



OCEAN
TRACKING NETWORK

Annual Report 2010 – 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, the 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 (“pingers”), 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 with 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 three autonomous vehicles (Slocum gliders) in support of oceanographic and tracking research.

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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

- Deploy sensor capacity to measure global ocean environmental conditions
- Identify critical habitats and migration pathways of aquatic animals, on small-to-large scales
- 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, 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

In 2010 – 2011 the Ocean Tracking Network spun-up from a concept and a plan to a fully operational project. It has been an intense period of staffing, equipment testing and purchase, and equipment deployments. These deployments will eventually extend into all of the world's oceans. It is a credit to the staff of the project, its industrial partners, and the international network of research collaborators that so much has been accomplished. You are pushing the envelopes of tracking technology, experimental design, and data storage and integration in ways that had not been conceived of before. Your results will help guide us in the stewardship of our precious ocean resources, and teach us much about the ocean realm.

OTN is a collaborative effort involving ocean researchers from around the world. The global scale and scope of the Network would not have been possible without 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 is grateful to have such strong Canadian Government support.

Dalhousie University is an "oceans university," with many of its programs and staff focused on the sea. As the host institution of the Ocean Tracking Network, Dalhousie University is proud of the science and technological contributions that the program is making, and of the global impact and reach of this project. We applaud the exciting results that have already been obtained, and look forward to those that the future will bring.

*Dr. Martha Crago
VP Research, Dalhousie University*

Message from OTN Executive Director

Life is sometimes kind and offers up an opportunity to do something magical. This is very much how I feel about my work with OTN. This global network of researchers and infrastructure has the potential to revolutionize our understanding of the key elements of the biology of marine animals, and also the way we go about doing our work as marine research scientists. We have unprecedented levels of technology at our service, which our investigators are bringing to bear on their work with great power. This technology is not static, but rather continues to advance at a rapid rate, permitting us to do more than we could have imagined even a few short years ago. Like a good surfer, the OTN will ride this wave. However, the real power of the Network lies not so much in its technology, but in its people. We have a global array of researchers and students, pooling ideas, data, and resources in ways that are massively expanding the power of OTN. Canada's Natural Sciences and Engineering Research Council has made clear its strong support for the concept by providing a major grant for OTN Canada, a nationwide network of researchers leveraging off the OTN infrastructure. This sharing, more than any other thing, has the potential to fundamentally change the way we operate as marine scientists and exponentially increase the science that we produce.

The annual report is one of a number of communication tools we will be producing to attempt to keep people abreast of the magic of OTN. This first edition is mostly about our start-up, as we are just completing our first fully operational year of the project. We look forward to reporting back to you in future years, as the real dream begins.

*Dr. Fred Whoriskey
Dalhousie University*

Message from OTN Global Scientific Director

The global Ocean Tracking Network spun off from the Census of Marine Life just as the Census was reporting its successes at the end of 2010. I feel extremely lucky to be back at Dalhousie and still able to remain connected to this global community. In any context other than this global project involving nearly 3,000 scientists who raised over \$650 million for marine science in a decade, OTN would seem audacious! But, many of the same people who made Census happen have been the stalwarts who kept OTN Global on track. In Census, 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 Fred tells me it is not always as easy for him to ship hardware across international borders as it is for the animals to cross them.

One advantage OTN has is that from the start 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 (UNESCO) in Paris. The IOC doesn't "rule the waves," but it is able to exert some powerful influence on its member states when things that need to get done are not getting done. For me, the single biggest success of the Census was when the IOC adopted its Ocean Biogeographic Information System (OBIS). This will bring 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 (IODE) 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.

OTN expects to have its own equipment out in 10 of its 14 regions by the end of 2011 and has partners already using their own equipment and

sharing data in two more. We knew from the outset that the Southern Ocean and the Southeast Pacific would be big challenges, but we continue to work with strong partners there to get equipment in place. Vemco is on schedule testing its next generation VR4s with 500 m depth capability. Satlantic pods are being deployed on several lines. The Scottish Marine Mammal Research Unit is testing methods for allowing Vemco mobile transducer tags on large animals to relay their detections directly to satellites to eliminate the requirement that these tags must be recovered, a limitation that is hard to overcome in places like the Arctic and Antarctic. We won't claim that there have been no setbacks, but overall global plans are on track!

Dr. Ron O'Dor
Dalhousie University

OTN Activities Review

The OTN project has multiple mandates. First and foremost, it is to provide a unique global infrastructure to track the movements and survival of marine animals at local-to-global scales. To do this, OTN is deploying arrays of acoustic receiver units at strategic locations in the world's oceans. The passing of a tagged fish within the detection range of any of these receiver arrays is logged, as are any data that might result from onboard sensors the tags may carry, reporting information such as the depth at which the animal is swimming and the temperature it is experiencing. By placing individual receivers in the oceans so that their detection ranges overlap, and judiciously positioning arrays of receivers to completely cover strategic places such as straits or continental shelves, it is possible to arrive at quantitative estimates of the numbers of tagged animals that have survived to particular migration points. This is critical information for all those interested in the fates of marine animals.

In order to determine how environmental variables influence these movements and the survival of the tagged animals, OTN is also deploying oceanographic sensors ("benthic pods") at selected sites as part of the infrastructure. These monitor and record changes in a suite of critical environmental variables, including temperature, oxygen, and salinity, so that changes in these variables can be correlated with changes in the movement patterns and mortality of the animals.

The second mandate is science. The OTN infrastructure is to enable a global network of scientists to research important questions about the biology of marine life, and the ocean environment in which they live. Some of these are curiosity-driven investigations that leave us with a sense of wonder at how the animals interact with each other and cope with their world. However, maritime communities globally are dependent upon the ocean's living resources for their livelihoods, and sustainable management of these resources is critical in maintaining jobs and communities. The science undertaken using the

OTN infrastructure will help with the recovery of endangered species, in the planning of Marine Protected Areas (MPAs), and in the development of sustainable management regimes for these resources.

A third mandate is to "innovate". Some of this innovation comes from finding novel ways of using existing technologies. However, OTN is also working with our industrial partners to spur the development of next-generation tracking capacities. The OTN infrastructure, and its science-industry networks provide unprecedented incubation and testing grounds for relevant new technologies. Our partner companies are in large measure Canadian, and our partnerships benefit the Canadian economy by assisting these firms in developing global markets.

We are proud to share with you the stories of our progress to date, and we look forward to reporting again in the future on the accomplishments of the Network.

Deployment Update

Halifax Line, Canada

The Halifax Line is OTN's inaugural listening line, first deployed in April of 2008, with 29 mooring stations extending more than 20 km offshore. In April of 2010, the line was extended out to approximately 30 km with the addition of eight new stations. Most recently, in March 2011, 35 additional stations were added, bringing the total to 72 stations. Also deployed at that time on one of the stations was a benthic pod, which will record oceanographic data including temperature, depth, salinity, and dissolved oxygen. Data from the Halifax Line are uploaded approximately every six months. Species detected so far are Atlantic salmon, Atlantic sturgeon, and Atlantic bluefin tuna from some half dozen different tagging projects.



Thomas Fullager (Dominion Diving) set to deploy mooring assembly on Halifax Line

The Halifax Line serves as a demonstration site where different mooring designs using components from various manufacturers (e.g. Teledyne-Benthos, ORE Offshore, Vemco, and Satlantic) are tested. Flotation collars from Romor Atlantic and Kintama were recently deployed with Vemco VR4 and VR3 acoustic receivers.

Principal Investigator:
Peter Smith

Partner Organization:
Fisheries and Oceans Canada
Bedford Institute of Oceanography

Perth Line, Australia

The Perth Line was OTN's first international listening line, deployed in January of 2009, with 53 stations extending west from Perth, Australia to Rottnest Island and beyond, out to about 50 km offshore.



Nick Jarvis uses SCUBA to service receiver on shallow water mooring

About half of the moorings on the Line consist of Vemco VR2W acoustic receivers mounted on shallow water moorings serviceable by divers, while the other half are located in deeper water and are each equipped with an 875t Teledyne Benthos release, VR2W, and air-filled floats.

The Perth Line is fully recovered, downloaded, and redeployed approximately once per year, with the latest complete rollover occurring in December 2010.

Species detected so far include southern bluefin tuna, great white shark, pink snapper, and tailor (known as bluefish in North America) from tagging projects at Western Australia Fisheries and the Australian Commonwealth Scientific and Industrial Research Organisation.

Principal Investigator:
Rory McAuley

Partner Organizations:
Department of Fisheries, Western Australia
Sydney Institute of Marine Science

Minas Passage Line, Canada

In July of 2010, an acoustic curtain of 12 receiver stations was deployed across the narrowest portion of the Minas Passage, from Cape Sharp to Cape Split, at the northeastern end of the Bay of Fundy. The equipment was recovered in November 2010, after five months in the harsh conditions that the 12-knot tidal currents impose on the gear in the area.



Unique mooring assembly designed to withstand extreme tidal currents in Passage

The Minas Passage Line was redeployed in April 2011 at the same location. OTN partner Acadia University, in collaboration with OTN, also deployed a second array of 17 receivers across the Passage, west of the OTN Line, in April 2011.

Species detected so far are spiny dogfish, Atlantic sturgeon, American eel, and striped bass.

SUBS flotation from Open Seas Instrumentation has proven to be the ideal floatation system to tackle the extremely high currents in the Passage. Moorings are equipped with Vemco VR2W receivers and Teledyne Benthos 875t acoustic releases. Each mooring is weighed down with a 400-lb anchor.

Principal Investigator:
Michael Stokesbury

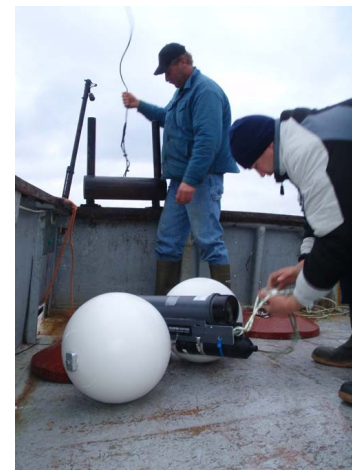
Partner Organization:
Acadia University

Cabot Strait Line, Canada

Phase 1 of the Cabot Strait Line began in October 2009, with the deployment of mooring stations extending northeastward from Cape North, Cape Breton Island, Nova Scotia, to St. Paul Island, a distance of approximately 25 km. In the fall of 2010, the line was extended to include three stations in the Canso Strait between mainland Nova Scotia and Cape Breton Island, effectively creating a curtain across this potential route between the Gulf of St. Lawrence and the North Atlantic Ocean. Plans are under way for Phase 2, which will see the line extended, as technological challenges are worked out, all the way across the Strait to Cape Ray, Newfoundland, a total distance greater than 100 km.

Species detected so far are Atlantic salmon, Atlantic cod, Atlantic sturgeon, and Atlantic bluefin tuna.

Simple air-filled flotation moorings are used in the shallower parts of the Strait, while a few deeper sites have benefitted this year from more sophisticated syntactic foam-filled instrument collars. Syntactic flotation moorings will eventually become ubiquitous for long-term deep deployments.



John Budge and Ambrose Dunphy prepare to deploy mooring assembly on Cabot Strait Line

Principal Investigator:
Martin Castonguay

Partner Organization:
Fisheries and Oceans Canada
Maurice Lamontagne Institute

Cumberland Sound Array, Canadian Arctic

The Cumberland Sound Array was first deployed as a double gate (staggered array setup) in August 2010 with 29 receiver stations extending into the Sound a few miles away from the small Inuit community of Pangnirtung on southern Baffin Island. Equipment will be recovered and data downloaded in the summer of 2011, and another 40 stations will also be deployed on the eastern side of Baffin Island.

OTN Canada researchers working in the area are examining the spatial, seasonal, and temporal interactions of fish and marine mammals in the Cumberland Sound ecosystem and have tagged Greenland halibut (turbot), Arctic skate, and Greenland shark, all of which are expected to interact with this array.



Mooring assemblies ready for deployment in Cumberland Sound

The Cumberland Sound array will allow insight into predator-prey interactions between acoustically tagged Greenland sharks and turbot. The double-gate setup will add directionality to the migration data.

Principal Investigator:
Aaron Fisk

Partner Organization:
University of Windsor

Lancaster Sound Array, Canadian Arctic

Placed near Resolute, Nunavut, this array consists of a series of subarrays first deployed and subsequently recovered in August to September 2010 in Allen Bay. Data on cetacean occurrence

(CPODs) as well as oceanographic data (conductivity, temperature, depth, carbon dioxide, and bathymetry) were also collected in the area. Species detected are Arctic cod, fourhorn sculpin, and shorthorn sculpin. The array makes use of Vemco's newer 180-kHz receiver technology and smaller V5 and V6 acoustic tags, and will be redeployed in 2011.



Deployment vessel with mooring assemblies ready for deployment in Lancaster Sound

Principal Investigator:
Terry Dick

Partner Organization:
University of Manitoba

Other Arrays Active in 2010

Project Name	No. of Stations
Antigonish Harbour, Nova Scotia, Trout Project	24
Nova Scotia Southern Upland Salmon Project	63
OTN Canada Sturgeon Project	10
OTN Canada Eel Project	39
OTN Canada Grey Seal Project	20

Glider Operations

OTN operates a fleet of three autonomous underwater vehicles in support of its research program. The Slocum electric gliders (www.webbresearch.com/slocumglider.aspx), designed by Teledyne Webb Research in the USA, can stay at sea up to a month at a time, patrolling a preprogrammed course. The glider surfaces at regular intervals to connect to the shore via satellite, reporting its position and, if needed, receiving new mission objectives. These vehicles will run missions in support of all of OTN over the life of the project, profiling the ocean for oceanographic parameters and carrying mobile acoustic receivers into places where deploying fixed receiver arrays is not feasible.



Glider testing in Halifax Harbour

Dr. John Cullen's research group of the Oceanography Department at Dalhousie University has been tasked with the maintenance and operation of the gliders. In this first year we have established the glider command and control centre, worked with Fisheries and Oceans Canada's Bedford Institute of Oceanography to create a home base for servicing the units between missions, trained a cadre of personnel qualified to operate and maintain the gliders, purchased and refit a mother ship for coastal deployments of the

glider, and run trial expeditions in both the Bedford Basin and offshore. Full scale operations of the glider fleet are planned to start in mid-2011.



OTN launches its new vessel in support of glider operations

Technology Advancement

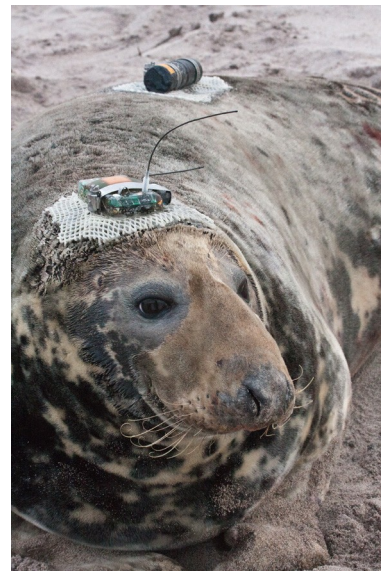
OTN researchers are working collaboratively with technology companies to develop and test new equipment needed by the scientific community. For example:

A team headed up by Sara Iverson and Don Bowen of OTN Canada is assisting Vemco, a Halifax-based manufacturer of acoustic telemetry equipment, to develop the Vemco Mobile Transceiver (VMT). The VMT is a combined tag and receiver, and can be mounted on large animals so that in the ocean they become mobile receivers. The team is fitting grey seals with VMTs and collaborating with researchers who are tagging Atlantic cod in areas where the seals are believed to feed. The seals also carry a separate satellite-linked GPS unit that provides detailed information on their positions at any given time. The VMTs will record interactions the seals may have with tagged cod, or with other seals that may also be fitted with the VMTs. This study will provide valuable feedback on the technology, supply information on interactions between seals and cod, and document any cooperative feeding strategies that seals may undertake. The present generation of VMTs store their detections until researchers can retrieve the units from predictable seal haul-out areas. Work is ongoing on engineering ways that the information can be fed from the VMT to the satellite-linked GPS system the seal also carries, and broadcast in near real time back to OTN investigators.

A second OTN Canada team, led by Ian Fleming, is working with Lotek Wireless, another Canadian-based company, on developing miniaturized archival tags. Archival tags “archive” data from a number of sensors that are built into them, and store the readings until the tag can be recovered and the information downloaded to a computer. The sensors can include the depths and temperatures a marine animal is experiencing, and a calculation of the location of the animal based on information from a light sensor. Although archival tags are relatively small, present models are still too big to fit on many ma-

rine animals. This project has now developed prototypes small enough to fit on juvenile Atlantic salmon heading out to sea (about 12 cm in length). The first release of juvenile salmon tagged with these units is scheduled for spring 2011.

Future technological innovation work will focus on developing ways to use autonomous underwater vehicles to patrol our receiver arrays, download any stored information via acoustic modems, and return this information to us in a timely fashion.



Grey seal with VMT attached to its back and GPS transmitter attached to its head (photo by Damian Lidgard, Dalhousie University)

The OTN Global–OTN Canada Link

The Canada Foundation for Innovation is the principal funder of OTN, providing \$35 million over the course of the project to establish and support the OTN infrastructure. In addition, many international partners have assumed the expenses for deployment and operation of OTN arrays in their waters, a contribution to the project valued at approximately \$82 million. This infrastructure is collectively referred to as the OTN Global project. In Canada, the Natural Sciences and Engineering Research Council, after peer review, awarded an additional \$10 million to fund a national network of researchers to work with the OTN infrastructure. This is OTN Canada, which is headquartered at Dalhousie University and has as its Scientific Director Dr. Sara Iverson, Dalhousie University. OTN Canada investigators operate in the Pacific, Arctic, and Atlantic regions of the country (termed the Pacific, Arctic, and Atlantic Arenas), and are executing a multitude of diverse studies. OTN Global is closely linked to OTN Canada. Scientists in OTN Canada are training many highly qualified personnel to use OTN infrastructure. OTN Global provides the telemetry and oceanographic infrastructure needed for the OTN Canada studies. It has also purchased tags for the studies of OTN Canada investigators, and provides a centralized, standardized, secure database for storage of its data. OTN Canada and OTN Global are working together to develop next-generation tracking technologies.

Social Sciences Initiatives

In November, 2010, a one-day workshop “Protecting Marine Species at Risk: Towards Integrating Natural and Social Science Perspectives” was held at Dalhousie University, where an initial core of OTN natural and social science researchers shared views on their research interests and discussed possible ways forward in synergizing interdisciplinary collaborations under the OTN umbrella. One of the key workshop conclusions was that, as a next strategic step, teams of Canadian natural and social science investigators would be encouraged to undertake comparative case studies for the Pacific, Arctic, and Atlantic. The studies would explore how selected marine species at risk are faring as to scientific understandings, tracking, social and environmental threats, and governance arrangements. A book publication would be an expected result.

To seek further support for building natural–social science collaborations, Professors David VanderZwaag and Richard Apostle took the lead in submitting a letter of intent to SSHRC in January 2011 for a partnership grant. The proposal, entitled “Tracking and Protecting Marine Species at Risk: An Interdisciplinary and International Partnership,” suggests various avenues for future research, namely, comparing national and regional approaches and challenges in marine species at risk protection, strengthening global governance for the protection of marine species at risk, and addressing social integration of the OTN knowledge base.

Planning for a future two-day OTN interdisciplinary workshop to be held June 1-2, 2011 was also initiated. The workshop will be aimed at allowing invited researchers to select and flesh out specific species case studies, to forge working teams, and to develop a common research methodology. Transboundary case studies will also be encouraged through the participation of U.S. social science researchers from both the Atlantic and Pacific coasts.

OTN Data Warehousing Review

Data Management Update

The OTN Data Centre (OTNDC) has been 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. The OTNDC is developing and operating an open source, standards-based data warehouse system and offering a range of information products based on reusable software and data.

Prior to official start up in 2010, the OTNDC adapted and used Pacific Ocean Shelf Tracking (POST) templates to collect data from OTN's Halifax, Cabot Strait, and Perth Lines and from animal taggers releasing fish detected on these lines. As well, Ocean Biogeographic Information System (OBIS) formatted data from the Greenland Shark Elasmobranch Education and Research Group (GEERG) and Canadian Sea Turtle Network (CSTN) projects were prepared. As a result, OTN built up its basic data processing capacity for handling both acoustic telemetry and satellite-based tracking data at the same time as providing input for development of the Dalhousie Computer Science Department's Platform for Ocean Knowledge Management (POKM) project, funded by CANARIE. Staff in the period consisted of a director of data management (R. Branton), a data manager/web master (S. Dufault), and a senior programmer (M. Mihoff). Software used was: Linux OS, Plone, PostgreSQL, PostGIS, R, and Geoserver. Hardware acquired during this period included: two rack-mounted servers in the Dalhousie computer centre for production and testing and a desktop workstation in general research space for development.

The 2010 calendar year marked the OTNDC's first year of true production with most activity focused on learning to work with data providers and improving data processing software to keep pace with rapidly expanding field programs. Functionality introduced during this period in-

cluded: false detection flagging, electronic instrument metadata from manufacturers, prefilled data collection templates, and Vemco mobile transceiver-satellite tag data integration. By year end, OTN's warehouse contained ~1.3 million records (Table 1) from 33 projects on 19 species. All data received were loaded to the data warehouse, more than quadrupling its size from the pre-2010 period.

Table 1 Number of data records by ocean region and year

Region	< 2007	2008	2009	2010	Total
Arctic		33,252	127	130	33,509
E Indian			1,508	4,123	5,631
NE Pacific			3,481	1,220	4,701
NW Atlantic	127,982	25,999	97,597	982,424	1,234,002
Total	127,982	59,251	102,713	987,897	1,277,843

Detection logs from Acadia University Minas Passage, Fisheries and Oceans Canada NE Newfoundland, and National Oceanic and Atmospheric Administration Gulf of Maine arrays are expected soon. Staff added during the reporting period included: a portal manager (L. Bajona) and an assistant programmer/data manager (B. Jones). Bi-weekly meetings were initiated with Dalhousie Computer Centre staff (J. Flynn, D. Lambert) to expedite technical service requests and orchestrate new hardware acquisitions. New hardware acquired during the period included: three processing servers and a storage area network server. Installation and testing (commissioning) of the new hardware by Computer Centre staff is under way.

Provision of missing data, new data from ongoing and new collaborations, and the introduction of new instrument types (e.g., benthic pods and gliders) could result in as much as a 10-fold increase in data and a doubling of the projects and species being managed in 2011. Calls for improved processing functionality (i.e., mooring history) will be routine. Commissioning of new computing hardware, integrated web site content management, role-based data access control, discovery metadata automation, assimilation of

POKM, and archiving of data to DFO/IODE will all be high priority initiatives in the coming year.

Platform for Ocean Knowledge Management

One of OTN's primary objectives is to foster and promote the creation of new and innovative computing tools to synthesize, analyze, and visualize the different types (marine animal tracks and physical ocean properties) of data collected by OTN's global infrastructure. To that end, OTN is working with a multidisciplinary team of researchers (Computer Science, Marine Biology, and Oceanography) to support the development of such a tool.



Led by Dr. Raza Abidi (Faculty of Computer Science, Dalhousie) the team is developing a state-of-the-art e-research platform (Platform for Knowledge Management or POKM) that provides ecoscientists the ability to (a) share, select, access, handle, and integrate high volumes of multimodal ocean and marine life data stored at global data repositories; (b) design and execute customized experiments using a range of data and scientific models; (c) analyze and visualize both raw data and experimental results; and (d) manage text-based knowledge artifacts. The POKM project, funded by CANARIE, utilizes CANARIE's high bandwidth networks to handle high volumes of ocean data and to facilitate collaboration between ecoscientists across the world to conduct multisite scientific experiments.

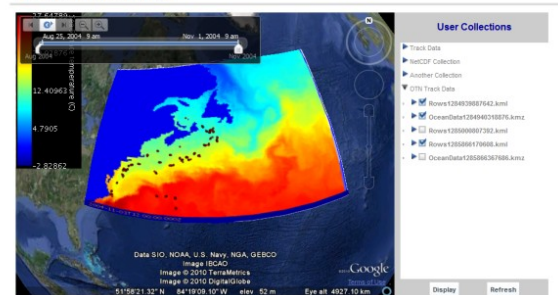
POKM has practical uses for ecoscientists, and is expected to be used to study a variety of ecosystem phenomena, such as the migration patterns of marine animals (especially leatherback turtles and salmon), the effects of coastal flooding, ocean desalination, changes in ocean behaviours, and so on.

“POKM provides a unique knowledge management perspective to support scientific investigations by working with the semantic descriptions of the components which enable seamless handling of large volumes of data, model execution, experimental workflows, data analysis, and visualizations” says Dr. Raza Abidi, Principal Investigator.

Dr. Ian Jonsen, a marine scientist working on the project and a user of POKM remarks: “POKM is an innovative solution for bringing marine scientists together as part of an online community. Now scientists around the world from different fields such as marine ecology, fisheries, and oceanography can collaborate and share their data, models, and other forms of knowledge online in a secure, efficient, and automated manner. POKM will free scientists to focus on what is important, conducting innovative research to



Collection Visualization



better understand the world's oceans.”

POKM is in its second year of development and the beta version of POKM was launched in February 2011.

OTN Partners and Collaborators

The power of the OTN initiative comes from its partnerships that ensure reliable and thorough data collection. The vision is to build a worldwide network and infrastructure that provide — for the first time in history — a clear and constant picture of marine life and ocean conditions around the globe. To accomplish that, OTN brings together scientists from academia, government agencies, and industry partners from around the world.

The table below lists the organizations and countries of OTN's scientific collaborators worldwide.

Collaborating Organization	Country
Australian Animal Tagging And Monitoring System	Australia
Acadia University	Canada
Australian Institute of Marine Science	Australia
Australian Antarctic Division	Australia
Alaska Ocean Observing System	USA
Atlantic Salmon Federation	Canada
Auckland University of Technology	New Zealand
Barrow Arctic Science Consortium	USA
Bayworld	South Africa
Bermuda Institute of Ocean Sciences	Bermuda
Centro Austral de Investigaciones Científicas Consejo Nacional de Investigaciones Científicas y Técnicas	Argentina
California State University at Davis	USA
Caribbean Coastal Ocean Observing System	USA
Carleton University	Canada
Cape Breton University	Canada
Centro de Ciências do Mar	Portugal

Collaborating Organization	Country
Centro de Estudios del Cuaternario	Chile
Centro de Investigación Científica y de Educación Superior de Ensenada	Mexico
City University of Hong Kong	Hong Kong
CoastTrack (NINA)	Norway
COISPA Teconologia & Ricerca	Italy
Comision Nacional del Medio Ambiente Facilidad Global del Medio Ambiente (Global Environment Facility)	Chile
Census of Marine Life	USA
Cornell University	USA
Commonwealth Scientific and Industrial Research Organization	Australia
Dalhousie University	Canada
Delaware State University	USA
Fisheries and Oceans Canada	Canada
Duke University	USA
El Colegio de la Frontera Sur	Mexico
Ezemvelo KZN Wildlife	South Africa
Fundy Ocean Research Centre for Energy	Canada
Universidade Federal do Rio Grande	Brazil
Great Lakes Commission	Canada
Grønlands Naturinstitut (Greenland Institute of Natural Resources)	Greenland
Gulf of Maine Ocean Observing System	USA
Global Ocean Observing System	France
Hokkaido University	Japan
Huntsman Marine Science Centre	Canada
Instituto Español de Oceanografía	Spain
Institut Français de Recherche pour l'Exploitation de la Mer	France

Collaborating Organization	Country
Instituto do Mar Departamento de Oceanografia e Pescas	Portugal
Institut National de Recherche Halieutique	Morocco
Intergovernmental Oceanographic Commission	France
International Oceanographic Data and Information Exchange	Argentina
Instituto de Investigação das Pescas e do Mar	Portugal
Institut de Recherche pour le Développement	France
James Cooke University	Australia
Korea Ocean Research and Development Institute	Korea
Mid-Atlantic Coastal Ocean Observing Regional Association	USA
Mid-Atlantic Regional Association Coastal Ocean Observing System	USA
Monterey Bay Aquarium Research Institute	USA
Marine and Coastal Management	South Africa
Marine Conservation Science Institute	USA
Maine Department of Marine Resources	USA
Memorial University of Newfoundland	Canada
Mote Marine Laboratory	USA
Marine Research Institute	Iceland
Marine Research Institute, University of Pretoria	South Africa
Margaree Salmon Association	Canada
Mount Allison University	Canada
Natal Sharks Board	South Africa
National Marine Information and Research Centre	Namibia
North-East Pacific Time-Series Underwater Networked Experiments (NEPTUNE)	Canada

Collaborating Organization	Country
Northeastern Regional Association of Coastal Ocean Observing Systems	USA
National Fisheries Research and Development Institute	Korea
Nelson Mandela Metropolitan University	South Africa
National Oceanic and Atmospheric Administration	USA
Norsk Polarinstitutt (Norwegian Polar Institute)	Norway
Norwegian Institute for Nature Research	Norway
U.S. National Science Foundation	USA
Nova Scotia Fisheries and Aquaculture	Canada
New York State University at Buffalo	USA
Oceans Research	South Africa
Offshore Energy Environmental Research Association	Canada
Oceanographic Research Institute	South Africa
Pacific Islands Ocean Observing System	USA
Programa de la Naciones Unidas para el Desarrollo Facilidad Global del Medio Ambiente (Global Environment Facility)	Chile
Pacific Ocean Shelf Tracking	Canada
Rhodes University	South Africa
South African National Biodiversity Institute	South Africa
South Africa National Parks	South Africa
South African Environmental Observation Network	South Africa
South African Institute for Aquatic Biodiversity	South Africa
Sociedad Argentina de Investigación en Bioquímica y Biología Molecular	Argentina

Collaborating Organization	Country
South Australian Research and Development Institute	Australia
South African Shark Conservancy	South Africa
Shark Research Centre - Iziko	South Africa
Sydney Institute of Marine Science	Australia
Stanford University	USA
Texas A & M University	USA
Tagging of Pacific Predators	USA
University of Auckland	New Zealand
Universitat de Barcelona	Spain
University of Hawaii	USA
l'Université Laval	Canada
University of Maine	USA
University of Manitoba	Canada
University of Maryland	USA
University of Michigan	USA
University of Tennessee	USA
University of Washington	USA
University of Windsor	Canada
Universidade dos Açores	Portugal
Universidad Austral de Chile	Chile
University of Algarve	Portugal
University of British Columbia	Canada
University of California Santa Cruz	USA
University of Cape Town	South Africa
University of Tromsø	Norway
University of KwaZulu-Natal	South Africa
United Nations Educational, Scientific and Cultural Organization	Belgium

Collaborating Organization	Country
U.S. Geological Survey	USA
Universitat de les Illes Balears	Spain
University of Tasmania	Australia
University of Victoria	Canada
Victoria Experimental Network Under the Sea (VENUS)	Canada
Western Australia Department of Fisheries	Australia
Woods Hole Oceanographic Institution	USA

Industry Collaborators

Lotek Wireless Inc., St. John's, Canada
 Satlantic Inc., Halifax, Canada
 Teledyne Webb Research, Falmouth, USA
 Vemco, a division of Amirix, Halifax, Canada

Funding Collaborators

Canada Foundation for Innovation (CFI)
 Natural Sciences and Engineering Research Council of Canada (NSERC)
 Social Sciences and Humanities Research Council of Canada (SSHRC)

Organization Structure

OTN Council

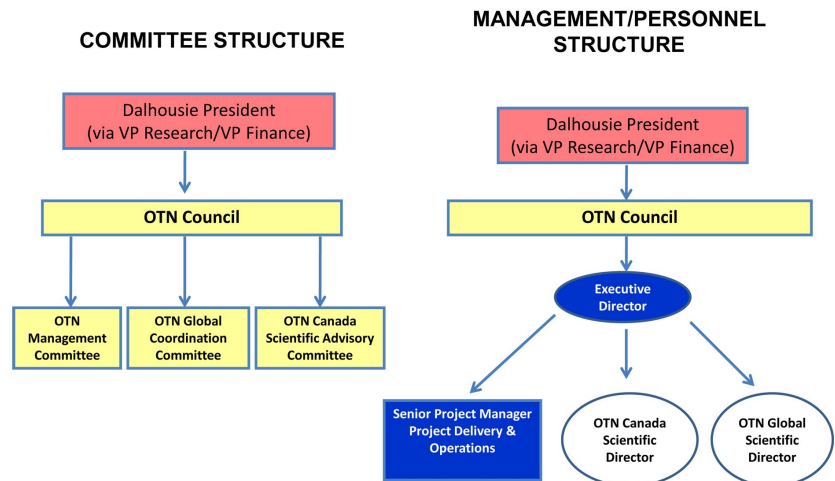
The primary role of the OTN Council is the stewardship of the OTN on behalf of Dalhousie University and other stakeholders. The Council provides direction to the scientific and management affairs of OTN that will ensure its development and enhance the value of its research leadership and assure its financial and scientific management. The Council provides for the quality, depth, and continuity of management required to attain OTN's major strategic and operational objectives. The Council oversees the conduct of OTN's research and supervises management, which is responsible for the day-to-day conduct of the research. In supervising the conduct of OTN research, the Council, through the Executive Director, who is an ex-officio member of the Council, sets the standards of conduct for the OTN.

The Council's three Committees are:

- OTN Management Committee
- OTN Global Coordination Committee
- OTN Canada Scientific Advisory Committee

OTN Management Committee

Chaired by the VP Research or designate, this committee ensures that OTN and the projects undertaken within its umbrella are managed responsibly and in accordance with CFI and NSERC guidelines and Dalhousie University regulations and policy, while minimizing the legal risk and liability to stakeholders.



OTN Organization Chart

OTN Global Coordination Committee

Chaired by a member of the international scientific community, this committee advises and reports on the planning and coordination among all projects undertaken under the OTN umbrella. This group assists OTN in ensuring that the science undertaken in countries around the world is consistent with national funding priorities and that the research is funded by various countries.

OTN Canada Scientific Advisory Committee

Chaired by a member of the Canadian scientific community, this committee advises and reports on the planning and coordination among all projects undertaken under the OTN umbrella in Canada. This group assists OTN in ensuring that the science undertaken in Canada is consistent with the international strategic direction, and that it is consistent with national funding priorities.

Bi-Annual General Meeting

On Friday, November 5, 2010, the OTN Global Coordination Committee (GCC) held its biannual business meetings at Dalhousie University in Halifax, Nova Scotia, Canada to discuss OTN's worldwide operations. The meeting was co-chaired by OTN Global Scientific Director Dr. Ron O'Dor and Tom Gross (Global Ocean Observing System), standing in for GCC Chair Keith Alverson. The theme of this year's meeting was "How can we make OTN more than the sum of its parts?"

Representatives from each of OTN's 14 Ocean Regions were in attendance to provide an update on activities within their region. Afternoon workshops focused on ways to foster collaboration locally, regionally, and globally. Additional workshops for GCC delegates were held earlier in the week and included discussions and demonstrations of OTN technical and data management operations.

2010 GCC Meeting Attendees

OTN Region	Delegate
Arctic	Terry Dick, Aaron Fisk
E Indian	Andrew Boomer
Mediterranean	Anna Sánchez Vidal
Mid-Pacific	Kim Holland
NE Atlantic	Karim Erzini, Pedro Afonso
NE Pacific	Chris Barnes
NW Atlantic	Peter Smith, Hassan Moustahfid
NW Pacific	Hiroshi Ueda
SE Atlantic	Paul Cowley
SE Pacific	Anelio Aguayo
Southern	Paul Rodhouse
SW Atlantic	José Muelbert, Monica Muelbert
SW Pacific	Jayson Semmens, Iain Field
W Indian	W Indian



OTN GCC meeting participants attend workshop on OTN data and technical operations. From left to right: Tom Gross, Jayson Semmens, Brian Jones (OTN Data Team), Karim Erzini, Stéphane Kirchoff (OTN Tech Team), Andrew Boomer, Pedro Afonso, Peter Smith, Anna Sánchez Vidal, Hassan Moustahfid (NOAA-IOOS).

OTN Staff 2010 – 2011



The OTN Team. Standing, left to right: Fred Whoriskey, Stéphane Kirchhoff, Lenore Bajona, Bob Branton, Duncan Bates, Marta Mihoff, Ron O'Dor, Margie Hall; seated, left to right, Ellen Walsh, Susan Dufault, Brian Jones.



Ron O'Dor, Global
Scientific Director

Dr. Ron O'Dor is the OTN Global Scientific Director and a professor of biology at Dalhousie University. As Senior Scientist for the Census of Marine Life for the last 10 years, Ron coordinated over 2,500 researchers from 82 nations in this decade-long initiative to assess and explain diversity, distribution, and abundance of marine life — top to bot-

tom, microbes to whales, past, present, and future. After degrees in biochemistry at UC Berkeley and physiology at U British Columbia, a post doc at Cambridge U and Stazione Zoologica, Naples, turned him to cephalopods and marine biology. Studying cephalopod behaviour and physiology in nature with acoustic telemetry led to large-scale tracking arrays. Ron is a world leader in biotelemetry, environmental physiology, and squid biology, and has published more than 100 peer-reviewed articles as well as several books. He was Canadian Geographic's Environmental Scientist of the Year for 2009.

Administrative Team



Fred Whoriskey
Executive Director

Fred was born and raised in Massachusetts. He graduated from Brown University in Providence, RI in 1976, and worked for five years at Woods Hole Oceanographic Institution (WHOI) before beginning Ph.D. studies at l'Université Laval in Quebec City. He graduated in 1984 and subsequently held a NATO postdoctoral

fellowship at the University College of Wales in Aberystwyth, UK. He was a Professor at McGill University from 1986 to 1995, then joined the Atlantic Salmon Federation in 1995, where he served as Vice President, Research and Environment, and was responsible for directing the Federation's science activities until 2010. While at ASF, he developed the organizations sonic tracking programs, which have included work on Atlantic salmon juveniles and adults, American eel, Atlantic cod, and alewives.

Fred's research interests are in fish biology and ecology, and the impacts of exotic species on native ecosystems. He has been heavily involved in public policy issues, especially with regards to environmental impact assessments, and has worked extensively in public education. He received a Gulf of Maine Visionary Award in 2008, and is a frequent public speaker. Fred served on the Board of AquaNet (Canada's National Centre of Excellence in Aquaculture) and Chairs the Board of the Huntsman Marine Science Centre. Fred became the OTN Executive Director in June, 2010.



Margaret-Ann Hall
Senior Project Manager

Margie graduated from Memorial University of Newfoundland with a Bachelor of Science degree in 1986. Having majored in Computer Science, she spent the next 15 years in various IT related roles developing, supporting, and implementing financial business systems. Over the last 10 years, Margie focused on developing project

management skills by managing small to medium sized projects for several large organizations throughout Atlantic Canada including ACOA, Clearwater Seafoods, Irving Oil Limited, and Manulife Financial.

In fulfilling the role of Senior Project Manager for the OTN, Margie is involved in the planning, scheduling, and overall logistical support of the daily operations of the OTN project. Margie works with our partners to guide them through the deployment process from completion of the paperwork, including collaboration agreements, through to acquisition and shipment of the equipment. She then coordinates with the OTN Tech Team to ensure that all things necessary for a successful deployment are in the right place at the right time. Once a line of receivers has been deployed, Margie coordinates between partners and the OTN Tech Team to schedule the download of data and the refurbishing of OTN equipment that has been deployed on the ocean floor and recovered.



Ellen Walsh
Administrative Assistant

Ellen graduated from the Henderson College of Business in Calgary, Alberta, with an Honours Diploma in Legal Secretarial and Accounting. Upon graduation, she spent 17 years working in a variety of different roles with Thermo Fisher Scientific with a focus on human resources and accounting. After returning to Halifax in 2009, Ellen worked in a variety of contract positions until starting her position with OTN in January of 2011.

In the role of Executive Assistant for OTN, Ellen is responsible for a myriad of tasks in support of the OTN Executive Director.

Data Centre Team

Robert M. Branton (Bob), OTN's Director of Data Management, is responsible for providing vision



Robert Branton, Director,
Data Management

and direction for the project as a whole, leading the data management team, and assuring the relevance of the resulting data services and products. Bob's technical interests are focused on capacity planning, warehouse design, visualization, and discovery meta-data. In addition to OTN, Bob is a scientist emeritus at the Bedford Institute of Oceanography and involved in various science informatics initiatives including: the Canadian National Committee for CO-DATA (Committee on Data for Science and Technology), Centre for Marine Biodiversity (CMB), and Coastal and Ocean Information Network for the Atlantic (COINAtlantic).



Lenore Bajona
Portal Manager

Lenore Bajona became Portal Manager of the OTN in June 2010, providing configuration and change management skills to the data management team. Lenore is on leave from Fisheries and Oceans Canada (DFO) where she has been a Science Informatics Analyst since 1996, providing computer programming and system analyses for various departments within the Science and Corporate Services Branches. DFO assignments have included working on ocean biodiversity informatics, providing technical and information management support for OBIS Canada and the Centre for Marine Biodiversity, including taxonomic standardization and enrichment.



Susan Dufault
Data Manager

Susan started working with OTN in 2008, organizing conferences, managing websites, and performing administrative duties. Later that year, she was hired on full time as the OTN Data Manager. Her role as Data Manager involves liaising with OTN's tracking collaborators to facilitate data acquisition.

Susan is a trained marine biologist (MSc, Dalhousie University) with extensive field and data management experience. Prior to joining OTN, she worked for the New England Aquarium as a marine mammal observer and field data manager and for the consulting firm of LGL Limited as a marine mammal specialist on environmental impact assessments.



Brian Jones
Database Programmer

Brian Jones was born in Halifax and has accumulated over 15 years of computer programming experience.

During the summer of 2009, Brian started a federal internship working for DFO at the Bedford Institute of Oceanography. His duties included the digitization and filling of historical fisheries records. Following

Brian's 6-month internship, he was granted contract work for the completion of several GIS-related projects.

At the end of Brian's DFO contract he accepted a position with OTN as a data loader and is re-

sponsible for the migration of project data into the OTN database. During the course of Brian's employment with OTN he has developed scripts used to aid the data loading process and he is now a programmer on the OTN project.



Marta Mihoff
Database Developer

Marta graduated with a BMath from the University of Waterloo in 1988. She started her career in the banking industry working in all areas of software development and design. In 2002 Marta moved home to Nova Scotia. Since then she has worked on various contract positions for DFO and several universities. Projects

included: data rescue (snow crab surveys, mesopelagic surveys, and leatherback turtle), database design (grey seal adipose and NaGISA), and data loading process (inshore lobster surveys, NaGISA).

Since joining the OTN Data Team in February 2010, Marta has worked on the design of the database structure including an inventory of metadata for instruments purchased by OTN and partners, and the database loading process. She is also designing and building products using data collected to provide generalized research aids, map presentations, reports, and tools that can be accessed from multiple third party applications. Marta is also working on management of false detections and the temperature and depth data collected from sensor tags.

Technical Team



Stéphane Kirchoff
Technical Leader

Stéphane Kirchoff is the OTN Technical Leader and has been part of the OTN technical team since mid-2008. He worked in the late 1990s for Dr. Nancy Rabalais at LUMCON (Louisiana Universities Marine Consortium) on the hypoxic zone off the coast of Louisiana and Texas, and a couple of years later moved to Halifax to work with Dr.

John Cullen in the Oceanography Department at Dalhousie University. There he became field operations manager for two coastal monitoring programs, and later network manager for the Lunenburg Bay Research project funded by the Canadian Foundation for Climate and Atmospheric Sciences.

As part of the OTN technical team, Stéphane has been involved with mooring and acoustic array design, deployment and recovery of acoustic receivers, data acquisition, and ocean gliders. Stéphane is also the co-owner of Under The Blue Pictures, a documentary film making company. His underwater footage has been shown on most of the major American and European networks. He has produced and participated in several documentaries that were shown on European national television channels.



Duncan Bates
Technician

Duncan Bates is the OTN Technician and has been an integral part of the OTN technical team since 2008. Duncan trained as a biologist at Acadia University in Nova Scotia, Canada, where he received his BSc in 1994.

After graduating from Acadia, Duncan spent a brief period tracking aquatic birds, (mainly common loons) with the Canadian Wildlife Service. From there he returned to his earlier work in the marine environment as a scallop farming pioneer in Atlantic Canada. Almost 25 years later Duncan still owns his own scallop farm and is no stranger to a rolling deck and long term mooring of heavy equipment in the ocean.

At OTN, he is involved in mooring and acoustic array design, equipment and materials testing, the deployment and recovery of receivers, collection of field data, and much more.

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 Windsor
 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), Terry Dick, U Manitoba, 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 Funding Partners



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