



OCEAN
TRACKING NETWORK

Annual Report 2011 – 2012



OTN and the South African Institute for Aquatic Biodiversity (SAIAB) partner on tracking projects in Mossel Bay and Algoa Bay, South Africa, beginning in 2011.

OTN in Brief

The Ocean Tracking Network (OTN) is a Canada Foundation for Innovation (CFI) □ International Joint Ventures Fund global research and technology development project headquartered at Dalhousie University, Halifax, Nova Scotia, Canada. Starting in 2008, OTN began deploying Canadian state-of-the-art acoustic receivers and oceanographic monitoring equipment in key ocean locations. These are being used to document the movements and survival of marine animals carrying acoustic tags, and to document how both are influenced by oceanographic conditions. OTN deployments will occur in all of the world's five oceans, and span seven continents. The species tracked include marine mammals, sea turtles, squid, and fishes including sharks, sturgeon, eels, tuna, salmon, and cod. The Natural Sciences and Engineering Research Council of Canada (NSERC) supports OTN Canada, a national network of researchers that works within the OTN infrastructure. The Social Sciences and Humanities Research Council of Canada (SSHRC) funds the participation of social scientists in OTN work. Over 200 international researchers from 15 countries are currently participating in the global network. OTN hosts a data warehouse that serves as a repository for data collected by OTN researchers, and is developing interpretation and visualization tools for tracking data. OTN also operates a fleet of two autonomous vehicles in support of oceanographic and tracking research.

Annual Report 2011 – 2012

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Message from OTN Global Scientific Director

The Global Ocean Tracking Network spun off from the Census of Marine Life (CoML) just as it was reporting its successes at the end of 2010. Many of the same people who made CoML happen have been the stalwarts who kept OTN Global on track. In CoML, it just seemed natural — draw a map of the world and divide the ocean into 14 regions based primarily on how animals use them — but it is not always as easy to ship hardware across international borders as it is for the animals to cross them.

One hallmark of OTN is that it was planned as a project of the Global Ocean Observing System of the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization in Paris. For me, the single biggest success of the CoML was when the IOC adopted its Ocean Biogeographic Information System. This brings the world repository of marine biological data under the same roof as the world repository of marine physicochemical data collected at the International Oceanographic Data and Information Exchange from National Ocean Data Centres around the world.

One of the biggest successes for OTN to date has been the anticipation that these data standards would prevail, making it almost easy to link animal behaviour to climate change, which was a primary driver for the OTN concept. An OTN alliance with the CANARIE Platform for Ocean Knowledge Management takes this next step, providing access to a wealth of marine data from satellites to OTN lines to undersea cables in an enhanced visualization system.

*Dr. Ron O'Dor
OTN Global Scientific Director
Dalhousie University*

OTN Mission

The OTN mission is to foster the conservation and sustainable use of the oceans by generating knowledge of the movements and habitats of aquatic animals, these animals' relationships to their physical, biological, and chemical environment, and how the ocean environment is changing.

OTN Objectives

- Develop and use state-of-the-art tracking technologies to identify critical habitats and migration pathways of aquatic animals important to humans, on small-to-large scales
- Deploy sensor capacity to measure global ocean environmental conditions
- Foster innovative technological advances that will expand and complement existing systems and arrays, and make Canada a global leader in conservation and the sustainable use of the oceans
- Provide results in a timely fashion and in forms easily understandable to the public and useful to inform public policy
- Create and maintain a secure master database ("data warehouse"), open to global researchers and other users, to support public communications, to store data from individual studies, and, in the longer term, to create a new meta-analysis tool
- Ensure OTN is an integral contribution to broader international efforts to monitor ocean conditions as a component of the Global Ocean Observing System, thereby developing synergies with other ocean monitoring efforts

Message from Chair of the OTN Council

OTN is now well on its way to becoming a beacon of comprehensive and integrative data management for better ocean stewardship. This is due in part to our partnership with industry that has been developing the use of novel and highly innovative technology. The integration of social science themes and collaboration between researchers from the Atlantic, Pacific, and Arctic Arenas ensures we have remarkable nationwide scientific strength with which to proactively protect Earth's delicate ocean ecology.

OTN's progress and outcomes are a direct testament to the leadership and the work of both national and international researchers, students, staff, and industry partners who have pushed OTN into the ranks of internationally recognized ocean science research organizations.

With the funding from the Canada Foundation for Innovation (CFI), the Natural Sciences and Engineering Research Council of Canada (NSERC) and the Social Sciences and Humanities Research Council of Canada (SSHRC), OTN will continue to grow as a leader in ocean science research. The scope and importance of the international network would not be possible without the support we have received from the Canadian Government.

We believe that sound research and protection of our natural resources are priorities for all Canadians. OTN has made exciting contributions to the technological and science communities in just a few short years. Dalhousie University is excited and proud to continue its support of the Ocean Tracking Network in producing the science to guide better oceans management.

*Dr. Martha Crago
VP Research, Dalhousie University*

Message from OTN Executive Director

It is with great pride that we look back on the accomplishments of the second full year of OTN operation. With our partners, we have significantly progressed in creating a new international ocean observing system to monitor the movements and survival of aquatic animals.

We have greatly expanded our national and international equipment deployments, and OTN now operates the globe's most extensive acoustic telemetry system. The OTN data warehouse is rapidly expanding, and is making available the network's quality-controlled data. OTN is fortunate to work with an extraordinary diversity of talented and dedicated scientists. World-class animal trackers from Canada and internationally are using our platform to make a difference on science issues affecting people. These range from helping to find ways to keep swimmers safe from shark attacks, to unraveling the mysteries of failing Pacific salmon returns. A talented group of modelers, statisticians, and computer scientists are providing innovative new visualization and analytic techniques. State-of-the-art social science researchers are helping turn data into knowledge that will guide resource managers and planners in the sustainable use of living marine resources. We are also pioneering the use of autonomous vehicles in telemetry work. It is an exciting and revolutionary time for ocean research.

I thank the staff and partners of OTN, and our funders in Canada (the Canada Foundation for Innovation (CFI), Natural Sciences and Engineering Research Council (NSERC), and the Social Sciences and Humanities Research Council (SSHRC), for their hard work, dedication, and for sharing the vision.

*Dr. Fred Whoriskey
OTN Executive Director, Dalhousie University*

OTN Activities Review

OTN project mandates include: (a) providing a global infrastructure to track the movements and survival of marine animals and determining how they are influenced by environmental variables, (b) providing a platform to enable a global network of scientists to research important questions about the biology of marine life and the ocean environment, and (c) driving technological innovation through collaboration with industry partners.

A summary of these activities follows.

Deployment Update

Halifax Line, Canada

The Halifax Line was OTN's inaugural listening line. First deployed in April of 2008, with 29 receiver stations, by March of 2012, the line had been extended to 166 stations and 100 kilometres from land. This is now the most extensive telemetry line in the world. The moorings at present are a mix of Vemco VR2W, VR3, and VR4 receivers with EdgeTech acoustic releases. Deployments of the VR3s and VR4s can last for up to five years before they are retrieved for servicing. During this period, data from the receivers is remotely offloaded at regular intervals via acoustic modems. Species detected so far include Atlantic salmon, Atlantic sturgeon, Atlantic cod, Atlantic bluefin tuna, and spiny dogfish, from 11 different tagging projects. Planning is in place to extend the Halifax Line all the way to the continental shelf, with a total of 256 receiver stations by the spring of 2012.

The Halifax Line serves as a test bed for emerging technology. In the fall of 2011, OTN began testing the Liquid Robotics Wave Glider as a way to offload data from Vemco VR4 acoustic receiver stations. It is hoped that the Wave Glider can reduce staff and ship time, and improve personnel safety, by servicing remote stations. Read more about the Wave Glider on page 19.

At this time, five benthic pods which measure key oceanographic parameters have been deployed on the inner half of the Halifax Line. Data from the pods show that there is variability in bottom temperature, salinity, and dissolved oxygen on a wide range of temporal



Benthic pod aboard *Dominion Victory* ready for deployment.

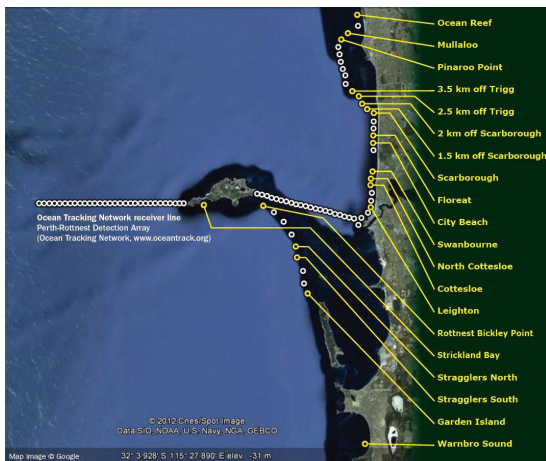
scales— from hours to weeks. Benthic pod data will be used to categorize the water masses at times when tagged fish cross the acoustic curtain. The location and timing of fish arrivals can be examined to determine whether or not these observations are correlated with physical conditions. Understanding variability in the currents and water properties as measured at the bottom by acoustic Doppler current profilers (ADCPs) and conductivity, temperature, and depth (CTD) sensors in the vicinity of the Nova Scotia Current will be helped by the inclusion of benthic pod data. Very little is known on the seasonal and interannual variability of the Nova Scotia Current, which is an important feature driving the ecology of the coastal ecosystem. The benthic pod data will also be used by modellers to understand ecosystem dynamics on the Scotian Shelf. The benthic pods provide high temporal resolution of bottom water properties at select locations over the year.

Principal Investigator:
David Hebert

Partner Organization:
Fisheries and Oceans Canada – Bedford Institute of Oceanography

Perth Line, Australia

OTN's first international acoustic array, the Perth Line, has been operational since January of 2009, with full data offloads annually. The line has 53 stations, extending west from Perth to Rottnest Island out to 50 kilometres offshore. About half of these Vemco VR2W acoustic receiver stations are mounted on shallow water moorings serviceable by divers, whereas the other half are in deeper water and are equipped with Benthos 875-TD acoustic releases and air-filled floats.



Shark Monitoring Network Stations near Perth. Yellow dots indicate satellite-linked acoustic receivers for real-time monitoring.

Species detected so far include southern bluefin tuna, great white shark, pink snapper, and tailor (known as bluefish in North America).

The Perth Line is integrated within the Western Australia Fisheries Shark Monitoring Network of receivers along the Perth coast, with a mandate to understand large-scale shark movements in order to mitigate shark–human interactions.

Principal Investigator:
Rory McAuley

Partner Organizations:
Department of Fisheries, Western Australia

Minas Passage Line, Canada

OTN has maintained an acoustic array of 12 receiver stations across the Minas Passage since 2010.

In total, 168 individuals from three species of concern (Atlantic sturgeon, striped bass, and American eel) were tagged with acoustic tags in the Minas Basin and its tributaries during the spring, summer, and fall of 2011. The OTN Minas Passage Line recorded data from these tags, including many measurements of depth, critical for planning hydropower turbine design and subsequent deployment and operation in the area.

The OTN line is one of several arrays in the region, including the Acadia Line and other smaller deployments of receivers at the Fundy Ocean Research Centre for Energy test site and inside the Minas Basin. These deployments are made by the Acadia Centre for Estuarine Research and Acadia University Biology Department in close collaboration with OTN. Animals tagged on this infrastructure include Atlantic salmon, spiny dogfish, and Atlantic sturgeon. The Minas Passage Line is an excellent example of OTN infrastructure helping to answer applied questions important to science, conservation, and industry, and demonstrates the benefit of OTN to the wider research community.



Tagging Atlantic Sturgeon (*Acipenser oxyrinchus*). Photo by Montana McLean.

Principal Investigator:
Michael Stokesbury

Partner Organization:
Acadia University

Cabot Strait Line, Canada

The Cabot Strait Line, which started out as 37 stations in 2009, was completed in the fall of 2011 and now consists of 151 VR2W acoustic receiver stations extending more than 100 kilometres from Cape Breton to Newfoundland. The current mooring design uses a single float and an acoustic release (primarily EdgeTech PORT MFE) with a rope riser suspending the receiver approximately 10 feet off the bottom.



OTN technicians make final preparations to the mooring prior to deployment.

The American eel is among the species that perform the most extensive movements, migrating as larvae from the Sargasso Sea spawning site to the continent. They settle into freshwater and brackish habitats where they grow for 20 years or longer before migrating back to reproduce and die in the Sargasso Sea. Little is known about this several thousand-kilometres-long return adult migration and the challenges eels face along the way. The OTN Cabot Strait Line, along with receivers deployed by Laval University and DFO researchers, will help detect eel movements out of the Gulf of St. Lawrence.

Other species detected on the Cabot Strait Line include Atlantic cod, Atlantic salmon, Atlantic bluefin tuna, and grey seals.

Principal Investigator:
Martin Castonguay

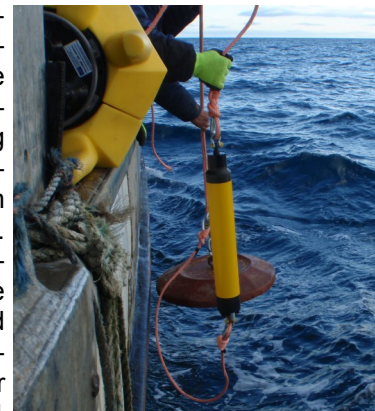
Partner Organization:
Fisheries and Oceans Canada —
Maurice Lamontagne Institute

Arctic Arrays

OTN began deployments at two locations in the Canadian Arctic in 2010— Cumberland Sound and Lancaster Sound, in Nunavut. This was the first ever effort to deploy acoustic telemetry equipment this far north, and we are gaining valuable experience with year-round operations in harsh Arctic conditions.

Twenty-eight of the 29 VR2W stations that overwintered in Cumberland Sound were recovered in 2011, with detections of a single Greenland halibut. Thirty VR2W stations were subsequently deployed in fishing areas and adjacent deep water. Also deployed were fixed Vemco mobile transceivers (VMTs) and range test tags to assess tag detection probabilities with and without ice coverage. OTN researchers also conducted CTD casts, tagged more than 200 fish (Greenland halibut, Arctic skate, Greenland shark), and set cetacean monitoring devices. Retrieval is slated for summer 2012.

2010 deployments in Lancaster Sound were primarily feasibility tests using Vemco Positioning System (VPS) arrays. The first full deployment of the Lancaster Sound Array was in early September 2011 with 21 receiver stations in Maxwell Bay, including 12 VR4 stations in Kintama floats with EdgeTech acoustic releases and nine 180-kHz VR2W stations.



Deployment of VR4 receiver station in Maxwell Bay.

Principal Investigator:
Aaron Fisk

Partner Organization:
University of Windsor

Vancouver Array, Canada

The OTN deployment known as the Vancouver Array is part of a larger system of receiver subarrays near the Fraser River Estuary, British Columbia, owned and maintained by Kintama Research Services, the University of British Columbia (UBC) or by the Vancouver Aquarium's Pacific Ocean Shelf Tracking project (POST). In 2011, OTN partnered with UBC researchers by providing 12 180-kHz VR2W receivers that were paired with 69-kHz receivers and deployed in the Chilko River to track juvenile out-migrating sockeye salmon. The 180-kHz detection frequency allows for smaller tags, implantable in very small animals like juvenile Pacific salmon.



Mooring design of paired 69-kHz and 180-kHz VR2Ws in the Chilko River, BC.
Photo by Matt Casselman.

In early 2012, OTN added the Northern Strait of Georgia Line to its Vancouver Array, with the deployment of 26 receiver stations consisting of a mix of VR3 and VR4 receivers. Kintama Research Services was contracted to carry out the actual deployment. This line has been maintained as part of the Pacific Ocean Shelf Tracking project since 2001.

Principal Investigator:
Scott Hinch

Partner Organization:
University of British Columbia

Strait of Belle Isle Line, Canada

The Strait of Belle Isle is the Northern exit of the Gulf of St. Lawrence to the Atlantic Ocean. The line here was first deployed by the Atlantic Salmon Federation (ASF) in 2006. It consists of 22 Vemco VR2W receivers that provide an 18-kilometre curtain between the coasts of Newfoundland and Labrador. Each mooring consists of an anchor, rope, and surface buoy (the receiver is mounted on rope eight to 10 metres below the surface). Since 2006, the line has been deployed in June and retrieved in early autumn to avoid ice flow risk to surface buoys.



Jonathan Carr prepares VR4s for deployment.

Beginning in 2011, OTN teamed up with ASF to provide limited year-round receiver coverage in the Strait. OTN deployed four VR4 receivers on moorings with Benthos 867-A acoustic releases in the deepest part of the Strait. The VR4 stations will be offloaded and their overwintering status assessed in

June of 2012 when the VR2W stations are redeployed.

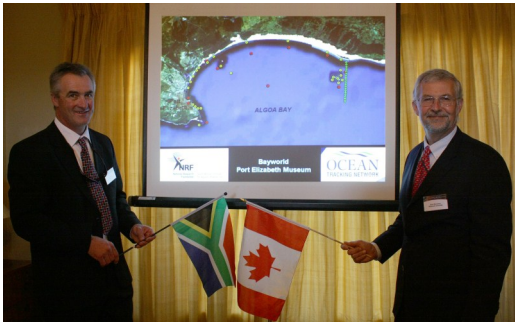
Species detected so far include Atlantic salmon (smolts and adult repeat spawners, or kelts), Atlantic bluefin tuna, and Atlantic cod. The line has provided critical information on the migration timing, swimming speed, and overall survival of salmon smolts and kelts (tracked from several rivers) passing through the Gulf of St. Lawrence.

Principal Investigator:
Jonathan Carr

Partner Organization:
Atlantic Salmon Federation

South Africa Array

OTN South Africa was officially launched at a function hosted at the Canadian High Commissioner's residence in Pretoria on August 2, 2011. Shortly after this event, 40 OTN VR2W receivers were deployed at two core monitoring sites, Algoa Bay and Mossel Bay, moored with Sub Sea Sonics AR-60-E acoustic releases.



Paul Cowley (SAIAB) and OTN Executive Director Fred Whoriskey display their national flags at the OTN South Africa Launch in Pretoria.

Dr. Paul Cowley from the South African Institute for Aquatic Biodiversity (SAIAB) and the SAIAB's main collaborating partners will be responsible for the maintenance and servicing of the acoustic receivers. Rollover of existing lines and further OTN deployments are scheduled to take place in 2012.

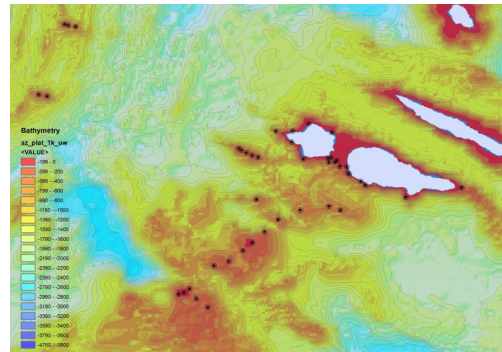
The OTN project in South Africa was instrumental in the development of the national Acoustic Tracking Array Platform (ATAP) that aims to provide a service to the greater marine science community to monitor the movements and migrations of inshore marine animals. Current research is focused on large predatory sharks and important coastal fishery species.

Principal Investigator:
Paul Cowley

Partner Organization:
South African Institute for Aquatic Biodiversity

Azores Array, Portugal

The Azores Array in the mid-Atlantic is the first OTN eastern Atlantic Ocean receiver line. Its 17 stations were first deployed in January 2012, adding to the pre-existing listening array maintained by the Institute of Marine Research, University of the Azores, since 2005. The array now totals approximately 50 stations, of which 30 are located on deep-sea (200 to 500 metres) island slopes and seamounts (principally the Condor Seamount). OTN receivers are located on the outer segment of this array, on the Azores-Princess Alice bank complex and the two Gigante banks over the mid-Atlantic ridge.



Locations of receiver stations on seamounts southwest of the Azores Archipelago.

Deep water stations use mostly VR2Ws moored with Sub Sea Sonics AR-60-E and EdgeTech PORT MFE releases. Three VR4s will be deployed later in 2012. The Azores array supports work on seamount resident and visiting fishes — blackspot seabream, wreckfish, devilray, kitefin, and hammerhead and blue sharks — and is expected to become a central tool to investigate large-scale movements of other ocean basin migratory species (e.g., tuna, eels, swordfish) through international collaborations.

Principal Investigator:
Pedro Afonso

Partner Organization:
Institute of Marine Research,
University of the Azores

Tasmania Array, Australia

The complex interplay of the water masses surrounding Tasmania strongly influences its diverse marine ecosystems and fauna in ways that are not well understood. Changes in the strength and extent of these water masses are currently being detected. For instance, the east coast of Tasmania now falls within an ocean warming "hotspot" resulting from extension and strengthening of the East Australian Current (EAC). As such, the east coast of Tasmania provides a unique opportunity to understand the response by marine ecosystems and fauna to variable and changing oceanographic conditions and to detect the nature and pace of climate change-induced impacts on these systems, and on the human activities that depend on them.

OTN, in partnership with the Australian Animal Tagging and Monitoring System (AATAMS), University of Tasmania, and Commonwealth Scientific and Industrial Research Organisation, deployed two Tasmanian OTN curtains in January of 2012. One line of 21 VR2W stations and the other of 60 VR2W stations were both moored with Sub Sea Sonics acoustic releases. This Tasmanian portion of the larger AATAMS east coast array is scheduled for southward extension along the EAC in late 2012.

One of the tagged species that is likely to be detected by the OTN curtains is the sevengill shark. Males of these sharks move from Hobart waters up to southern New South Wales waters in late autumn and then return to Hobart in early summer. However, the route they take and the timing of each stage are unknown. The OTN array will help unravel this information, along with that of many other migratory species.

Principal Investigator:
Jayson Semmens

Partner Organization:
University of Tasmania



Detections of sevengill shark (*Notorynchus cepedianus*) on this array will help elucidate their migratory path.

Other Arrays Active in 2011-2012

Project Name	No. of Stations
Antigonish Harbour, Nova Scotia, Trout Project	17
OTN Canada Sturgeon Project	13
OTN Canada Eel Project	98
OTN Canada Grey Seal Project	20

Upcoming in 2012-2013

Phase I of the OTN Hawaii Array is planned for April 2012. OTN's VR2W stations will form part of the Pacific Islands Ocean Observing System.

Plans are underway for the completion of the Halifax Line in May of 2012, with extension out to 256 stations and 180 kilometres from its point of origin.

Deployments of an array in the Prince William Sound as well as Phase II of the South Africa Array are planned for late 2012.

VR4 test deployments are planned for the Strait of Gibraltar. Full deployment (Morocco to Spain) is slated for early 2013.

OTN Data Warehousing Review

Data Management Update

The OTN Data Centre (OTNDC) at Dalhousie University is tasked with making the world's ocean tracking data and related information freely accessible to the broader science community, while respecting the intellectual property rights of its providers, and supporting the creation of new and innovative database, analytical, and visualization tools.

The number of data records in the OTNDC after its first year of operation was 1.3 million, from 33 projects on 19 species. As of the 2011–2012 fiscal year, it contained over 9.3 million records from 50 projects on 25 species (Table 1). Continued rapid growth is expected in the coming years.

Table 1 Cumulative number of data records in thousands by ocean region.

Region	Total
Arctic	419.6
E Indian	5.8
Global	90.7
Great Lakes	.2
Mid Pacific	.0
NE Atlantic	.1
NE Pacific	103.1
NW Atlantic	8,607
SW Pacific	.2
W Indian	.1
Total	9,226.7

Progress on the data group's priorities included: (a) processing functionality improvements introduced for animal, tag, and sensor ID matching, station detection and sensor data compression, and high volume data loading, (b) commissioning new hardware (identical development, staging, and production servers) in conjunction with a campus-wide network and security upgrade;

moving data and software to new hardware and old hardware removed; monthly data publishing, (c) migrating OTN Global, Canada, and Member web servers to a Plone-based content management system on new hardware; installation of OTN Canada content on Plone and preparation of documentation on the new server for staff training; members' content, which was moved from the Centre for Marine Diversity Plone server to OTN's new hardware early in the commissioning process, requires review and restyling to match OTN Global and Canada sites, (d) developing additions to extend the Plone system to give principal investigators (PIs) role-based data access control over PostgreSQL and Geoserver objects with ongoing installation, (e) creation of software to automate discovery metadata report posts to Plone; an extension to automatically inform PIs of relevant new data postings is in development, (f) production of procedures for archiving OTN data to Canada's National Oceanographic Data Centre (NODC) for submission to DFO's Integrated Science Data Management (ISDM) branch, (g) acquisition of a standalone server to test the Platform for Ocean Knowledge Management (POKM) software developed by Dr. Rasa Abidi's team and funded by CANARIE (refer to the next section for more on POKM); preparation of data products for a POKM workshop in April 2012 and the OTN Canada symposium in June 2012.

Other activities and progress during 2011–2012 included: (a) hosting a feasibility workshop and completion of a project plan, loading POST resource and receiver metadata into OTN systems, and developing a GoogleEarth flyover capability (POST tag metadata and detections will be loaded in the near future; POST materials will add approximately 20 million records to the OTN data warehouse), (b) hosting user site workshops to demonstrate sensor ID and station compression functionality, (c) providing data ar-

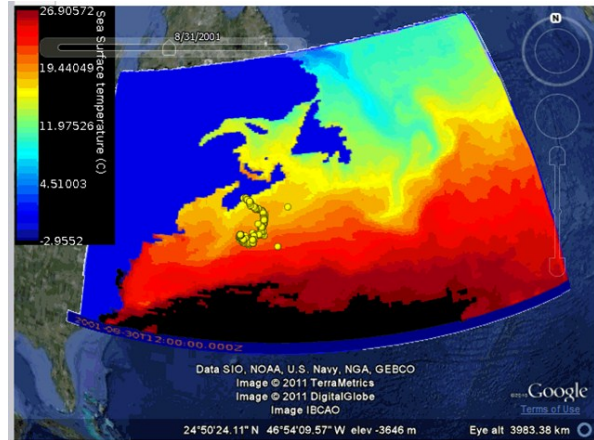
chiving support for oceanographic instruments, including ADCPs, benthic pods, and Slocum Gliders.

Priorities for 2012–2013 include: (a) finishing the transfer of existing POST data to the OTN warehouse, (b) producing ISO/XML and NetCDF standards-based products for use by the network, (c) submitting prototype National Ocean Data Centre (NODC) data archiving procedures for OTN-created data to the Department of Fisheries and Ocean that hosts the NODC, and (d) investigating options for near-real-time data acquisition from cabled receivers, bluetooth-enabled transceivers, and archival tags.

Platform for Ocean Knowledge Management (POKM)

In February 2011, the newly developed POKM data management and analysis platform was first demonstrated to OTN Canada researchers. POKM is the result of a multidisciplinary collaboration between OTN and Dalhousie computer scientists. Originally funded by CANARIE, Canada’s Advanced Research and Innovation Network, POKM is a web-based environment that provides tools for: (a) access, visualization, and analysis of OTN tracking data, (b) merging tracking data with environmental data products, and (c) sharing data, analysis tools, and products with colleagues throughout OTN and the broader scientific community.

Using a variety of ecosystem phenomena, including migration patterns of leatherback turtles and Atlantic sturgeon in the Northwest Atlantic, POKM was shown to effectively provide a unique knowledge management platform to support scientific investigations. During the 2011–2012 period, OTN provided proof of concept for POKM, although additional development will be



Example of data visualization output from POKM showing modeled sea surface temperature and turtles tracked by the Canadian Sea Turtle Network.

required to make the platform fully operational for OTN. The POKM team will seek new funding opportunities in 2012 to support this required development. Future goals for POKM include: (a) enhancing POKM’s capacity for simultaneous users, (b) building secure links from POKM to OTN tracking data collections and to available environmental data, and (c) populating POKM with a more comprehensive library of data visualization and standard analysis tools.

POKM has the potential to become the principle platform for accessing and visualizing OTN data, and for collaboration among OTN researchers through built-in secure web sharing and digital publication services.



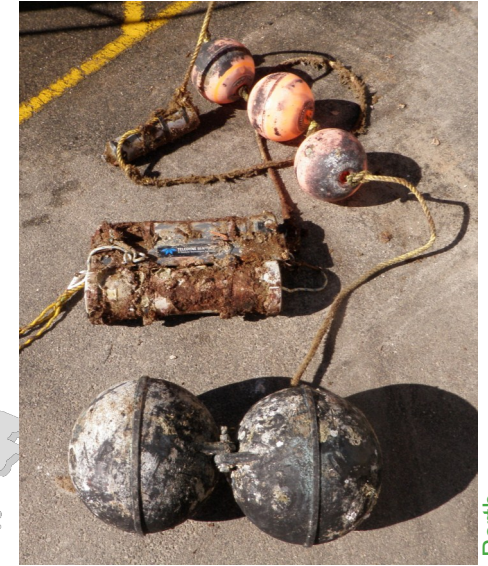
Cabot Strait



Lancaster Sound



Azores



Perth



Cabot Strait



Vancouver



South Africa



◆ 2011–2012 Active Arrays ◆ 2011–2012 Planned Arrays



Tasmania

Animal Tracking Initiatives in Canada

Message from OTN Canada Scientific Director

Substantial progress was made during 2011–2012 on all scientific projects and sub-projects of the OTN Canada research Network, across all ocean Arenas. OTN Canada's research is funded by the Natural Sciences and Engineering Research Council of Canada, but functions only with the tremendous support of the OTN Global team, working together toward achievement of mutual and complementary goals. During 2011–2012, OTN Canada focused on increasing networking and delivering outcomes across research themes and Arenas and on applying science to oceans governance. The Network is dedicated to the education and training of highly qualified personnel (HQP), and during the report year was supporting some 68 students and post-doctoral fellows.

The year also brought increased emphasis on international outreach and collaborations. Highlighting just a few of these activities, OTN Canada's Scientific Director and researchers attended the annual meeting of the U.S.–Canadian Great Lakes Acoustic Telemetry Observing System (GLATOS) in February, and explored future collaborations on the connectivity between the Lakes, St. Lawrence River, and Atlantic, which will allow study of important migratory and invasive species; OTN's data group is collaborating with GLATOS on data warehousing. OTN's executive (S. Iverson and F. Whoriskey) co-hosted a special OTN session at the International 2012 Ocean Sciences Meeting in Salt Lake City, during which new collaborations were fostered. Finally, international exchange of HQP is occurring between Canada and the U.S. and Australia, including HQP from Acadia University who spent several months training in Australia. These activities are an extremely high priority as research programs advance.

*Dr. Sara Iverson
OTN Canada Scientific Director
Dalhousie University*

OTN Canada Pacific Arena Activities

The Pacific Arena had a productive field season in 2011–2012. Over 1,400 sockeye smolts were tagged in the Chilko River to evaluate out-migration survival and behaviour.



*Sockeye salmon (*Oncorhynchus nerka*) wait to access spawning grounds in Scotch Creek, British Columbia. Photo by Matt Casselman.*

Adult Pacific salmon in the ocean and the lower Fraser River were also tagged. Endangered adult coho were fitted with acoustic tags to assess the post-release bycatch mortality associated with a First Nations fishery. Experiments with heart rate biologgers implanted in coho were used to experimentally evaluate the role of different crowding procedures in order to identify best practices for fishers. Sockeye captured by anglers during catch-and-release fishing in the lower river were also tagged to identify whether techniques hypothesized to facilitate post-angling recovery improved survival. In the ocean, sockeye salmon were tracked while simultaneously recording oceanographic conditions. A subset of sockeye were released with novel accelerometer transmitters and tracked for several hours. The accelerometers were calibrated in a swim tunnel to determine the relationship

between acceleration (i.e., transmitter output) and tailbeat frequency, swimming speed, and oxygen consumption. Those relationships will be used in subsequent years to estimate the field energetics of tagged Pacific salmon while swimming from the ocean to spawning grounds and are possibly the first formal accelerometer tag validation for finfish.

Findings from the 2011 coho bycatch mortality study resulted in changes to the mortality values used in conservation planning models. The Pacific team also delivered presentations at a variety of international meetings and institutions; Scott Hinch was a keynote speaker at the first World Fish Telemetry Conference in Sapporo, Japan.

Arena Leaders:

Steve Cooke, Carleton University
 Scott Hinch, University of British Columbia

OTN Canada Arctic Arena Activities

The Arctic Arena’s activities were focused in Cumberland Sound near Pangnirtung in the eastern Arctic, and the Lancaster Sound-Resolute Bay region in Nunavut.

Research in Cumberland Sound was focused on understanding the seasonal and spatial movements of deep-water marine fish, including the commercially important Greenland halibut, and their relationship with marine mammals and oceanographic conditions. Research in the Resolute Bay area was focused on (a) understanding the movement and ecology of Arctic cod, a keystone species in the Arctic that links lower trophic levels with marine mammals and seabirds, and (b) oceanographic conditions, sea ice in particular.

The goal of the Cumberland Sound Array was to quantify when and if Greenland halibut moved from summer grounds to winter grounds. One individual was detected by the array in January and left in May 2011. These were the first data

that have indicated that halibut moved north into shallower water as ice formed. Pop-off archival satellite (PAT) tags deployed on Greenland halibut and Arctic skate have indicated that the depth and temperature preferences overlap between these species, but skate occupy a wider depth range. A more comprehensive deep-water acoustic array was established in August 2011 in Cumberland Sound and will be retrieved in August 2012.

Fieldwork in Lancaster Sound included extensive hydroacoustic surveys of Arctic cod, deployment of two deep-water long-lines for Greenland sharks and associated tagging/sampling of animals, collection of oceanographic data, deployment of a 16-kilometre acoustic array, bird and marine mammal surveys, and positive communication established with Resolute Bay Hunters and Trappers Association. This work provides important baseline data and information on logistics for the implementation of the 2012–2013 research schedules.

Arena Leaders:

Aaron Fisk, University of Windsor
 Svein Vagle, University of Victoria



Attaching floats to moorings on the boat in Lancaster Sound.

OTN Canada Atlantic Arena Activities

The Atlantic Arena encompasses research on a number of interrelated activities ranging from observations of the ocean environment and development and refinement of oceanographic models, to the tracking of marine animal (salmon, sturgeon, eel, cod and grey seal) movements and development of new tag technologies.

In the past year, routine deployment of Slocum Gliders, equipped with a multi-disciplinary suite of sensors to describe the physical, chemical, and biological properties of the water column, began on the Halifax Line. These and other observations have been fed into data-assimilative ocean models.

Simulation results from these models are being used to inform our understanding of the potential physical environment influences on Atlantic eel migration behaviour. Modelling of the movement and migration of the eels will follow. Tagging results from both acoustic and pop-up satellite archival tags indicated that American eel are subjected to very high mortality in the Gulf of St. Lawrence, possibly resulting from predation.

Tagged grey seals are being used as “bioprobes.” Selected seals are fitted with sensors recording their position (via satellite), water temperature, and light information from the water column collected during the seal’s free-ranging movements. Information from these sensors is being used to infer phytoplankton abundance at different points in the ocean and to inform oceanographic models. The seals have also been equipped with VMTs, which act as both an acoustic tag identifying the seal, and a receiver that can record signals from other tagged animals. VMTs are a powerful tool to provide information on encounters between the seals and other marine animals (cod, salmon, tuna, and seals), and to document predator—prey relationships in marine activity hotspots.

The Atlantic salmon and sturgeon are other key species under investigation. During 2011–2012,



A Sable Island grey seal (*Halichoerus grypus*) fitted with a VMT and satellite tag.
Photo by Damian Lidgard.

novel miniaturized archival tags and attachment procedures were developed for and deployed on Atlantic salmon smolts. The archival tags have the potential to provide an unprecedented, detailed record of the movements and environmental conditions encountered by the smolts during their ocean migration. Acoustic tagging of Atlantic salmon smolts from various rivers has also been carried out and is identifying marine migration patterns and causes of mortality, while archival tags are identifying behavioural patterns of salmon kelt at sea. Atlantic sturgeon work is focused in the Saint John River and within the tidally dynamic Minas Basin of the Bay of Fundy where studies are beginning to identify their migratory patterns and timing. High frequency accelerometer tags are being developed for use with this species and tested in the laboratory to explore whether fish acceleration can be related to growth and behaviour. If tests are successful, accelerometer tags will provide valuable tools to infer fish growth and behaviour from the field. Field testing will begin in 2012.

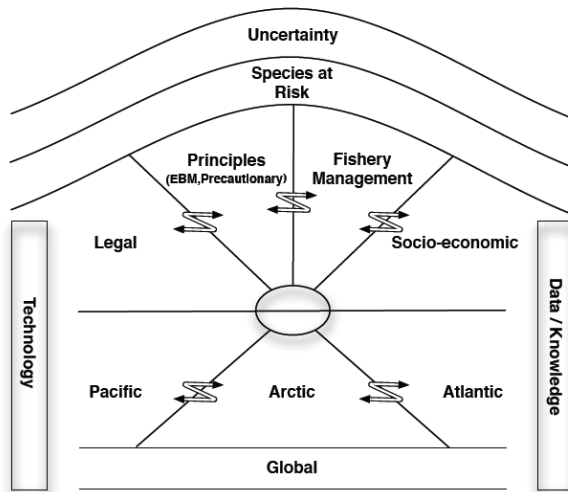
Arena Leaders:

Katja Fennel, Dalhousie University
Ian Fleming, Memorial University of Newfoundland

Social Sciences Initiatives

In June 2011, a two-day workshop entitled “Protecting Marine Species at Risk: Towards Integrating Natural and Social Science Perspectives” was held at Dalhousie University. OTN natural and social scientists shared views on their research interests and discussed possible ways of synergizing interdisciplinary collaborations under the OTN umbrella.

One of the key workshop outcomes was a list of species at risk case studies to be pursued. Among these case studies are American eel, Atlantic sturgeon, Pacific salmon, killer whale, and grey seal–cod interaction. These studies will explore the tracking and the scientific status of the marine species, the social and environmental threats they face, as well as governance arrangements and challenges. Results from these case studies will be published in a special issue of *Journal of International Wildlife Law & Policy* in 2013.



Collaborations across Canadian research Arenas and Themes for best-practice fishery management.

Planning for a future OTN interdisciplinary workshop was initiated. The workshop will be aimed at allowing the working teams of natural, social, and legal scholars to develop a common re-

search methodology and discuss preliminary findings in their respective fields.

Australian ocean tracking and management researchers have proposed a project linking OTN Canada with OTN Global, whereby Canadian and Australian approaches and challenges in tracking and sustaining marine animals would be compared.

In early 2012, David VanderZwaag met with representatives from the Universities of Sydney, New South Wales, Tasmania, and Western Australia, as well as researchers from the Australian National University, the University of Technology at Sydney, the Australian Fisheries Management Authority, the Australian Institute of Marine Science, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), the Department of Sustainability, Environment, Water, Population and Communities, and the Department of Fisheries, Government of Western Australia. As a follow-up, a full project proposal is expected to be drafted under the lead of the social science team and submitted to SSHRC.

Ocean Governance Theme Leaders:
 Richard Apostle, Dalhousie University
 David VanderZwaag, Dalhousie University

Glider Operations

Slocum Electric Gliders are a class of autonomous maritime vehicles (AMV) that continuously and precisely measure ocean parameters for researcher analysis and reaction. Developed by Teledyne Webb Research, Slocum Gliders function by using onboard batteries to change their buoyancy and translating the resultant vertical displacement into horizontal movement. Their deployment periods are limited by the life of their battery packs, with OTN missions typically running for a month or less. OTN presently operates two Slocum Gliders.

The goal of the glider component of OTN Canada is to conduct interdisciplinary autonomous surveys of ocean ecosystems to provide context for measurements of animal movements. To do this, the glider group deploys gliders on the Halifax Line, a major OTN installation covering the continental shelf and designed to identify north-south movements of marine animals along the North American east coast. Since May 2011, OTN Canada gliders have logged 3,300 kilometres on the Halifax Line over 138 days.

Slocum Gliders are deployed on preprogrammed missions with mission parameters set by researchers. Once at sea, the glider surfaces every six hours to obtain a GPS fix and to connect to a shore computer via Iridium satellite communications. The glider uploads a small subset of the data it has collected and receives steering instructions. Before diving, the glider compares its current GPS location with its dead-reckoned location and adjusts its heading accordingly in order to proceed to the next programmed waypoint. The difference between the two locations is caused by currents pushing the glider out of its path. An estimate of depth-averaged currents can be obtained by using this information.

OTN Canada gliders are equipped with a suite of sensors including a Sea-Bird CTD, a Satlantic OCR504 radiometer, and WET Labs triplet optical sensors for measuring physical, geochemical, and bio-optical parameters in the water column. OTN has begun actively working with in-

dustry collaborators to develop mechanisms to provide real-time and near real-time data retrieval capabilities. This will open up new research opportunities and could significantly alter present management capabilities for valued marine living resources. OTN is also experimenting with developing ways of mounting acoustic receivers on the gliders to turn them into mobile receivers.



A Slocum Glider equipped with a Vemco acoustic receiver as part of tests of mobile tracking platforms.

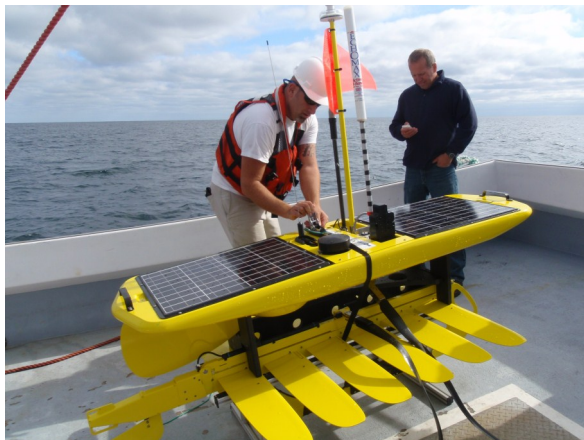
The OTN Canada glider group has implemented a water-sampling program to calibrate and validate measurements made by the glider. Each time a glider is deployed or recovered, vertical profiles of temperature, salinity, chlorophyll fluorescence, and downwelling irradiance are taken. At the same time, water is collected from two to four different depths for further detailed analysis back in the lab. To expand water sampling opportunities, personnel accompany DFO in bi-monthly sampling trips to Station 2 of the Halifax Line.

Technology Advancement

Wave Glider Testing

Part of OTN's mandate is to work collaboratively with technology companies to develop and test new equipment needed by the scientific community.

In the fall of 2011, OTN began testing of the Liquid Robotics Wave Glider as a way to remotely offload data from acoustic modem-equipped receiver stations. This AMV harvests wave energy for propulsion and is equipped with solar panels to provide electricity to power sensors and other equipment, thus it can stay at sea for far longer periods than other autonomous vehicles, and at far lower costs than for a ship. Its low operating costs and high degree of navigation control through satellite positioning and communication make this a potentially ideal vehicle to cost-effectively service the OTN receiver platform.



Eric Brager (Liquid Robotics) and Tim Stone (Vemco) prepare the Wave Glider for launch.

Working together with Vemco, the designer and manufacturer of the acoustic receiver technology used by OTN, the Wave Glider was equipped with an acoustic modem and transducer to remotely offload data from the surface. VR4 communication tests during missions on the Halifax Line in October 2011 were very promising. The Wave Glider was able to precisely hold station

and successfully offload data at distances up to 800 metres from the station.

As OTN deployments such as the Halifax Line extend to a hundred metres or more offshore, maintenance costs will inevitably rise and the servicing of the line via ships will become more complex and risky. Our future goal is to develop complementary technologies so that the glider can support the Halifax Line and other lines equipped with receivers with acoustic modems to reduce staff and ship time.

A second round of OTN Wave Glider testing is planned for the summer of 2012 off the east coast of Canada. This phase of testing will involve assessing the ability of an on-board receiver to detect tagged fish.

VMT Technology

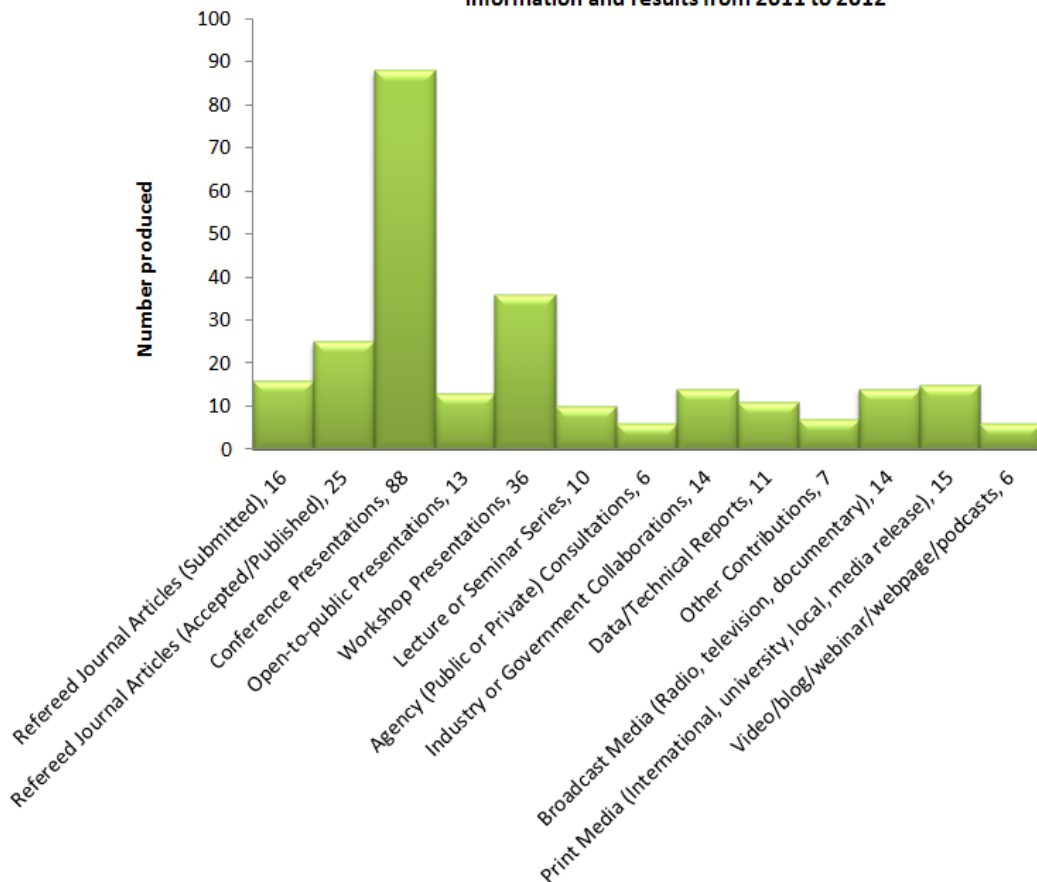
VMT technology continues to advance. Sixteen of 20 grey seal "bioprobes" on Sable Island, Nova Scotia, in June of 2011 were successfully recaptured in late December and early January for recovery of the VMTs. Proof of concept has been demonstrated with detections of Atlantic cod, Atlantic salmon, and Atlantic bluefin tuna as well as other grey seals.

Acoustic Receiver Upgrades

OTN's extensive use of Vemco VR4 acoustic receivers, first deployed in 2008, has led to the expansion of several Canadian and international arrays. VR4s now make up over half of the Halifax Line at 43 units. Modifications during 2011–2012 included modem upgrades to allow for an additional 151 unique modem addresses.



Contributions, deliverables, and dissemination of information and results from 2011 to 2012



OTN Communication Review

Communication and Media

OTN's research results and technology platforms are gaining interest among the media and the public. It is important that OTN remain visible in the community to educate and inform those to whom ocean science matters most.

OTN has been working closely with Dalhousie University Communications and Marketing to create promotional and educational materials to help our audience stay abreast of OTN activities and outcomes and to share in our excitement and success.

Since the inception of the project, OTN has been featured by *Canadian Geographic*, *The Globe and Mail*, CBC, and many international news outlets where OTN deployments occur.

Publication of the previous year's annual report represented a significant step in sharing detailed reports of OTN activities and progress. This and future reports will cover Canadian and international tagging initiatives in addition to global receiver deployments.

Continued growth of the project has necessitated more frequent communication. 2011–2012 saw the first two issues of a biannual newsletter aimed at comprehensive updates to members, partners, stakeholders, and the public. These reports, news, and scientific publications are available and regularly updated on the OTN Canada and Global websites.

Education and Outreach

Many OTN principal investigators and HQP discuss their OTN Network research via science and open-to-public symposia, conferences, presentations, as well as in print and broadcast. During the 2011–2012 year, members contributed 88 conference presentations, 13 public presentations, 14 radio, television or documentary interviews, and 36 workshop presentations among the many other achievements shown at left.

School age groups are also a focus of OTN outreach in and effort to promote, excite and educate youth and future leaders regarding ocean science and sustainability.



Fred Whoriskey talks to students about the importance of understanding oceans.

In February, Fred Whoriskey visited a local Halifax school to give students a lesson on oceans research. Students were introduced to key ideas behind OTN, the concept of acoustic tracking, and the importance of oceans to human and the Earth. In March, OTN HQP Damian Lidgard gave presentations to school groups in the United Kingdom on his work with grey seals and the seal bioprobe project.

OTN Staff 2011-2012



Left to right:
Lenore Bajona, Portal Manager; Susan Dufault, Data Manager; Sara Iverson, OTN Canada Scientific Director



Left photo: Stéphane Kirchhoff, Technical Lead; Margie Hall, Senior Project Manager; Ellen Walsh (seated), Administrative Assistant.

Above photo: Ron O'Dor, Global Scientific Director

Not pictured: Shauna Baillie, OTN Canada Administrative Assistant; Daniela Turk, OTN Canada Network Manager; Bobbi Ciz, Research Grant Administrator



Fred Whoriskey, Executive Director



Bob Branton, Director of Data Management; Marta Mihoff, Database Developer



Glenn Crossin, OTN Canada Network Manager (joined February 2011)



Ian Beveridge (left), Technician (joined October 2011); Duncan Bates (right), Technician (became technical lead in July 2011)



Brian Jones, Database Programmer



Tracy Rounds, Administrative Assistant (joined October 2011)

Organizational Structure

OTN Council

Chair:

Dalhousie President or designate – Martha Crago, VP Research

Members:

Dalhousie Vice President Finance and Administration or designate – Ken Burt, VP Finance
 Dalhousie University Assistant Vice President Research – Iain Stewart
 Two senior academic administrators, appointed by the President – Chris Moore, Dean of Science; Kim Brooks, Dean of Law
 Dalhousie administrator, appointed by the President – Iain Stewart
 Chair, OTN Global Project Coordination Committee – Keith Alverson
 Chair, OTN Canada Scientific Advisory Committee – Keith Thompson
 Industry representative, appointed by the President – Jim Hanlon
 Three scientists representing OTN theme areas of research (appointed by the President) (non-voting) – Katja Fennel (Atlantic), Terry Dick (Arctic), Scott Hinch (Pacific)
 OTN Executive Director (ex officio, non-voting) – Fred Whoriskey
 OTN Global Scientific Director (ex officio, non-voting) – Ron O'Dor
 OTN Canada Scientific Director (ex officio, non-voting) – Sara Iverson
 Federal government representative, appointed by the President (on the recommendation of the Department of Fisheries and Oceans, non-voting observer) – Siddika Mithani
 CFI representative (non-voting) – Olivier Gagnon

Observers:

Senior Project Manager – Margaret-Ann Hall
 Dalhousie-CFI Liaison – Nancy Hayter

OTN Management Committee

Chair:

Dalhousie Vice President Research or designate – Iain Stewart, AVP Research

Members:

VP Finance or delegate – Darrell Cochrane
 Dalhousie Dean, Associate Dean, or Assistant Dean, appointed by Dalhousie President or their representative – Dan Jackson
 OTN Executive Director (ex officio, non-voting) – Fred Whoriskey
 OTN Global Scientific Director (ex officio, non-voting member) – Ron O'Dor
 OTN Canada Scientific Director (ex officio, non-voting) – Sara Iverson
 Senior Project Manager (ex officio, non-voting) – Margaret-Ann Hall
 Dalhousie Director of Research Services or designate (ex officio, non-voting) – Nancy Hayter
 OTN Canada Network Manager (ex officio, non-voting) – Daniela Turk

OTN Global Project Coordination Committee

Chair (*international scientific community*): Keith Alverson

Members:

Member from the scientific community representing each of the recognized ocean regions of the world:
 Arctic – Terry Dick, Canada, U Manitoba; Aaron Fisk, Canada, U Windsor
 NE Atlantic – Karim Erzini, Portugal, U Algarve; Ricardo Serrão Santos, Portugal, U Azores
 NW Atlantic – Peter Smith, Canada, DFO; John Kocik, USA, NOAA
 SE Atlantic – Mike Roberts, S Africa, MCM; Paul Cowley, S Africa, SAIAB
 SW Atlantic – Gustavo Lovrich, Argentina, CADIC-CONICET; José Henrique Muelbert, Brazil, FURG
 E Indian – Mark Meekan, Australia, AIMS; Alistair Hobday, Australia, CSIRO
 W Indian – Laurent Dagorn, France, IRD; Warwick Sauer, S Africa, Rhodes U
 Mediterranean – Miquel Canals, U Barcelona; Salah Ben Cherif Morocco, INRH
 Mid Pacific – Kim Holland, USA, U Hawaii; Marc Taquet, France, IFREMER
 NE Pacific – Chris Barnes, Canada, NEPTUNE; Churchill Grimes, USA, PaCOOS, NOAA
 NW Pacific – Hiroshi Ueda, Japan, U Hokkaido; Yasunori Sakurai, Japan, U Hokkaido
 SE Pacific – Roberto de Andrade, Chile, CONAMA-GEF; Thomas Colnot, Chile, CEQUA
 SW Pacific – Rob Harcourt, Australia, AATAMS; Barry Bruce, Australia, CSIRO
 Southern – Scott Gallager, USA, WHOI; Dan Costa, USA, TOPP

OTN Executive Director (ex officio, non-voting) – Fred Whoriskey
 OTN Global Scientific Director (ex officio, non-voting member) – Ron O'Dor
 OTN Canada Scientific Director (ex officio, non-voting) – Sara Iverson
 Senior Project Manager (ex officio, non-voting) – Margaret-Ann Hall

OTN Canada Scientific Advisory Committee

Chair (*Canadian scientific community*): Keith Thompson

Members:

Two members from the scientific community representing each of the recognized ocean regions of Canada – Ian Fleming, Memorial U, and Katja Fennel, Dalhousie U (Atlantic), Svein Vagle, UVic (Arctic), and Aaron Fisk, U Windsor (Arctic), Scott Hinch, UBC, and Steve Cooke, Carleton U (Pacific)
 Oceans Network Canada – Chris Barnes
 Federal government representative – Alain Vezina
 Industry representative – Dale Webber
 Member of the international scientific community – Michelle Heupel
 NSERC representative (non-voting) – Alison Janidlo
 OTN Executive Director (ex officio, non-voting) – Fred Whoriskey
 OTN Global Scientific Director (ex officio, non-voting member) – Ron O'Dor
 OTN Canada Scientific Director (ex officio, non-voting) – Sara Iverson
 OTN Canada Network Manager (ex officio, non-voting) – Daniela Turk



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OTN is a pilot project of
**The Global Ocean
Observing System**



OTN is an affiliated project of

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OF MARINE LIFE**

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