Fromm**, from the National Ocean and Atmospheric Administration's Sandy Hook laboratory in New Jersey, worked with Vladimir Kostylev on Gulf of Maine habitat mapping and participated in a cruise to the Bay of Fundy with Brian Todd. **Mr. Ibon Galparsoro** from AZTI, Tecnalia, Spain, also worked with Vladimir Kostylev and Brian Todd, on habitat mapping along the Basque coast.

Acadia University student **Dan Lake** worked with Brian Todd from January to April. Dan's work involved recovering Bay of Fundy seismic data from old tapes, reformatting the data into a useable form, and finally undertaking seismostratigraphic interpretation of the information. Dan's findings were archived in a geographical information system, thus completing the task of reviving previously inaccessible data into a platform that makes the data available to all. Several students from other universities also visited scientists at NRCan.

Reflections on 2009

Michael Sinclair



Dr. Michael Sinclair, since 1999 the DFO Director of Science, Maritimes Region and Director of the Bedford Institute of Oceanography, will be retiring from DFO in June 2010. His contributions to the Institute and to ocean science over 30 years are numerous and significant. The favourable-to-Canada decision on the Canada-US Georges Bank Transboundary Dispute in 1984 was in no small part due to Mike's efforts. In 1988, he published a book on a new theory of marine populations, which is even more relevant today. During his management tenure at BIO, he always maintained his research, and most recently, in a return to an early interest, is undertaking a global study of herring population structure and regulation. Prospective managers can learn from Mike the need to maintain focus and be tenacious. His directorship, often through tight fiscal times, was committed to maintaining BIO's place as an effective ocean science organization. Mike has earned the respect and appreciation of staff at the Institute. He departs BIO to assume the presidency of the International Council of the Exploration of the Seas (ICES).
Bob O'Boyle

Eric Mills published in 2009 a delightful and insightful book titled *The Fluid Envelope of our Planet: How the Study of Ocean Currents Became a Science*. The book addresses the history of physical oceanography from a global perspective. We are fortunate that Eric is a Canadian, in that he covers the historical development of oceanography in Canada in considerable depth. He describes the rapid expansion of oceanographic institutes in the United States and Canada following the Second World War, including the establishment of the Institute of Oceanography at Dalhousie University in 1959, half a century ago. We in Atlantic Canada were very fortunate that Gordon Riley, of Yale University, was attracted to Halifax as the first Director of the Dalhousie Institute. He was already an established leader in the study of the role of physical and chemical oceanographic processes on marine productivity. Professor Riley, and his new team of marine scientists, forged fruitful linkages with BIO when it was created a few years later in 1962. The importance of this academic-government partnership was highlighted in the lecture given by Dr. William Van Steenburgh at Dalhousie University during the opening ceremonies for BIO in 1962. The two institutes grew up together, as it were, and very quickly put Nova Scotia and Atlantic Canada on the map within the global marine science community.

It is perhaps fair to say that, during the past decade or so, this dynamic relationship has waned to a certain degree, at least at the institutional level. It has taken a newcomer to the community, Dr. Martha Crago (the new Vice-President for Research at Dalhousie University), to identify the necessity and opportunity for renewal of this relationship and its expansion to include the overall marine science

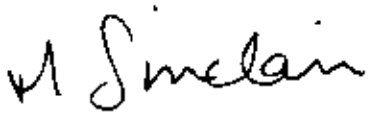
community in the Halifax-Dartmouth area. During 2009, Dr. Crago led a vigorous process involving the universities, local marine industries, and the public sector to identify in general terms the societal needs for marine science and engineering in the coming decades. No doubt a renewed, enlarged partnership of the marine science community will reflect well the earlier vision of Professor Riley and Dr. Van Steenburgh a half-century ago. Thus, 2009 has been a period of reflection and transition at BIO.

The reflection has also addressed internal governance on the BIO campus. As the activities on the campus of BIO have broadened during the past several years, including the move of the Canadian Coast Guard functions to the Institute and the planned move of additional DFO sectors, it has become clear that there is a need to focus on the vitality of the marine science activities and the multi-disciplinary research carried out by the four departments (NRCan, EC, DND, and DFO). We are fortunate that Dr. Alain Vézina, a biological oceanographer with interests similar to Professor Riley's, is the incoming Director of BIO in 2010. Dr. Vézina has the vision and leadership to steer the Institute through the transitions (both the internal governance challenges and the renewal of strategic partnerships) and through the inevitable rough waters ahead due to financial challenges.

The celebrations of the 40th anniversary of the 1969 departure of the CSS *Hudson* on the circumnavigation of the Americas, was perhaps the highlight of 2009 for the Institute. There was a true feeling of a family getting together to share fond memories of the "good old days". The warm relationship amongst the ship's crew and the scientific staff is a reminder of the essential requirement of teamwork for careful observations of the oceans and making discoveries. The reflections on the research achievements during this historic expedition pointed out that during past decades the Institute addressed, in a bold manner, global oceanographic issues, and generated some introspection that we need to recapture this larger 1960s vision.

Charles Darwin's anniversary year was also celebrated at BIO. Having the full Symphony Nova Scotia perform in our auditorium was very moving, and the acoustics were remarkably good. Bringing together music and science has been a great tradition of the Institute. Niles Eldredge, our invited lecturer following the music, remarked that he felt a special ambiance, and his address on Darwin's life and work was marvellous.

In closing, I note that this is the 10th BIO Annual Review that I have had the pleasure to oversee. We have been fortunate indeed to have had excellent editors, Dianne Geddes and Judith Ryan, and their editorial teams (most recently, Pat Dennis, Carolyn Harvie, and Jane Avery), during this past decade. They have produced most attractive reports that have summarized well the multi-disciplinary work of the Institute. I thank them for this important contribution to BIO. We also congratulate Dalhousie University on 50 years of oceanography, and thank them for sustaining the warm and fruitful partnership initiated by Professor Riley and Dr. Van Steenburgh.



PEOPLE AT BIO

Awards and Honours

2009 Huntsman Award winner, Dr. James Syvitski, with Dr. Charlotte Keen, Scientist Emeritus at NRCan, who presented the award

The 2009 **A.G. Huntsman Award** was presented to **Dr. James P.M. Syvitski** of the University of Colorado at Boulder. Dr. Syvitski is an exceptionally productive scientist with a wide range of interests in the marine sciences including fjords, rivers, deltas, estuaries, particle dynamics, simulation of sediment transport and stratigraphy, continental margin sedimentation, gravity flows, and animal-sediment interactions. Dr. Syvitski's investigative strategy comprises a combination of numerical modeling, *in situ* measurements and classical sampling techniques. His research has addressed both broad and focused issues such as land-ocean interactions in various coastal zone hydrodynamic settings, sediment deposition processes in iceberg-dominated glaciomarine environments and fjords, the changing microfabric of suspended particulate matter in the fluvial-to-marine transition, and numerical model developments aimed at elucidating new understandings on climate-driven riverine sediment fluxes. Dr. Syvitski received his Ph.D. from the University of British Columbia in 1978 and worked at BIO as a sedimentologist with the Geological Survey of Canada (Atlantic) from 1981 to 1995. In 1995 he became Director of the Institute of Alpine and Arctic Research at the University of Colorado. Professor Syvitski has held various academic appointments at the University of Colorado and since 2007 has been Executive Director of the Community Surface Dynamics Modelling System.

The A.G. Huntsman Award recognizes international scientists for research excellence and outstanding contributions to marine science. The award is presented annually in one of three categories: Marine Geosciences; Physical/Chemical Oceanography; or Biological Oceanography and Fisheries Sciences. The award was created in 1980 under the leadership of BIO scientists to honour the memory of Dr. Archibald G. Huntsman, a pioneer Canadian oceanographer and fishery biologist. The 2009 award was presented by Dr. Charlotte E. Keen, representing the Academy of Sciences of the Royal Society of Canada, at a special ceremony at BIO on November 12.

Michael Sinclair, Director of BIO and Regional Director of Science for DFO Maritimes Region, **was elected president of the International Council for the Exploration of the Sea** (ICES). Mike, who has been active in ICES since the early 1980s, will serve as president for three years (until October 2012).

The **BIO Science Display** is a venue for BIO scientists to showcase their research to colleagues and visitors. To ensure research is current, the display changes monthly. Located adjacent to The Gully Room near the cafeteria, it is maintained by the Science Display Committee with members from the participating groups: NRCan's Geological Survey of Canada and DFO's Science and Oceans, Habitat and Species at Risk branches. Committee members ensure the posting of submissions from their groups, judge the submissions, and seek ways to improve the display area. To generate more interest among the in-house scientific community, the display submissions are subject to a friendly competition. Every year, the 12 posted displays are judged by the Committee on the following criteria: visual impact, communication value, science promotion value, and the degree of representation of regional science activities. Congratulations to the winners, and thanks to all of the poster creators for helping to communicate the many and varied science activities at BIO.

Bruce Anderson of the Canadian Hydrographic Service was the 2009 recipient of the annual Oceans Association Beluga Award in recognition of his special contributions to the internal life of BIO and to the outreach initiatives that present BIO to Canadian society and to the world. For more than 20 years, Bruce's enthusiasm and can-do attitude have inspired volunteers who make successes out of events like the Canadian Hydrographic Association 2006 International Hydrographic Conference and BIO Open Houses. He continues to be a positive influence for the type of cooperation and success that enhances the very concept of the Institute.

Natural Resources Canada Sector Merit Awards are awarded by the Earth Sciences Sector (ESS) of NRCan to recognize the behaviours, actions, or results of an individual or team whose level of impact and scope has enhanced the profile and contributed to the success of ESS. In 2009, the following BIO staff received Merit Awards:

Borden Chapman for Innovations in Marine Data Acquisition (Criteria – Innovation)
Borden designed a system to collect seismic data in the Arctic under extremely difficult conditions. This seismic data is crucial in defining the outer limits of Canada's continental shelf.

Kevin DesRoches and **John Shimeld** (Criteria – Achievement)
Kevin and John were responsible for preparing a complicated Request for Proposal to carry out data collection in areas far offshore, and for evaluating the bids received. They also monitored data collection, both on the ship and onshore, to ensure data of the highest possible quality was collected for Canada's submission to the United Nations.

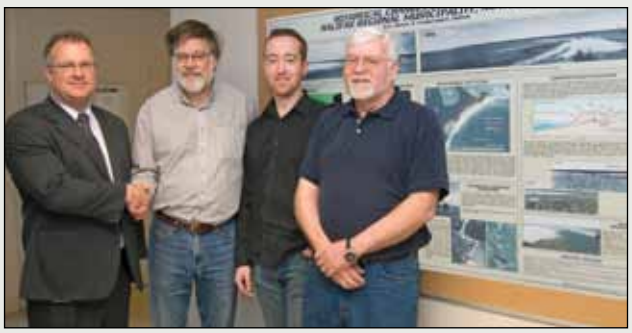
Steve Blasco and **Bob Harmes** (Criteria – Collaboration)
Steve and Bob were part of a team that developed a model for western Arctic community consultation that is now a Best Practice for engaging communities and communicating federal research results.

Ross Boutilier and **Matt Salisbury**, ESS Office Analysts (Criteria – Achievement)
Ross and Matt were on the team of six analysts who made important, substantial, and repeated contributions to ensure that ESS programs were designed to achieve results that matter to Canadians.

NRCan Long Service Awards
10 Years Service Award: Robbie Bennett, Calvin Campbell, Chris Jauer, Ned King, Philip Spencer, Barbara Szlavko, Brian Todd, Hans Wielens

The poster, ***Shortnose Sturgeon***, won **First Place** in the **2007-2008 BIO Science Display** competition for its creators, shown, from left: **Arran McPherson, Lynn Cullen, Dawn Sephton, Kimberly Robichaud-LeBlanc, Diane Beanlands (all from DFO's Species at Risk Management Division [SARMD])** and **Francis Kelly (DFO Communications). Missing from the photo is Koren Spence (SARMD)**.

Second Place went to **Darren Hiltz** of DFO's **Habitat Protection and Sustainable Development Division** for the poster ***Good Habitat/Bad Habitat Practices***. **Third Place** was a tie between **Steven Campana, Linda Marks**, and **Warren Joyce** of DFO's **Population Ecology Division** for ***Sharks*** and **Gordon Cameron** and **Edward King** of the **GSC Atlantic** for ***The Gully: A Late Quaternary History of a Submarine Canyon***.



For the year **2008-09, First Place** went to a **GSC Atlantic** team for ***Historical Changes in Cow Bay Beach, Halifax Regional Municipality, Nova Scotia***. Shown are, from left: Stephen Locke, Director, GSC Atlantic, and the poster's creators: **Robert Taylor, Eric Patton**, and **Dave Frobel**.

Second Place went to **Jennifer Bates** and **Michael Parsons** of the GSC Atlantic for ***The Challenge of Collaborative Environmental Science***. **Third Place** was won by **Dawn Sephton, Kim Robichaud-LeBlanc, David Millar, Koren Spence, Diane Beanlands**, and **Melissa McDonald** of **SARMD**, and **Francis Kelly** of DFO **Communications** Branch for their poster ***Proposed Recovery Strategy for the North Atlantic Right Whale in Canada – Summary***.

NRCan Merit award recipient, Bob Harmes (right) with Stephen Locke, Director of GSC Atlantic

15 Years Service Award:	**Peter Giles, Stephen Locke**
20 Years Service Award:	**John Shaw**
25 Years Service Award:	**Cheryl Boyd, Rob Fensome**
30 Years Service Award:	**Bob Harmes**
35 Years Service Award:	**Dave Frobel, Anne Mazerall**
40 Years Service Award:	**Bob Fitzgerald**

The **DFO Distinction Award** is granted to an employee for outstanding achievement and contributions that further the objectives of DFO and/or the Public Service of Canada. The award is based on excellence in service delivery; valuing and supporting people; and value, ethics, and excellence in policy and/or science. The following staff at BIO received Distinction Awards in 2009:

Kimberly Robichaud-LeBlanc of the Species at Risk Management Division successfully led the process to develop a Recovery Strategy for the endangered inner Bay of Fundy salmon population. She brought exceptional professionalism, leadership, and dedication to the negotiations among multiple stakeholders (often with conflicting views) and DFO sectors, resulting in a mutually acceptable solution.

The Nova Scotia Power-DFO Memorandum of Understanding Working Group consisting of **Marcia Penney and David Longard of DFO's Habitat Protection and Sustainable Development Division**, and from **Nova Scotia Power Inc., Ken Meade** and **Terry Toner**, developed a Working Agreement to formally acknowledge their ongoing commitment to ensuring the continual improvement of fish habitat in Nova Scotia as it relates to Nova Scotia Power's facilities and operations. Both parties will work together to ensure that electricity is generated in a way that results in minimal harm to fish and fish habitat, and is compliant with the *Fisheries Act*, *Species at Risk Act*, and *Canadian Environmental Assessment Act*.

Bedford Institute of Oceanography Oceans Association: Activities in 2009

Robert O'Boyle

The Bedford Institute of Oceanography Oceans Association (BIO-OA) was established over ten years ago by former staff, to foster the continuing fellowship of members, which now number more than 250, and to maintain links to the Institute. The OA's mandate includes increasing public understanding of ocean science and the preservation of BIO's history and spirit.

One of the most significant events at BIO during 2009 was the 40th anniversary celebration of the CSS *Hudson*'s circumnavigation of the Americas. Many Association members were involved in planning, organizing, and hosting the event, held November 16-19. A highlight was the lecture by Dr. Peter Wadhams on his experiences during the trip. Peter's book of the voyage, *The Great Ocean of Truth*, was also released at the celebration. (See ***Celebrating the 40th Anniversary of the* Hudson 70 *Expedition*** and **Hudson 70 – *What Was Accomplished.***)

Another significant event in 2009 was the 150th anniversary of the publication of Charles Darwin's *On the Origin of Species*. A lecture series commemorating the event was sponsored and organized by the Nova Scotian Institute of Science, Dalhousie and Saint Mary's universities, the BIO Centre for Marine Biodiversity, and the BIO-OA. The OA also received permission from author and noted Darwin scholar Michael Ruse to reprint his column "The Godfather

Oceans Association member and Beluga Award Committee chair, René Lavoie congratulates 2009 Beluga Award winner Bruce Anderson, at right.

of Evolution" from the *Globe and Mail* newspaper, in its newsletter. (See ***Darwin 2009 Celebrations***.)

The Association hosted a well attended and most informative lecture on tidal power in Nova Scotia, by Dr. John Woods, Vice-President of Minas Basin Pulp and Power. Other events enjoyed by OA members in 2009 were trips to Sugar Moon Farm and Memory Lane Heritage Village, the Association annual picnic—this year's at Bob Cook's residence, and an Annapolis Valley Winery Tour.

The Association was active on a variety of projects. Progress was made on the Commemorative Stamp Project, a proposal to have Canada Post issue a stamp in 2012, the 50th Anniversary of the founding of BIO. The Association will learn in 2010 whether its submission was successful. Another project has been the compilation of the oceanographic history of the HMCS *Sackville*. This project will help ensure that the *Sackville*'s proper place in Canadian ocean research history is better known. Also, efforts continued to archive and thus preserve for posterity the wide array of ocean-sampling equipment (e.g., BATFISH, BIONESS, DOLPHIN, CAMPOD) developed at BIO over the years.

One of the most active areas of the Oceans Association's mandate is fostering communication among past and present BIO staff. The OA newsletter, a quarterly publication, is particularly noteworthy in this regard as it keeps the membership abreast of oceans affairs within and outside BIO. A 2009 highlight, in the April issue, was a dramatic account of the 1988 *Athenian Venture* disaster in which the CSS *Hudson* played a role. The Association was contacted by Mr. Sebastian Szulkowski seeking information on the disaster on behalf of the surviving families. Sebastian was nine and his brother six when his parents died aboard the *Athenian Venture*. Thanks to the efforts of the Association, notably member Gregory MacLellan, some of Sebastian's questions have been answered.

HMCS *Sackville* approaches a wharf in Dartmouth, Nova Scotia. Photo is courtesy of Sandy McClearn. © Sandy McClearn (smcclearn.smugmug.com)

Finally, the Association sponsors the Beluga Award, given annually to recognize the unselfish contributions of past and present BIO staff members. In 2009, Bruce Anderson received the award at the BIO-OA Annual General Meeting on May 19 for his long-term and outstanding commitment to promoting and fostering a wonderful sense of community at BIO.

Charitable Activites at BIO

In 2009, BIO staff continued their long tradition of giving back to their community.

The Government of Canada Workplace Charitable Campaign (GCWCC) is the oldest and largest workplace charitable campaign in Canada. Approximately 50 local agencies benefit from this campaign, which brings together two main recipient organizations—United Way and Healthpartners—in a co-ordinated fund-raising effort. Alternatively, employees can give to a third option, their Charity of Choice(s). Both DFO and NRCan employees gave generously this year by individual pledges, and also through several fundraising events. A favourite event with staff is the annual used book sale put on by BIO Library staff, which, in 2009, raised more than $2600.00, its largest amount yet.

As in previous years, NRCan was instrumental in organizing BIO staff to pack and deliver Christmas dinners for the Parker Street Food and Furniture Bank. BIO further supports this food bank throughout the year with donations of food and clothing.

The Canadian Hydrographic Service provided several gift-filled boxes for the Halifax Mission to Seamen's Christmas Appeal, when the Mission gives Christmas Shoe Boxes of Gifts to seafarers visiting the port over the holidays. A box typically contains a warm hat, scarf, socks, toiletries, and candy. In further charitable activity, the DFO Ecosystem Research Division continued its practice of helping individuals and families at Christmas by holding Easter and Hallowe'en coffee parties and selling tickets on gift baskets. *BIO Friends of Symphony Nova Scotia* again supported the symphony's Celebrity Concert Series through the BIO Musical Chair of viola musician, Binnie Brennan; the Canadian Cancer Society's annual daffodil campaign was well subscribed; and other charities were helped on an occasional basis.

The Ecosystem Research Division Hallowe'en coffee party: Helen Hayden (left) selects from the goodies.

People at BIO in 2009

DEPARTMENT OF NATIONAL DEFENCE

LCdr Jim Bradford*
LCdr Scott Moody
Lt(N) Jason Karle
CPO2 Dale Langille
PO2 Tim Craig
PO2 Ryan Gaudet
PO2 Marilyn Gilby
PO2 Jim McNeill
MS Gerard Arsenault
LS William Brown
LS Chris Dorion
LS Harris Pollard
Dan Moore

ENVIRONMENT CANADA

Christopher Craig
Patti Densmore
David MacArthur
Lauren Steeves

FISHERIES AND OCEANS CANADA

Canadian Coast Guard - Technical Services

Marine Electronics
Robert MacGregor, A/Supervisor
Terry Cormier
Gerry Dease
Jason Green
Julie LeClerc
David Levy
Richard Malin
Phil Pidgeon
Morley Wright

Marine Engineering
Dan Chipman, Supervisor
Steve Christian
Paul Crews
Richard LaPierre
Ensor MacNevin
Stan Myers
Steve Myers
David Usher
Martin LaFitte
Leonard Mombourquette
Richard Myers
Mike O'Rourke
Larry Petrol
Raymond Smith
Kyle Woods

SIGMA-T Crew
Rick Starr
Charles Hamilton

Dartmouth Technical Workshop
Paul McKiel, Supervisor
Lorne Anderson
Bob Brown*
Greg Dauphinee
Maurice Doucet
Peter Ellis
Milo Ewing
Tim Hooper
Andrew Hughes
Heather Kinrade
Katie LaFitte
Chad Maskine
Andrew Morrison
Derek Oakley
John Rowe
Helmut Samland*
Mike Szucs
Philip Veniot*

Science Branch

Regional Director's Office
Michael Sinclair, Director
Karen Curlett
Sharon Morgan
Sherry Niven
Adrianna Pleau
Bettyann Power
Heather Smith

Canadian Hydrographic Service (Atlantic)
Steve Forbes, Director, Hydrography
Atlantic
Richard MacDougall*, Director UNCLOS
Bruce Anderson
Carol Beals
Graham Bondt
Frank Burgess
Fred Carmichael
Lynn Collier
Chris Collins
Mike Collins
Chris Coolen
Jacinthe Cormier
Gerard Costello
Andy Craft
John Cunningham
Peter Dobeck
Tammy Doyle
Theresa Dugas
Chris Eastman
Julian Goodyear
Jon Griffin
Judy Hammond
James Hanway
Heather Joyce
Glen King
Mike Lamplugh
Christopher LeBlanc
Paul Light
Philip MacAulay
Bruce MacGowan
Carrie MacIsaac
Clare McCarthy
Dave McCarthy
Michael McMahon
Mark McCracken
Michael Nickerson
Larry Norton
Stephen Nunn
Charlie O'Reilly
Nick Palmer
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Stephen Parsons
Bob Pietrzak
Sara Rahr
Doug Regular
Glenn Rodger
Dave Roop
Tom Rowsell
Chris Rozon

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* Retired in 2009 ** Deceased in 2009

Mike Ruxton*
Kelly Sabadash
June Senay
Andrew Smith
Christian Solomon
Michel Therrien
Herman Varma
Tammy Waechter
Michael White
Sara Withrow
Wendy Woodford
Craig Wright
Craig Zeller

Ecosystem Research Division
Alain Vézina, Manager
Debbie Anderson
Craig Brown
Sheila Shellnutt
Judy Simms

Centre for Offshore Oil and Gas Environmental Research (COOGER):
Kenneth Lee, Executive Director
Dan Belliveau, Student
Jay Bugden
Susan Cobanli
Jennifer Mason
Roderick Doane
Paul Kepkay
Thomas King
Zhengkai Li
Haibo Niu, Postdoctoral fellow
Brian Robinson
Peter Thamer

Habitat Ecology Section:
Eddy Kennedy, Head
Brian Amirault
Anne Aubut, Student
Lindsay Beazley
Robert Benjamin
Megan Best
Monica Bravo
Chiu Chou*
Pierre Clement
Andrew Cogswell
Peter Cranford
Karen Devitt, Student
Claudio DiBacco
Candice Eastwood. Student
Deanna Ferguson
Jennifer FitzGerald
Jennifer Harris
Laura Hartman, Student
Jocelyne Hellou
Joanne Keays
Ellen Kenchington
Michelle Kenny
Brent Law
Camille Lirette
Tina Lum
Barry MacDonald
Kevin MacIsaac
Edward Marchant, Student
Andrew McMillan
Leslie Nasmith
Vanessa Page
Shawn Roach
Dawn Sephton
Saima Sidik
Daryl Silva
Sean Steller
Phuc Tran, Student
Robin, Tress, Student
Bénédikte Vercaemer
Melisa Wong
Kees Zwanenburg

Ocean Research and Monitoring Section:
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Carol Anstey
Benoit Casault
Carla Caverhill
Grazyna Folwarczna
Erica Head
Diane Horn
Edward Horne
Catherine Johnson
Mary Kennedy
Marilyn Landry
William Li
Alan Longhurst, Visiting Scientist
Heidi Maass
Richard Nelson
Kevin Pauley
Tim Perry
Catherine Porter
Nancy Shackell
Karen Scarcella, Student
John Smith
Jeffrey Spry
Wei Xie, Student

Centre for Marine Biodiversity:
Victoria Clayton

POGO Secretariat:
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Brendan DeTracey
Adam Drozdowski
Jonathan Fisher, Postdoctoral Fellow
Ken Frank
Dave Greenberg
Charles Hannah
Krista Hayes
Casey O'Laughlin, Student
Ingrid Peterson
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Liam Petrie
Roger Pettipas
Trevor Platt
Peter Smith
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Charles Tang
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Yongsheng Wu

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Yuri Geshelin
Blair Greenan
Lanli Guo, Visiting Scientist
Helen Hayden
Ross Hendry
Haiyan Li, Visiting Scientist
Zhenxia Long
Youyu Lu
Ryan Mulligan, Visiting Fellow
William Perrie
Steve Punshon
Tara Rumley
David Slauenwhite**
Brenda Topliss
Bash Toulany
Barb Upshon
Zeliang Wang
Dan Wright
Xie Tao, Visiting Scientist
Fumin Xu, Visiting Scientist
Zhigang Xu, Visiting Scientist
Igor Yashayaev
Biao Zhang, Visiting Fellow
Lujun Zhang, Visiting Scientist

Ocean Physics:
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Brian Beanlands
Don Belliveau
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Richard Boyce
Derek Brittain
Jason Burtch
Zachariah Chiasson
Norman Cochrane
John Conrod
Mylene DiPenta
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Adam Hartling
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Flo Hum
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Carolyn Harvie
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Peter Hurley
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Brian Jones
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Ian Jonsen
Warren Joyce
Peter Koeller
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Mark Lundy
Bill MacEachern
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Marta Mihoff
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Kurtis Trzcinski
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Daisy Williams
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Linda Worth-Bezanson
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* Retired in 2009 ** Deceased in 2009

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Gilbert Donaldson
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Chris Cannon
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Bob Page
Shaun Styche

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Francis Kelly
Carl Myers

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Kevin Ritter

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Canh Hang, Student
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Francis MacLellan
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Aaron West
Suzanne Wilcox

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Rebecca Arsenault
Rhonda Coll
Lori Collins
Lois Loewen
Maureen Martin
Marilynn Rudi

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Myrtle Barkhouse
Carla Sears

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Azharul Hoque, Postdoctoral Fellow
Sheila Hynes
Kimberley Jenner
Kerstin Jerosch, Postdoctoral Fellow
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Vladimir Kostylev
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Maureen MacDonald
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Patrick Meslin
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David Piper
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Bob Taylor
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Dustin Whalen
Bruce Wile

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Pat Dennis
Kevin DesRoches

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Anne Mazerall
Patsy Melbourne
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Programs and Operations Division
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Andrew Sherin*

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Steven Bell
Cheryl Boyd
Terry Hayes
Cecilia Middleton
Julie Mills
Christine Myatt
Wayne Prime
Barb Vetese

Special Assignment
Dick Pickrill

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Tony Barkhouse
Tim Buckler
Bob Cameron
Paul Fraser
Jim Frost
Geoff Gritten
Garry MacNeill
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Arthurina Smardon
Phil Williams
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Marilyn Devost
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John Dunlop
Lee MacIntosh
Dale Murphy
Don Smith

CAFETERIA STAFF

Mark Vickers

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Venetia Stuart, Executive Scientist

Fishermen and Scientists Research Society (FSRS)
Jenna Fletcher, Student
Krista MacEachern
Tricia Pearo
Shannon Scott-Tibbetts

Geoforce Consultants Ltd.
Ryan Pike
Dwight Reimer
Graham Standen
Martin Uyesugi

Contractors
Derek Broughton, Population Ecology
Cathy Budgell, Library
Barbara Corbin, Records
Ewa Dunlap, Coastal Ocean Science
Maud Guarracino, Coastal Ocean Science
Jennifer Lavallee, COOGER
Chris L'Esperence, Ocean Circulation
Xiacwei Ma, COOGER
Alan McLean, CHS
Stephen Middleton, CHS
Nadia Nasrallah, CHS
Jeff Potvin, Informatics
Nicole Prinsenburg, COOGER
Daniel Ricard, Population Ecology
Ron Selinger, Records
Gerald Seibert, Ocean Circulation
Victor Soukhovtsev, Coastal Ocean Science
Jacquelyn Spry, Ocean Research and Monitoring
Jenny Take, CHS
Tineke van der Baaren, Ocean Circulation
Michael Vining, Ocean Physics
Rob Walters, CHS
Alicia Williams, Population Ecology
Kari Workman, COOGER
Inna Yashayaeva, Ocean Data and Information Services

Scientist Emeritus/Science Alumnus
Peter Amiro
Piero Ascoli
Bob Branton
Allyn Clarke
Ray Cranston
Richard Eisner
Jim Elliott
George Fowler
Donald Gordon
Alan Grant
Doug Gregory
Ralph Halliday
Gareth Harding
Bert Hartling
Alex Herman
Lubomir Jansa
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Charlotte Keen
Tim Lambert
René Lavoie
Mike Lewis
Brian MacLean
Clive Mason
David McKeown
Bob Miller
Peta Mudie
Neil Oakey
Doug Sameoto
Hal Sandstrom
Charles Schafer
Glyn Sharp
Shiri Srivastava
Nick Stuifbergen
James Stewart
John Wade
Philip Yeats

Recognition

BIO staff wish to recognize the contribution and support provided by the Captains and crews of Canadian Coast Guard vessels tasked to assist scientific research at BIO.

Term and casual employees, interns, students, and contractors are listed if they worked at BIO for at least four months in the year 2008.
* Retired in 2009 ** Deceased in 2009

Retirements 2009

Retirement notices are usually prepared by colleagues in the organizations where the retirees were employed.

Mary Allen retired from DFO's Mactaquac Biodiversity Facility in January, after working seasonally over a 32-year period. Mary began as a fish tagger in 1977 and for most of her career was a hatchery assistant working at both the early-rearing facility and the main hatchery, below the Saint John River Mactaquac Hydroelectric Dam. She was an experienced and skilled fish tagger, carlin-tagging hundreds of thousands of smolts and producing thousands of tag returns over a 30-year period, principally from the Mactaquac Dam fishway but also from Greenland, Newfoundland, and Maritime waters.

Mary received a Group (Team) Merit Award in 2001 as a member of the Mactaquac staff and Engineering Division team which was recognized for the inner Bay of Fundy salmon Living Gene Bank (LGB), an innovation that resulted in important improvements to operations at LGB facilities, and a new deep-water supply line intake. The Mactaquac staff will miss Mary's important contribution to preparations and data recording at spawning time in November, along with her reliability, friendly face, and cheerful manner.

Peter G. Amiro of DFO's Population Ecology Division retired in January after a career as a respected and innovative salmon stock assessment biologist. Peter began his career as a salmon technician within the Resource Development Branch in 1973. For 35 years Peter observed, studied, and analyzed Atlantic Salmon and their habitat in Eastern Canada. He prepared over 60 publications on habitat surveying, juvenile production assessment and modeling, pre-season and in-season forecasting of adult returns, and population status. His research on the once robust population of the inner Bay of Fundy (iBoF) salmon in the 1980s led to his successful petition to the Committee on the Status of Endangered Wildlife in Canada in 2001 to list the iBoF salmon as endangered. Peter innovated and developed methods and techniques still used for salmon assessment and led surveying, electrofishing, and snorkelling field trips as crew leader, and to the delight of the crew, as camp cook. As well, he recruited and mentored many students and employees. Peter was a member of the American Fisheries Society (AFS) and served in many capacities including successfully pitching and chairing the local arrangements for the 1994 AFS 124th Annual Meeting in Halifax. Peter enjoys home renovation, wood-working, and many outdoor pursuits with his family.

Diane Beanlands retired in January after 33 years with DFO at BIO. Diane began her career in the 1970s as a summer student for the Science Branch's Freshwater and Anadromous Division, conducting lake and stream surveys. In 1979, she was hired as a technician with the Marine Fish Division. Although her undergraduate degree was in education, she enthusiastically took on the challenge of working in science, becoming proficient in stock assessments and learning highly technical skills such as gel electrophoresis. These experiences led her to take the lead in the monkfish stock assessment, subsequently becoming the coordinator of the fish aging function for the division. Her work with the haddock re-aging project was recognized with a DFO Merit Award in 1998.

Diane transferred to the Species at Risk Office in 2004 where, until her retirement, she developed SARA listing documents to support listing decisions for aquatic species, coordinated consultations with stakeholders, and served as the main contact with other DFO regions. Her colleagues will miss her warm manner, her work ethic, and the helpful and enthusiastic nature she exhibited in professional and personal dealings. Diana was a strong contributor to activities at BIO, volunteering for such events as the BIO Open House, Oceans Day, food bank campaigns, and divisional events. Since her retirement she has been enjoying skiing, gardening, and travelling with her husband, Phil.

Darrell Beaver enjoyed a diverse career with NRCan. Darrell began at BIO in 1971, working in administration. Quickly he embraced emerging computer techniques and began collecting and processing navigation and field-station data for Geological Survey of Canada (GSC) marine field surveys. He worked as part of the Atlantic Geoscience Centre Data Section for more than 20 years, then went on to adapt and master the emerging multi-beam bathymetric survey techniques developed at the Canadian Hydrographic Service. A technologist who could do it all from field mobilization, through data collection, to post-processing, Darrell played a significant role in GSC Atlantic's successful seabed-mapping efforts.

LCdr Jim Bradford retired in January after over 32 years of dedicated and commendable service to the Canadian Forces. Jim joined the Department of National Defence in 1976 where he had a full and rewarding career as a Maritime Surface Officer (naval officer), with ten sea postings on as many of Her Majesty's Canadian ships. He fulfilled the duties of Combat Control Officer, then achieved the distinction of Maritime Advanced Navigation Officer (MANO), the pinnacle of navigation. The Advanced Navigation course provided him with the knowledge to navigate deep-draught ships (tankers), teach navigation, and to be a Staff Officer in a navigation posting. Jim navigated one of the tankers and spent time as a Staff Officer at the Mapping and Charting Establishment in Ottawa. As a MANO, he garnered a letter of distinction for his excellence and professionalism. In 1993, Jim was instrumental in moving the Route Survey Office from the Halifax Dockyard to BIO and was here until his retirement, with the exception of two years at the University of New Brunswick where he completed his Masters of Engineering (Geomatics). While employed at the Trinity Route Survey Office he was instrumental in the development and furtherance of the route survey organization and related knowledge, both within Maritime Forces Atlantic and the Canadian Forces overall. Jim will remain in the Halifax area with his wife and family and explore opportunities within the spectrum of underwater surveillance.

J.G. Robert Brown retired in July after 35 years of federal public service. Bob started his career with the fleet maintenance group at the Department of National Defence. He joined the Canadian Coast Guard in the mid-1980s, working out of the Dartmouth

Ships Electronic Workshop. One of the highlights of Bob's career was as a crew member on the *Louis S. St-Laurent* when it travelled to the North Pole in 1994.

Robert Harmes retired from Natural Resources Canada in August after more than 30 years of service. Bob worked as a geological technician with the Geological Survey of Canada and spent much of his career in the Arctic, collecting and processing seabed geological and geophysical data offshore Labrador, in the Northwest Passage, and in the Beaufort Sea. Bob assisted Steve Blasco in the organization, preparation, and conduct of more than 50 different field programs to the Arctic, the Great Lakes, and Bermuda. He was a master at handling the complex logistics around multi-agency, multidisciplinary field surveys, often having to adjust equipment and procedures to a variety of platforms and experiments in harsh environments. Bob is happily enjoying retirement, and finding more time to focus on his excellent woodworking.

Leslie R. Harris retired in the fall of 2008 after 30 years of exemplary service in DFO's Biological Oceanography (now Ocean Research and Monitoring) Section at BIO. Les joined the group in early 1978 and quickly established himself as a talented and valued member of the cohesive, hard-working team of sea-going and laboratory-proficient technicians who supported lower-trophic-level research. Although he is best known by his colleagues as one of a handful of zooplankton taxonomic experts in Canada, he has distinguished himself also by the breadth of his knowledge of plankton ecology and oceanography and his analytical skills in the laboratory, ranging from investigations of zooplankton biochemistry and metabolism to stable isotope tracer measurements of primary productivity. Les took a leading role in organizing and implementing much of the under-ice plankton research undertaken by Biological Oceanography in the early to mid-1980s in Resolute, Northwest Territories. More recently, he has been the DFO Maritime Region's principal zooplankton taxonomist supporting the Atlantic Zone and the Labrador Sea monitoring programs and has provided valuable interpretation of the data. Les is well known for his appreciation of good food and drink, reflected in both his culinary skills and his knowledge of fine wines. He is an avid skier, either on the slopes in western Canada or Europe, and often enjoys time in the restful countryside of southern France. When he is not travelling, Les is on the golf course.

Ruth Jackson retired from NRCan in February, after a lengthy and distinguished career with the Geological Survey of Canada (GSC). Since joining the GSC at BIO in the early 1970s, Ruth has participated in more than 25 scientific expeditions in the Arctic Ocean and Canadian offshore. She was principal investigator or chief scientist on over half of these, including the multidisciplinary CESAR Expedition and the Canadian Ice Island programs in the 1980s. Ruth published more than 70 journal papers and has been recognized nationally and internationally for her many contributions as a marine geophysicist. More recently, she has played a key role with the UNCLOS program, leading expeditions to the Canadian Arctic and participating in the efforts to establish Canada's extended continental shelf. Ruth plans to continue this work as an emeritus scientist.

Brian Jollymore of the Habitat Protection and Sustainable Development Division retired from DFO after 30 years of service. Brian joined the Resource Branch in 1980 as a young and energetic habitat protection engineer after working for the City of Halifax and in the consulting field. During his time with DFO he helped the program grow through its numerous iterations, and forwarded the message of fish habitat protection to all who would listen. Always the consummate teacher, Brian helped develop and mentor Division staff, and DFO overall has benefited from his expertise. Brian also spent many years as the main DFO contact on the Regional Environmental Emergencies Team (REET), responding to environmental emergencies throughout the Atlantic Provinces. He helped develop the REET program into the multi-disciplinary success that it is today. Through his professional and consistent approach to business, Brian earned the respect of his colleagues within the Department, as well as others he has worked with over the years.

J. Richard MacDougall retired in March after almost 40 years with DFO. A graduate of the Saint John Institute of Technology, Dick joined the Canadian Hydrographic Service (CHS) in the summer of 1969. After working over two summers on the Saint John River, he completed the Basic Hydrography Course in Ottawa and British Columbia then transferred to the CHS Central and Arctic Region where he worked on Playgreen Lake, Manitoba and the Great Lakes. Dick went to the Arctic for the first time in 1973, with the Polar Continent Shelf Project (PCSP) and later on board the CCGS *Narwhal* in James Bay. From 1974 until 1979, he worked as a hydrographer throughout Canada and the United States and Canada, playing a pivotal role in leading-edge automated hydrographic techniques and data processing. He also completed a Bachelor of Science (Surveying Engineering) degree in 1979 at the University of New Brunswick. Subsequently, he formally qualified as a land surveyor and registered engineer.

He then took on increased responsibilities with the CHS, as Project Manager, Supervisor, and Hydrographer-In-Charge of Aerial Hydrography, contract surveys, and PCSP Surveys. In 1985, he moved to Ottawa where he supervised mapping and database projects and assumed enhanced responsibilities in nautical geodesy, tides and water levels, Notices to Mariners, chart production and distribution, and quality control.

Dick was appointed Director of the CHS Atlantic in January, 1999. During his tenure, he focused on making Atlantic Canada's nautical charts compatible with the Global Positioning System and promoted integrated seabed mapping as the basis for integrated management of Canada's submerged lands. In 2003, he became the DFO lead in preparing Canada's submission of the outer limits of the continental shelf under the United Nations Convention on the Law of the Sea (UNCLOS). In December, 2006, he assumed the new position of Director, UNCLOS. His accomplishments in this initiative reflect his ethics, intricate knowledge of hydrography, and tireless efforts. Throughout his career, Dick enjoyed taking on new challenges and was always willing to participate on committees, working groups, and innovative projects. He was an excellent field technician, an exceptional executive in the Public Service of Canada, and was noted for his attention to detail and writing skills. He made significant contributions to the CHS and will be missed by his many colleagues throughout Canada and abroad. In retirement, Dick will continue to contribute to the UNCLOS project while spending more time enjoying the family cottage in New Brunswick and travelling with his wife, Marion.

Linda Marks retired in February after more than 31 years with DFO. Linda started her career at the Halifax Fisheries Research Laboratory where she participated in the major Chedabucto Bay oil spill review by surveying bacteria from the Bay water and mud for hydrocarbon-utilizing capabilities. She went on to do research in infectious diseases of marine animals, establishing a rapid diagnostic test to identify the causative bacterium of gaffkemia, a fatal and costly infection of lobsters. Following the 1987 incident where human illnesses and

deaths resulted from the consumption of Blue Mussels containing the neurotoxin, domoic acid, Linda served as a biologist with the Habitat Ecology Division at BIO studying this and other phycotoxins. She participated in the development of diagnostic methods for domoic acid and put into operation a tissue culture technique for detecting paralytic shellfish poisons.

In 1994, Linda returned to the Halifax Fisheries Research Laboratory to work with the Fish Health and Nutrition Section. From 1997 until her retirement, she worked at BIO as a fisheries technician with the Marine Fish Division where she participated in shark and fish otolith research. (An otolith is an earbone, used to determine fish age.) She aged otoliths from a variety of fish species and Linda's skills in handling the tiny otoliths and managing the lab and the image analysis system were superlative. Also, her assistance to Steve Campana in the production of an illustrated otolith atlas of Atlantic marine fish species was invaluable. At the Institute, Linda contributed her efforts to social and charitable activities, particularly to BIO's Symphony Nova Scotia chair sponsorship and she will be missed by her many friends and colleagues. In retirement, she will continue to be active in the Nova Scotian Institute of Science and plans to enjoy life at the family cottage, on the golf course, and seeing the world.

David Roop retired in October after 32 Years with the Canadian Hydrographic Service (CHS). Dave graduated from Acadia University with a B.Sc. in Geology in 1973 and in 1977 began his career with the CHS as a field hydrographer. He sailed on the CSS *Maxwell*, CSS *Baffin*, and CSS *Matthew* carrying out hydrographic surveys in the Eastern Arctic and Atlantic Canada. He obtained his Canada Land Surveyors (CLS) Certification in 1987 and took great pride in his membership as a CLS. In the 1980s, Dave was part of the multi-disciplinary hydrographer program and worked in various sections of the CHS including Data Validation, Tidal, and Chart Production. His last few years were primarily working in data quality control where he spent a great deal of time working with CHS Connections Clubhouse staff, providing training and guidance in a wide variety of data transformation tasks. Dave was well known in the CHS for his commitment to family and his myriad interests including chess, skiing, gardening, horses, and the family farm. Upon leaving BIO he is going to Kandahar, Afghanistan, where he is scheduled to do a civilian-duties posting before retiring to his farm in Windsor, Nova Scotia.

Mike Ruxton retired in January after 33 years with the Canadian Hydrographic Service (CHS). A graduate of Carleton and Dalhousie universities, Mike spent the first 17 years of his DFO career as a hydrographer, working on the CSS *Baffin*, the FCG *Smith*, and charter vessels. In 1992, he accepted a computer science position in the Hydrographic Development (now Geomatics Support) section of the CHS Atlantic. Known for his analytical and methodical problem-solving skills as well as his love of music and literature, Mike will be missed by his colleagues on both personal and professional levels.

Matthew Salisbury retired from NRCan in July, after many years of making significant scientific, management, and administrative contributions to the Geological Survey of Canada (GSC), Earth Sciences Sector, and the wider scientific community. Matt joined the GSC in 1988 after spending his earlier career at Scripps Institution of Oceanography and Dalhousie University. Matt maintained strong ties with Dalhousie as an adjunct professor and director of the GSC-Dalhousie High Pressure lab, one of the largest high-pressure facilities in the world dedicated to acoustic research. His research interests included acoustic properties of rocks and ores and the composition and structure of oceanic and continental crust and upper mantle. Matt spent several years prior to retirement serving as a senior analyst within the Earth Sciences Sector office, helping to review and guide its scientific programs. Matt plans to continue his scientific and other activities as an emeritus scientist at BIO.

Helmut Samland retired in March after a 27-year career. Helmut was a valued member of the CCG Dartmouth Technical Workshop. His wit and jack-of-all-trades ability will be missed by his colleagues.

Murray Scotney retired from DFO in November, after 40 years of exemplary service to the oceanographic community at BIO and abroad. Starting as an Electronics Technologist in the Coastal Oceanography Section, Murray became one of the world's leading experts in ocean mooring and current meter technology. In 2000, he became Head of the Technical Operations Group in the Ocean Sciences Division, helping to ensure that BIO remained a leader in oceanographic research. Murray's career paralleled the rapid development of ocean instrumentation and he was a key factor in the integration of these technologies into the Institute's science program. In 2007, he received the BIO Ocean Association's Beluga Award in recognition of his contributions to the BIO community. His calmness when faced with challenging conditions at sea and the depth of his experience have been major reasons for the high success rate of BIO's mooring and related programs.

Robert Semple retired from DFO in December after 35 years of public service. Bob's latter years were with the Population Ecology Division at BIO where he was the technician for the unique seaweed program in Maritimes Region. He was an avid SCUBA diver and served as Regional Dive Safety Officer for many years, during which the region's SCUBA safety record was almost flawless, far better than recreational or commercial dive statistics nationwide. Bob mentored scores of SCUBA divers during his tenure. He is also an internationally recognized underwater photographer. His work can be seen in the Waterworld Gallery in the lobby of BIO's Katherine Ellis Laboratory building.

Glyn Sharp retired from DFO in January after 32 years of service. Glyn's latter years were with the Population Ecology Division at BIO where he was the biologist for the unique seaweed program in Maritimes Region. Glyn and Bob Semple (*see above*) were a seasoned SCUBA diving team, working on commercial seaweeds, invertebrates, and fish. Glyn was responsible for developing the science now applied to the management of the rockweed fishery in New Brunswick. Without his efforts, this relatively new fishery model may not have been established. Glyn is known for his ability with small boats and is an avid sailor.

Andrew Sherin retired from NRCan in October after more than 35 years of service. Andy began his career in 1971 as a student geochemist with the Atlantic Geoscience Centre (AGC), working on a variety of marine environmental geoscience projects, including the impacts of the Canso Causeway, which connects Cape Breton Island to mainland Nova Scotia. He was appointed as the first curator of marine collections in 1974 and later led the AGC Data Section. Andy was an early adopter of the Geographic Information System technology, which has since become the primary platform for geoscience mapping and geospatial analysis. Toward the end of his career, he took an assignment with the Earth Sciences Sector (ESS) office, moving to Ottawa for three years. Andy became head of the ESS office and continued in that role after returning to Nova Scotia. In this context, his grasp of science and policy issues supported and influenced research across the ESS from coast to coast.

Philip Venoit retired in January, after more than 30 years with the Canadian Coast Guard. Phil was employed as an electronics maintenance technologist, working primarily on land-based systems. Most of his career was spent at Halifax Coast Guard Radio. In 1997, he relocated to the Dartmouth Coast Guard Base, as part of the merger of the Ketch Harbour and Dartmouth Technical workshops.

Malcolm Webb retired from DFO's Mactaquac Biodiversity Facility in January, after almost 22 years as Maintenance Superintendent/Electrician. Mac demonstrated exceptional reliability and skilled responses to a wide variety of challenging emergencies. After the serious 2008 Saint John River Flood below the Mactaquac Hydroelectric Dam, his restoration of Mactaquac's electrical systems was greatly appreciated and was recognized by a departmental "Immediate" award. His efforts were especially noteworthy since he came off sick leave to restore power to the facilities.

Mac was similarly recognized in 2005, following a less serious flood, for his initiative and excellent work in repairing extensive damage to the Visitor Facility gardens. In addition, he received a Group (Team) Merit Award in 2001 as a member of the Mactaquac staff and Engineering Division team which was recognized for the inner Bay of Fundy salmon Living Gene Bank (LGB), an innovation that resulted in important improvements to operations at LGB facilities, and a new deep-water supply line intake. Mactaquac staff will miss the personal touch Mac gave to the Mactaquac grounds and the special pride he took in selecting and nurturing the trees that complement the approach to the facility. His sense of humour and Mac Webb view of events will be hard to replace in the lunch-room banter.

Trudy Wilson began her career as a teacher at Dartmouth High School. She then lived in various cities in Canada before joining the Federal Public Service in Ottawa, where her first employment was with the Receiver General for Canada. Later, Trudy transferred to Halifax and worked as a financial advisor for the Regional Director General, Supply and Services Canada. She next went to DFO, where she worked in Finance and, since 1999, for Oceans at BIO.

Trudy was instrumental in helping to establish the Oceans Branch and in fostering its evolution to its present form as the Oceans, Habitat and Species at Risk Branch, where she concluded her career as Assistant Regional Director. As well, she played an important role as the regional lead for the Departmental Assessment and Alignment Project and on BIO committees, including the BIO Tuesday Club. Her common-sense approach and commitment to excellence will be missed by all.

In Memoriam

On November 25, BIO lost a special person, with the untimely passing at age 46 of **Stephen Nolan**, a Crustacean Research Technician with DFO's Population Ecology Division. Steve started at BIO in 1989 as a Species Interaction Technician, following the completion of his B.Sc. (Honours) in Marine Biology from Dalhousie University and several years as a DFO offshore observer. He was a versatile, ingenious, and resourceful field technician who made valuable contributions to the study of near-shore populations. He loved working in the field and nothing gave him more joy than being on the water in his assigned vessel, a 21-foot (6.4-metre) Boston Whaler.

Stephen Nolan

Throughout his career, Steve contributed substantially to numerous field projects, including kelp and sea urchin surveys on the open coast from northern Cape Breton to Cape Sable Island, planktonic lobster larvae surveys from Sambro to Shelburne, and field experiments using baited traps and temperature–light-current measurements. He contributed also to the collection of lobster and sea urchin catch-and-effort data from logbooks and sampling lobsters at sea; to lobster growth and movement studies through tagging; and to lobster maturity studies. Most recently, he was key in organizing logistics associated with the construction, assembly, deployment, and retrieval of juvenile lobster collectors from Cape Breton to St. Marys Bay. During this project he also tended divers who were sampling for young-of-the-year lobsters in Southwest Nova Scotia. Other contributions included a preliminary survey for urchins in Queens County and help with tending divers during the establishment of biological diversity sampling sites.

In the course of his work, Steve learned a lot from fishermen and they from him. He considered communication with industry essential and had many friends within the industry. Steve's passing reminds us to accept things as they are and to enjoy our lives fully. As quoted by a dear friend of his at his Celebration of Life, "May Steve have fair winds, and following seas, and long may his big jib draw."

Dr. David Slauenwhite, a chemical oceanographer with the Ocean Circulation Section of DFO's Ocean Sciences Division (OSD), passed away on August 21. Dave graduated from Dalhousie University with his B.Sc (Honours) in Chemistry and his Ph.D. in Chemical Oceanography (1991). He subsequently held a Postdoctoral Fellowship at Dalhousie, before becoming a laboratory manager at Saint Mary's University.

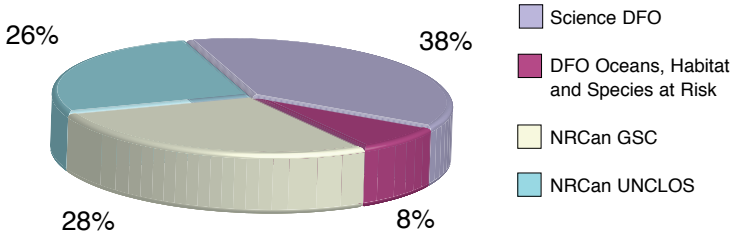
Dave began working at BIO in 2006. In collaboration with Dr. Kumiko Azetsu-Scott, he was the scientist responsible for the management and operation of the OSD chemical oceanographic laboratory, where analyses are conducted to measure dissolved oxygen, alkalinity and inorganic carbon, chlorofluorocarbons as ocean tracers, and most recently, ocean acidity. Just before his illness, Dave fully participated in BIO's annual oceanographic survey of the Labrador Sea in May 2009. During his short tenure at BIO, Dave established himself as a congenial, conscientious, hard-working, and highly competent team member and became a good friend to many who worked with him. He will be greatly missed.

David Slauenwhite prepares to collect seawater samples for chemical tracer measurements from on board the CCGS *Hudson*.

FINANCAL AND HUMAN RESOURCES

Where BIO obtains funding and how it is spent

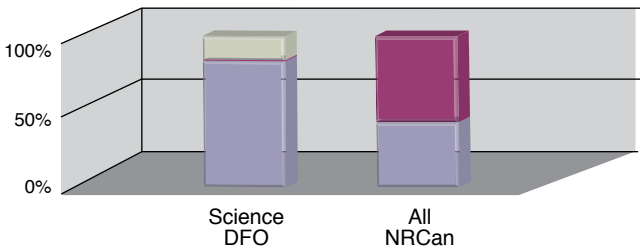
Annual appropriation from government



DEPARTMENT	SECTOR	AMOUNT ($000)
DFO	Science	31,604
DFO	OHSAR	6,268
NRCan	GSC	23,357
NRCan	UNCLOS	21,455

DFO Informatics, Environment Canada, and DND have staff working at BIO. The resources used by those staff members are not captured in this report.

Other sources of funding

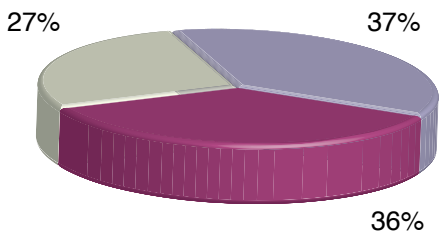


DEPARTMENT	SECTOR	GOVERNMENT ($000)	INSTITUTIONS ($000)	INDUSTRY ($000)
DFO	Science	13,156	260	1,813
NRCan	GSC & UNCLOS	5,940	6,919	

Industry Institutions Government

DFO Science spending

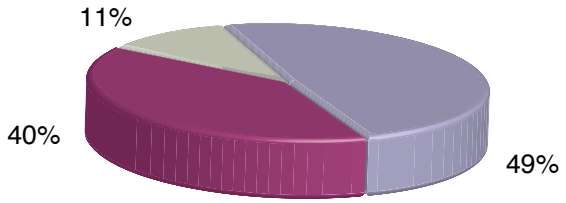
DFO Science



STRATEGIC OBJECTIVE	AMOUNT ($000)
Healthy and Productive Aquatic Ecosytems	17,313
Sustainable Fisheries and Aquaculture	16,937
Safe and Accessible Waterways	12,483

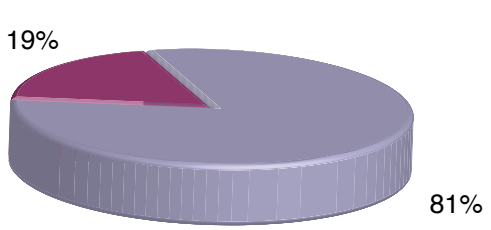
Program spending cont.

DFO Oceans, Habitat and Species at Risk



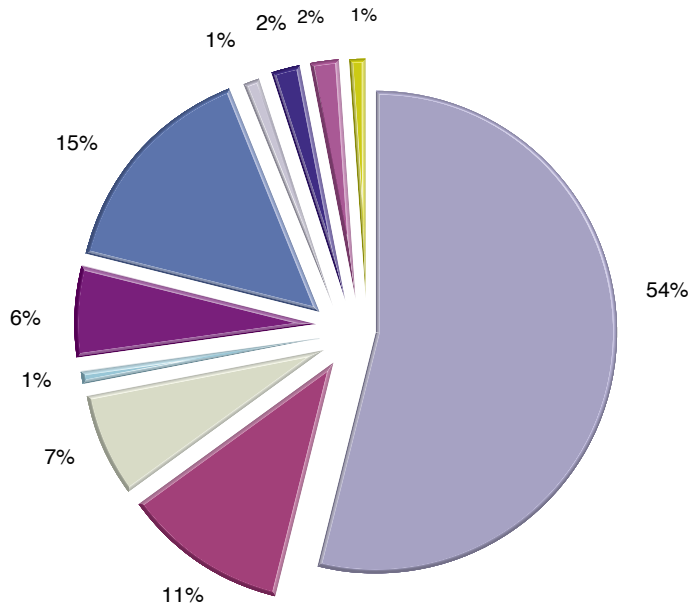
PROGRAMS	AMOUNT ($000)
Habitat Management	3,056
Oceans	2,523
Species at Risk	689

NRCan



	AMOUNT ($000)
Research	47,017
Technology/Equipment	10,855

BIO staff by Division/Department



DFO - Science	365
DFO - Oceans, Habitat & Species at Risk	75
DFO - Informatics	47
DFO - Other	7
DFO - Coast Guard Tech Services	44
NRCan - GSC Atlantic	101
EC - Operational Laboratories	4
DND - Survey Office	13
PWGSC - Site Operations	13
Research Coordination Units	9
Total	678

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

PUBLICATIONS AND PRODUCTS

Publications 2009

BEDFORD INSTITUTE OF OCEANOGRAPHY

Scientific Journals

DFO: Science Branch

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Chen, Z., C.S. Zhan, and K. Lee. 2009. Formation and vertical mixing of oil droplets resulting from oil slick under breaking waves - a modeling study. Environ. Forensics 10: 347-353.

Chen, Z., C.-S. Zhan, K. Lee, Z. Li, and M.C. Boufadel. 2009. Modeling oil droplet formation and evolution under breaking waves. Energy Sources, Part A: Recovery, Utilization, and Environmental Effects 31: 438-448.

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The Swedish icebreaker ODEN *was used to conduct a joint Danish-Canadian expedition to map the Lomonosov Ridge in 2009. The survey was in support of the UNCLOS work being done by both countries to better define their respective claims in the Arctic. The Canadian representative (Michael Lamplugh, Canadian Hydrographic Service, DFO) can be seen on the right holding a Canadian flag in this group picture taken during a stop at the North Pole at midnight on August 22. Photo is courtesy of Adam Jeppesen who was the artist and photographer for the trip.*

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