**Canadian activities in the Arctic and the North Atlantic**

Participants:

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This draft report provides an overview of current and planned oceanographic investigations of the western Arctic and Atlantic. It is based on the knowledge of participants and does not yet represent a comprehensive account (and is thus subject to revision by members of the Canadian community who did not attend the meeting).

**Current projects and networks**

**1. Network Centers of Excellence**

**1.1. ArcticNet (lead PI: Louis Fortier, Université Laval)**

ArcticNet is a Network of Centres of Excellence of Canada that brings together scientists and managers in the natural, human health and social sciences with their partners from Inuit organizations, northern communities, federal and provincial agencies and the private sector. The objective of ArcticNet is to study the impacts of climate change and modernization in the coastal Canadian Arctic. Over 145 ArcticNet researchers from 30 Canadian Universities, 8 federal and 11 provincial agencies and departments collaborate with research teams in Denmark, Finland, France, Greenland, Japan, Norway, Poland, Russia, Spain, Sweden, the United Kingdom and the USA. A full suite of physical, chemical and biological oceanographic sampling is performed during annual expeditions of the CCGS Amundsen across the western Labrador Sea, Baffin Bay, the Canadian Archipelago (CAA) and the Beaufort Sea. Expeditions started in 2004 and will continue until 2018. Different lead PI can be contacted depending on topics (e.g., Productivity and nutrient dynamics: JE Tremblay; Gas exchange: Tim Papakyriakou; Contaminants: Gary Stern) Details of the network and specific projects can be found at: [www.arcticnet.ulaval.ca](http://www.arcticnet.ulaval.ca)

**1.2. MEOPAR (2012-2026)**

* **MEOPAR** (*Marine Environmental Observation Prediction and Response Network*) brings together Canadian researchers, stakeholders and users in a multisectoral partnership to better understand and predict the impact of marine hazards on human activities and ecosystems. This includes predictions and projections of changes in storms; coastal flooding and waves on local scales with consideration of associated economic, safety, planning, regulatory, and policy issues; assessment of the impact of long term oceanic change on Canadian coastal communities, ecosystems and economic interests, including implications for resource management, regulation and policy. <http://meopar.ca>

**2. Projects run under the Climate Change and Atmospheric Research (CCAR) program of NSERC (2013-2018)**

The CCAR initiative addresses both national research priorities and global challenges, including those associated with the *Belmont Challenge Freshwater Security and Coastal Zone Vulnerability Initiatives* by supporting a number of large, integrative projects involving university researchers and Canadian government scientists, along with other partners and international researchers (<http://www.nserc-crsng.gc.ca>). Three major multi-disciplinary projects are currently funded under this umbrella:

**2.1. VITALS (lead PI: Paul Myers, U. of Alberta)**

The VITALS (*Ventilation, Interactions and Transports Across the Labrador Sea*) research network addresses fundamental questions about how the deep ocean exchanges carbon dioxide, oxygen, and heat with the atmosphere through the Labrador Sea. New observations and modeling will determine what controls these exchanges and how they interact with the varying climate, in order to resolve the role of deep convection regions in the Carbon Cycle and Earth System. VITALS is a pan-Canadian initiative involving scientists from 11 Canadian universities as well as multiple federal government laboratories (Fisheries and Oceans Canada, as well as Environment Canada), industrial and foreign partners. The central objective is to understand and model the functioning and vulnerability of the Labrador Sea as a key component of the earth's climate system, including its uptake of oxygen, anthropogenic carbon, and exchange of heat with the atmosphere. Comprehensive sampling for physics, chemistry and biology (stocks and rates) will be performed during annual surveys (May) of the AR7W line by the CCGS Hudson, in collaboration with the AZOMP monitoring program supported by DFO’s Bedford Institute of Oceanography (see 4.2 below). Remote sensing and a combination of fixed (moorings and Sea Cycler) and mobile platforms (gliders, Argo floats, undulating CTD profiler) will be used to resolve processes at a variety of relevant scales of time and space. Details of the program and survey area can be found at: <http://assyria.eas.ualberta.ca/~myers/VITALS/index.htm>

**2.2. Canadian Arctic GEOTRACE (lead PI: Roger François, UBC)**

This GEOTRACE program aims to identify processes and quantify fluxes that control the distribution of key trace elements and isotopes that regulate or serve as tracers for critical biogeochemical and physical processes in the ocean and to establish their sensitivity to changing environmental conditions. Two different transects will be sampled in 2015, one in the eastern Canada Basin and another across the CAA, Baffin Bay and the Labrador Sea using the CCGS Amundsen. General information on the program can be found at <http://www.geotraces.org>

**2.3. NETCARE (lead PI: Jon Abbatt)**

NETCARE (*Network on Climate and Aerosols: Addressing Key Uncertainties in Remote Canadian Environments*) will focus on the Arctic and Western Canada in order to target aerosol sources and processes most important in areas remote from industrial influences.  The Arctic is an area of focus given its extreme sensitivity to pollutant input and as a bellwether of climate change.  Observations will extend across the Arctic from land stations, an icebreaker, and a research aircraft.  Western Canada is also an area of interest because it receives intercontinental pollution from Asia, as well as being subject to clean marine air and biomass burning input from forest fires.  The interplay between these sources needs to be assessed given the potential for significant effects arising from changing Asian emissions and forest fire activity. Details can be found at: <http://www.netcare-project.ca>

**3. Joint Canada/US program in the Canada Basin (Lead PI: Bill Williams, DFO)**

The Joint Ocean Ice Study (JOIS) is a contribution from DFO (Institute of Ocean Sciences) to international Arctic climate research programs. Primarily, it involves the collaboration of Fisheries and Oceans Canada researchers with colleagues in the USA from Woods Hole Oceanographic Institution (WHOI). The scientists from WHOI lead the Beaufort Gyre Exploration Project (BGEP, <http://www.whoi.edu/beaufortgyre/>) which forms part of the Arctic Observing Network (AON). The central objective is to understand the impacts of global change on the physical and geochemical environment of the Canada Basin of the Arctic Ocean and the corresponding biological response, linking decadal-scale perturbations in the Arctic atmosphere to inter-annual basin-scale changes in the freshwater content of the Beaufort Gyre, freshwater sources, ice properties and distribution, water mass properties and distribution, ocean circulation, ocean acidification and biota distribution.

**4. DFO’s monitoring programs in the western Atlantic**

**4.1. AZMP** (Atlantic Zone Monitoring Program)

The main objectives of AZMP are twofold: (1) to collect and analyze biological, chemical, and physical data to characterize and understand the causes of oceanic variability at the seasonal, interannual: and decadal scales; and (2) to provide the multidisciplinary data sets that can be used to establish relationships among the biological, chemical, and physical variability. The AZMP was implemented in 1998 and covers the Gulf of Saint-Lawrence, Québec, the Maritime and Newfoundland regions of DFO. Its sampling strategy is based on 1) Seasonal and opportunistic sampling along "sections" to quantify the oceanographic variability in the Canadian NW Atlantic shelf region, 2) Higher-frequency temporal sampling at more accessible "fixed sites" to monitor the shorter time scale dynamics in representative areas, and 3)Fish survey and remote sensing data to provide broader spatial coverage and a context to interpret other data. Data from other existing monitoring programs such as CPR (Continuous Plankton Recorder) lines, Sea Level Network, nearshore Long-Term Temperature Monitoring, Toxic Algae monitoring, etc., or from other external organizations (e.g., winds and air temperatures from Environment Canada) complement AZMP data. Details can be found at: <http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/azmp-pmza/index-eng.html>

**4.2. AZOMP** (Atlantic Zone Off-Shelf Monitoring Program, initiated in 1990)

The objective of the Atlantic Zone Off-Shelf Monitoring Program (AZOMP) is to monitor variability in the ocean climate and plankton affecting regional climate and ecosystems off Atlantic Canada and the global climate system. AZOMP has three primary components: 1) the [Labrador Sea Monitoring Program](http://www.bio.gc.ca/science/monitoring-monitorage/azomp-pmzao/labrador/labrador-eng.php), the largest component of AZOMP, collects and analyzes physical, chemical and biological observations on an oceanographic section across the Labrador Sea, referred to as the AR7W Line, 2) the [Scotian Slope/Rise Monitoring Program](http://www.bio.gc.ca/science/monitoring-monitorage/azomp-pmzao/slope-pente/slope-pente-eng.php) collects and analyzes physical, chemical and biological observations over the Scotian Slope and Rise at deep-water stations added to the offshore end of AZMP's Halifax Line. The stations are referred to as the extended Halifax Line (XHL), 3) temperature and salinity profiles from the [Argo Float Program](http://www.bio.gc.ca/science/monitoring-monitorage/azomp-pmzao/argo-eng.php) are used to complement observations from AR7W and XHL. The Bedford Institute of Oceanography contributes to the [International Argo Program](http://www.argo.ucsd.edu/). AZOMP contributes to international ocean observation, climate and carbon programs such as the Global Ocean Observation System ([GOOS](http://www.ioc-goos.org/)), the Climate Variability and Prediction project ([CLIVAR](http://www.clivar.org/)), the Global Ocean Ship-based Hydrographic Investigations Program ([GO-SHIP](http://www.go-ship.org/)), and the International Ocean Carbon Coordination Project ([IOCCP](http://www.ioccp.org/)). More details can be found at: <http://www.bio.gc.ca/science/monitoring-monitorage/azomp-pmzao/azomp-pmzao-eng.php>

**5. Canada Excellence Chairs (CERC)**

**5.1. CERC in Remote Sensing of the New Arctic Frontier (lead: Marcel Babin)**

This CERC involves 7 different PIs and laboratories. It applies the most recent advances in remote sensing, completed by process studies at sea, to track the response of arctic marine ecosystems to climate variability and change. The team develops diagnostic and predictive models of arctic marine ecosystems, perfecting the deployment of profiling floats and autonomous underwater vehicles in ice-covered seas. The activities of this CERC are linked to the French-Canada international research unit Takuvik (<http://www.takuvik.ulaval.ca>), which focuses on the impact of ongoing climatic and anthropogenic changes on Arctic marine and terrestrial ecosystems and geosystems. Details on this CERC can be obtained at <http://www.cerc-arctic.ulaval.ca>.

**5.2. CERC in Arctic Geomicrobiology and Climate Change (lead: Soren Rysgaard)**

This CERC investigates the biogeochemical transformations of carbon in sea ice and their impact on the concentration of carbon dioxide in the atmosphere, and, therefore, the rate of climate change (<ww.cerc.gc.ca/chairholders-titulaires/rysgaard-eng.aspx>). It studies and quantifies the importance of fundamental microbial activities using state-of-the-art assessment techniques in a comprehensive three-pronged combination of ice tank experiments, in situ observations and modeling studies. Modeling activities range from small-scale studies within the sea ice and sediment compartments to local coastal regions of strategic importance and the large-scale systems of the Arctic Ocean and neighboring seas.

**5.3. CERC in Ocean Science and Technology (lead: Doug Wallace; Dalhousie)**

This CERC is developing new observation instruments that are more sensitive to biogeochemical oceanic change than current methods of detection. Packages of these instruments are being stationed on research vessels, but also on commercial ships that will act as “volunteer” observing platforms as well as on autonomous vehicles. The data will be used to measure, for example, how the uptake of fossil-fuel-derived carbon dioxide by the ocean is changing. As the first science director of the new Halifax Marine Research Institute, Wallace is playing a critical role in establishing a broad, long-term research agenda for the region. Bringing together academics and government researchers, the institute will serve as a bridge between the marine research community, the private sector and policy-makers, as well as becoming an integral part of joint projects with other nations. <http://www.cerc.gc.ca/chairholders-titulaires/wallace-eng.aspx>

**6.** **Ocean Tracking Network (lead PI: Sarah Iverson, Dalhousie)**

OTN Canada, launched in January 2010, is a countrywide interdisciplinary network of science teams working within the global OTN infrastructure to address key scientific questions of both national and international concern and relevance. OTN Canada is focused in the Pacific, Arctic and Atlantic Arenas to reach and respond to questions in vastly different ocean ecosystems across the country. Included for each Arena are measurements of oceanographic characteristics and variability at various spatial and temporal scales, movements of key species at several trophic levels, and analysis of key "bioprobes" (animals that carry tags which record locations visited, ocean conditions and interactions with other tagged animals in the open ocean) and "roboprobes" (remotely controlled gliders) to complement measurements from fixed OTN receivers. More information at <http://oceantrackingnetwork.org/otn-canada>

**8. Participation in international programs**

* **OSNAP (US-led).** Canadian PIs: Blair Greenan (DFO) & Brad de Young (Memorial U)
* **Redfish Survey (Iceland).** Canadian PI: Doug Wallace (Dalhousie)
* **Carbon Bridge (Norway).** Canadian PI: Jean-Éric Tremblay
* **TRANSSIZ (ART).** Canadian PIs:Jean-Éric Tremblay, Marcel Babin, Christine Michel

**Planned initiatives**

 **1. GreenEdge (lead PI: Marcel Babin, Université Laval)**

GreenEdge aims to understand the dynamics of ice-edge spring blooms (IEBs) and determine their role in the Arctic Ocean of tomorrow. More specifically, the project seeks to 1) understand the key physical, chemical and biological processes that govern IEBs, 2) identify the key phytoplankton species involved in IEBs and model their growth under various environmental conditions, and 3) predict the fate of IEBs and related carbon transfer through the food chain and toward the bottom sediments over the next few decades. To reach the first objective, a spring bloom event will be monitored (2016 target) in Baffin Bay, from its onset under melting sea ice in May to its conclusion within the seasonal ice zone in July. The distribution of relevant physical, chemical and biological properties will be described at various time and space scales using a fleet of profiling floats and gliders and an autonomous underwater vehicle, all equipped with a suite of physical and bio-optical sensors. Process studies will be conducted from an ice camp and then from a research icebreaker to document phytoplankton growth, nutrient dynamics and the transfer of carbon through the food web and toward the bottom sediments. To reach the second objective, key phytoplankton species will be isolated and grown in the laboratory under various conditions to model their response to environmental factors and to understand their succession during spring. Finally, the third objective will be reached using a coupled physical-biological model optimized for simulating the spring bloom in the Arctic Ocean and for predicting changes in the phytoplankton community composition. Additionally, past and present trends in the intensity and spatial distribution of the spring bloom will be documented using a paleoceanography approach, and using remote sensing.

**2. Baffin Bay observatory**

This initiative aims to coordinate and leverage existing observation capacities (from academia and federal agencies) to develop a full-fledge observatory of Artic outflows across major gateways (Lancaster Sound and Nares Strait) to Baffin Bay, freshwater inputs from Greenland and Canadian glaciers, as well as the response of the Bay’s interior to these changes. The project would involve fixed and mobile autonomous sampling (including an acoustic positioning system) with ship-based and shore-based process studies. Current partners involve the three Canadian CERCS (see section 5), ArcticNet and the Arctic Science Partnership (<http://www.asp-net.org>) between Canadian, Danish and Greenlandic scientists. Discussions are underway with potential partners involved with bordering observatories (e.g. Davis Strait).