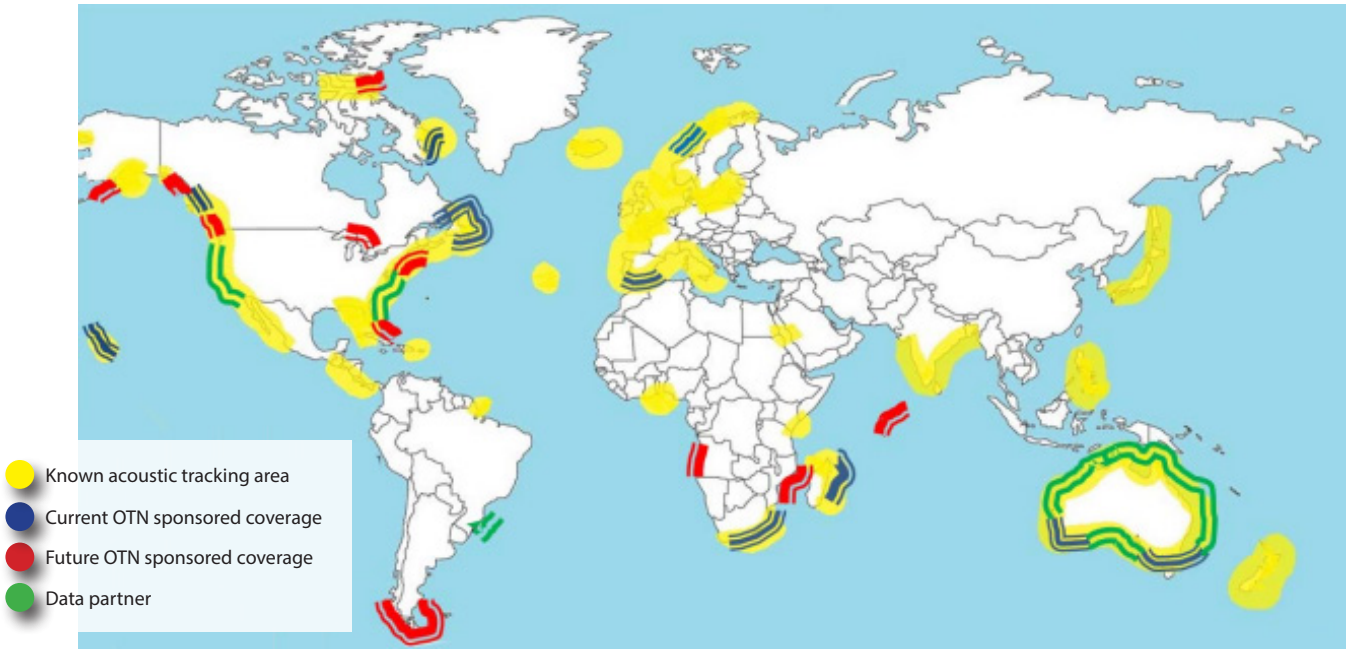
OCEAN TRACKING NETWORK

Annual Report 2012–2013

OCEAN TRACKING NETWORK

Headquartered at Dalhousie University, Canada



OTN in Brief

The Ocean Tracking Network (OTN) is a Canada Foundation for Innovation (CFI) – International Joint Ventures Fund global research and technology development platform headquartered at Dalhousie University in Halifax, Nova Scotia, Canada. Starting in 2008 and beginning full operations in 2010, OTN has been deploying Canadian state-of-the-art acoustic receivers and oceanographic monitoring equipment in key ocean locations around the world. These acoustic receiver lines are being used to track the movements and survival of marine animals carrying acoustic tags, and to document how both factors are influenced by oceanographic conditions. OTN deployments will occur in all of the world's five oceans and span seven continents. OTN is tracking many keystone, commercially important, and endangered species, including marine mammals, sea turtles, squid, and fishes including sharks, sturgeon, eels, tuna, salmonids, and cod. The Natural Sciences and Engineering Research Council of Canada (NSERC) supports OTN Canada, the seven-year (2010-2016) national network of researchers that work with the OTN infrastructure across Canada. The Social Sciences and Humanities Research Council of Canada (SSHRC) funds participation of social scientists in OTN work. Over 390 international researchers from 15 countries are currently participating in the global network along with many more trainees, graduate students, and postdoctoral fellows—in Canada alone, OTN has directly supported more than 130 students and trainees. OTN hosts a data warehouse—more than 53 million animal tracking records and growing—that serves as a repository for data collected by researchers, and is developing interpretation and visualization tools for analysis of tracking data. OTN also operates a fleet of autonomous marine gliders in support of oceanographic and tracking research.

Learn more at oceantrackingnetwork.org
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OTN Mission

OTN's 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

OTN is building an entirely new ocean observation system: one that is centered on measuring marine animal movements, habitat use, and survival in relation to changing oceans while advancing an international social and legal framework for the oceans. OTN's objectives are to:

- 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 ocean monitoring systems and arrays, and make Canada a global leader in conservation and the sustainable use of the oceans
- Foster national and international partnerships in research endeavors and 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 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
- Provide scientific guidance in development of strategies for research activities, analysis, integration, and dissemination of data and knowledge gained
- Ensure that 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.

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Canada at the Forefront of a Revolutionary Global Ocean Observing System

Message from the Chair of the OTN Council

Canada is at the forefront of an exciting and revolutionary global ocean observing system. OTN, a highly collaborative global network and innovation powerhouse headquartered at Dalhousie University in Halifax, Nova Scotia, connects people, nations, disciplines, and thinking towards better oceans research and governance.

In a period of tight budgets and global-scale problems, more than ever before, we must pool our global resources and expertise, and move towards integrated approaches to understanding events that know no political or geographical boundaries. Researchers from all corners of the globe recognize the importance of collaborative studies to advance our collective knowledge of delicate ocean ecosystems, re-establish healthy fish stocks, and communicate critical information to policy makers, stakeholders, and the public.

By linking up with members of industry, OTN is expanding strategic monitoring efforts to offshore oil and gas infrastructure; creating new, autonomous, mobile tracking and monitoring platforms; and supporting Canada's marine industries and job markets.

OTN has worked assiduously with its partners in marine technology and natural resources to identify effective approaches to tracking and monitoring. This has translated into two of the longest and most comprehensive marine acoustic telemetry arrays in the world as well as various novel, cost-effective methods by which to capture data from OTN Canadian and global arrays.

Scientists working under the OTN umbrella are making significant discoveries and producing high-priority knowledge on animals' global pathways, habitat use, and survival as well as ocean climate change and variability. It is through these unique research partnerships that ocean ecosystem knowledge is collected, connected, and communicated for future generations' livelihood and quality of life.

OTN is a model for international research and industry partnerships working towards long-term sustainability and sound public policy. As OTN continues to grow, remarkable collaborations and scientific innovation will continue to produce some of the most important oceans discoveries of our time.

Dr. Peter Harrison
OTN Council Chair and
Professor, School of Policy Studies
Queen's University, Canada

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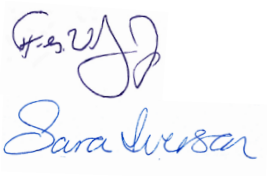
Dr. Fred Whoriskey,
Ocean Tracking Network Executive Director
and
Dr. Sara Iverson,
Ocean Tracking Network Scientific Director
(doing their best Steve Zissou)



Message from the OTN Executive and Scientific Directors

It is with great satisfaction that we look back at OTN's progress over the last year. The growth of the network has been truly astonishing. In the last year, five new major locations were added to our acoustic array deployments and OTN now has over 1,000 active receiver stations (compared to 600 in the previous year) in Canadian and international waters. OTN, with ship time support from Fisheries and Oceans Canada, took ownership and operating responsibility for three of the Pacific Ocean Shelf Tracking (POST) project's Pacific Ocean receiver lines as POST wound down. We now have more than 395 scientists and many-fold more highly qualified personnel (HQP—students, postdoctoral fellows, and other personnel-in-training) using our infrastructure. A new autonomous vehicle, a Liquid Robotics Wave Glider, was added to the OTN glider fleet. This vehicle will complement the oceanographic data collection currently carried out by the OTN Slocum gliders, will provide a new mobile receiver platform reporting detections of tagged animals in realtime via satellite, and will be developed to remotely interrogate VR4 acoustic receivers, providing operations and maintenance support at a fraction of the cost of chartering ships.

OTN researchers generated 77 high-quality peer-reviewed publications and 123 conference or workshop presentations over the last year. The NSERC-funded Canadian research network also underwent a rigorous and very positive external peer review of its first years of activities and was given a green light for the evolving activities and research proposed for the coming years with ever-increasing international connections and collaborations. These are all tremendous achievements for an infrastructure that is only in its third full year of operation. All of this is built on the partnerships that have been forged with academia, government, and the private sector.

Some of our most exciting developments are in the data management field. The design of OTN's Data Warehouse is living up to its promise and the warehouse has now grown to over 53 million animal tracking records (up from 10 million last year) covering 164 projects on 52 species. This year saw the successful integration of the POST database into the OTN Data Warehouse, where it will remain available to researchers. OTN data staff have worked with their Australian and U.S. counterparts to develop a common data-format standard for tracking data. We expect that this will become the global standard for such data, and it will enable OTN to seamlessly link existing databases to create a global resource. Thus, the "big data" source on the movements of aquatic animals is rapidly becoming a reality. In parallel, a talented group of OTN data analysts and visualizers are forming an international team whose focus will be on generating and sharing new methods for processing tracking data and integrating these with other ocean observations.

The last year also saw significant structural changes to OTN. A new OTN Council was formed, composed of extraordinarily talented people. An International Scientific Advisory Committee drawing on experts from the global scientific community was also created, and integrated closely with the Canada-based Scientific Advisory Committee that oversees the NSERC-funded research by Canadian scientists working with the CFI infrastructure. A strategic plan for OTN was completed, a new international science strategy was developed, and a public relations officer was engaged to assist with outreach and communicating the activities and successes of the network.

Looking forward, in the next year our scientists will continue their groundbreaking research and scientific innovation all across the globe. In support of these efforts, OTN will be undertaking another suite of equipment deployments that will greatly expand our international footprints. We are working with the UN's Global Ocean Observing System (GOOS) new Biology and Ecosystems Panel to make aquatic telemetry and the OTN one of this panel's core ocean observing systems. OTN members will also be major participants or conveners of a number of international symposia, including at the ICES Annual Science meeting in Reykjavik in September 2013, at the American Association for the Advancement of Science in Chicago in February 2014, and as host of the 3rd International Conference on Fish Telemetry in Halifax in 2015.

The OTN is making a difference for people who depend on the ocean in many parts of the globe. The work ranges from studies on sharks in South Africa and Australia to reduce the possibilities of fatal attacks on people, to providing data on fish movement and survival in both fresh and salt water to inform fisheries management decisions from polar regions to the tropics. We look forward to the future with confidence and excitement. We also continue to thank our major Canadian funders, OTN's partners, and the critical staff of OTN, for all their hard work, dedication, and sharing the vision.

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Doug Wallace (MEOPAR), Martha Crago (VP Research, Dalhousie), Sara Iverson (OTN Scientific Director), Jim Hanlon (CEO, HMRI), and Gilles Patry (President, CFI) attend the opening of the Dalhousie Ocean Sciences Building in June 2013.

In June 2013, OTN headquarters relocated to the new Dalhousie Ocean Sciences Building. The $41-million building houses the offices and labs of Dalhousie's key global oceans research networks including the Halifax Marine Research Institute (HMRI) and the Marine Environmental Observation Prediction and Response (MEOPAR) network in addition to OTN. The 76,000-square-foot, LEED-certified space adjacent to the university's life sciences departments boasts innovative research tools like shipping containers designed to become highly portable ocean laboratories and an expansion of the Dalhousie Aquatron, now the largest aquatic research facility in Canada. The building allows researchers and oceans leaders to connect in a collaboration-conducive environment sharing tools, knowledge, and expertise towards integrative approaches to oceans research. Sara Iverson (OTN), Jim Hanlon (HMRI), and Doug Wallace (MEOPAR) hoisted the sail (in lieu of a traditional ribbon cutting) of Paralympic sailor, Nova Scotian, Paul Tingley to celebrate the building's opening.

"Conducting research in the oceans is a massive challenge requiring dedication, skill, and significant resources, the cost of which is often far beyond the research capacity of any one nation."

Dr. Gilles G. Patry
President, Canada Foundation for Innovation
The Embassy, Iss 455, 2013

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Gobal Research and Operations

Global Research and Deployments

A priority within OTN's global ocean observing capacity is to foster collaboration. We enable our international partners to conduct research addressing their countries' economic and environmental concerns with the goal of providing the scientific foundation for policy action on local to global scales. OTN provides the backbone for cutting-edge research in the form of a global acoustic receiver infrastructure, a huge data warehousing capacity, and an analytical platform which our partners use to support tagging and ocean monitoring projects. Currently, OTN serves over 390 researchers at 82 institutions worldwide.

OTN Research Framework and Cross-cutting Activities

Through the simultaneous processes of the OTN Canadian NSERC research network undergoing an external peer review of its first three years (2010 through 2012) and the formation of an International Scientific Advisory Committee to complement the Canadian Scientific Advisory Committee, OTN scientists developed a set of plans to better address strategic questions of national and international importance as OTN moves forwards. Three core scientific framework questions and four cross-cutting activities (which include methods and approaches that cut across and help inform the framework questions) were identified and formalized to provide an umbrella under which all global OTN activities could be strategically aligned. This overall organization of research questions and activities ensures a conceptual understanding of how projects are interrelated, illustrates how these can be most effectively aligned and integrated across the network, and allows rapid dissemination to interested parties and stakeholders of all individual research projects and programs. This approach also fosters a breadth of training opportunities, exchange, and exposure for HQP.

Framework questions:

1. How do oceanographic and environmental features (both physical and biological) affect animal habitat use, movements, and migrations?

2. How do species interactions and areas of ecological significance relate to habitat use, movement patterns, and biotic/abiotic features?

3. How do anthropogenic activities and development influence aquatic animal behaviour and ecology?

Cross-cutting activities:

1. Assimilating animal tracking data with coastal and offshore oceanographic models

2. Visualization and modelling of complex aquatic and marine observations

3. Advancing animal tracking technology and tagging techniques

4. Policy, stakeholders, and mechanisms for feeding into outreach and management; cooperation of natural and social scientists

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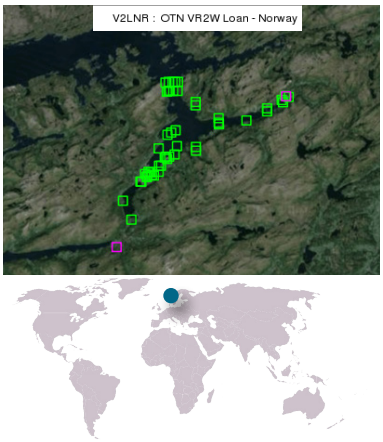
Update on OTN Global Acoustic Lines

Perth, Australia

Installed in January 2009, the Perth Line is of great importance to Australian researchers and is a major contribution to our partners at the Australian Animal Tagging and Monitoring System (AATAMS), part of the Australian Integrated Marine Observing System (IMOS). Western Australia Fisheries provides the operation and maintenance support necessary to keep this line active. The Perth region is a hotspot for multi-species migrations. Researchers from many institutions have been tracking species like whale sharks, great white sharks, pink snapper, tailor, Australian sea lions, southern elephant seals, and Southern bluefin tuna. As these animals cross the Perth Line, investigators gain valuable insights on their migrations and behaviour. The line is also a part of the shark-monitoring network of Western Australia Fisheries that monitors tagged sharks near Perth beaches in support of their Shark Response Unit. The line consists of 53 active receiver stations.

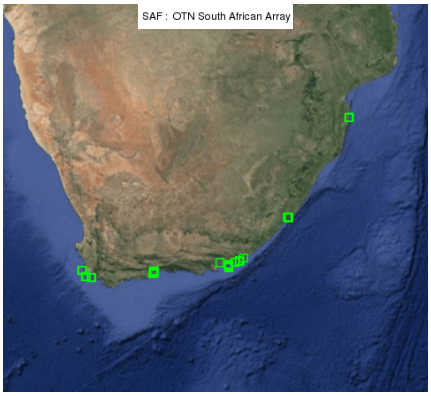


Norway

This partnership among OTN, the Norwegian University of Science and Technology, and their collaborators is investigating physiological and biological interactions between sea trout and the coastal marine environment. The work is documenting i) how sea trout habitat use and interaction with the environment vary seasonally during the marine feeding migration and ii) whether sea trout are opportunistic feeders (feeding on multiple food sources) or are instead individual feeding specialists. Data from this tracking study will play an integral role in helping to implement protective and recovery measures for declining sea trout stocks. Preliminary results have garnered high interest from fisheries management agencies. The line, on loan for a period of two years, consists of 48 active receiver stations.

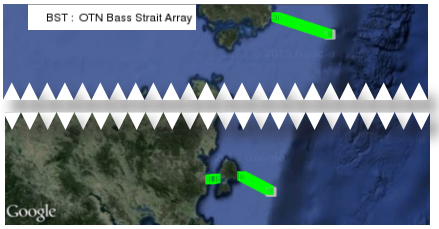
Alaska, United States

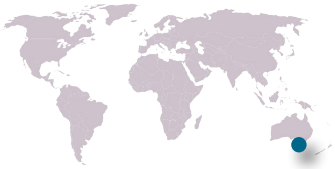
In March 2013, OTN technicians worked with staff from the Prince William Sound Science Center to install acoustic receivers in six channels of Prince William Sound. The array will support a study investigating post-spawning movements of Pacific herring, in which 69 fish were tagged in April 2013, and has the potential to detect fishes, including green sturgeon and Pacific salmon ,tagged further to the south in the U.S. and Canada. The University of Alaska Fairbanks will soon release fish with temperature recording tags that will help investigators obtain long-term data on ocean temperatures in two of the major entries to Prince William Sound. The line consists of 34 active receiver stations.



South Africa

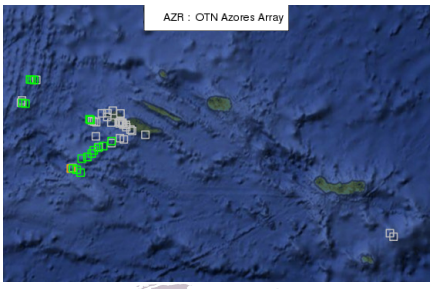
In 2012, in collaboration with the South African Institute for Aquatic Biodiversity, OTN added two new lines to the existing South African Array, bringing our array total in South Africa to four distinct acoustic lines. The new receiver stations were added in Port St. John's, known as "the deadliest beach in the world" for shark attacks, and in False Bay, which is home to some of the largest great white sharks in the country. Additional receiver stations were installed in secondary monitoring sites, principally in estuaries along the eastern coastline. South African researchers take focus on large predatory sharks with the goal of gaining a better understanding of shark migration and behaviour to protect swimmers, surfers, and other sea-goers. Other species detected on the South African Array include ragged tooth sharks, dusky kob, leervis, and white steenbras. There has been substantial growth in the number of participating researchers and several high-level research projects now routinely use OTN tracking infrastructure. There are a total of 76 active receiver stations in South Africa.





Tasmania, Australia

The OTN Tasmania deployment has also become an important component of the AATAMS network. It consists of a receiver line located southeast of Tasmania that extends from the shoreline, outward to Maria Island, and beyond. A second line of receivers is located northeast of Tasmania off Cape Barren Island. Together, these cross-continental shelf lines are known as the Bass Strait Array. The array has assisted researchers in observing large-scale species movements of a variety of species and is documenting how the East Australian Current is influencing these movements. These lines total 63 active receiver stations.



Azores, Portugal

The first OTN Eastern Atlantic acoustic receiver line, the Azores Array, was deployed during 2011–2012 to complement pre-existing receivers maintained by the University of the Azores Institute of Marine Research. The Azores Array is a unique OTN line in terms of deployment specifications and research activities—stations are located on island slopes and sea mounts including the Condor Seamount, Princess Alice Bank, and the Gigante Banks over the Mid-Atlantic Ridge. The array supports work on migratory and resident species including blackspot seabream, wreckfish, devilrays, kitefin, and blue and hammerhead sharks. The array is now composed of 50 receiver stations.

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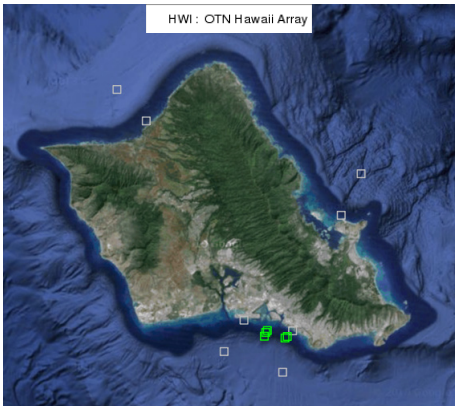
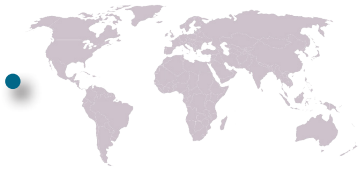
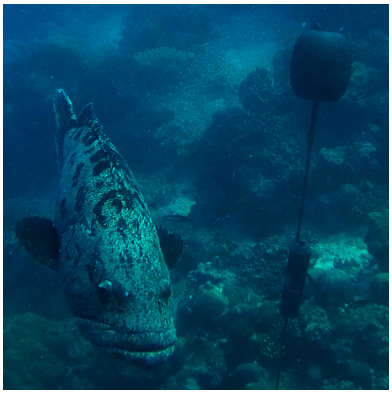




Hawaii, United States

The island of Oahu, Hawaii, is the center of several projects investigating the movements and ecology of species including coastal sharks, deep-water snappers, and open-ocean pelagics such as tuna and marlin. These projects are the current focus of the long-established telemetry interest in Hawaii that has elucidated the habitat use and physiology of a wide range of species inhabiting inshore reefs, deep reef slopes, and pelagic zones in the open ocean. OTN deployments were made in 2013 to provide additional capacity to these ongoing efforts and in particular to support work documenting the movements of hammerhead and tiger sharks. Hammerhead sharks' use of the Kaneohe Bay pupping ground is of particular interest. In addition to monitoring the movements of "resident" Hawaiian species, recent results indicate that Hawaii is visited by highly migratory species like great white sharks. Thus, acoustic tracking in Hawaii serves both a local and pan-Pacific function. The array consists of 13 active receiver stations.



Clockwise from top: A grouper "guards" a VR2W acoustic receiver in South Africa; acoustic receiver mooring being loaded onto a Zodiac in the Strait of Gilbraltar; acoustic mooring anchors use volcanic rock in the Azores; seahorses in South Kohala, the site of the OTN Hawaii Array; VR2W acoustic receiver and float ready for deployment.

Expanding Operations

Strait of Gibraltar

In August 2012, OTN, together with our Spanish partners, ran a trial deployment of ten acoustic receivers in the Strait of Gibraltar between Spain and Morocco. The 14-kilometre-wide strait is the main gateway between the Atlantic Ocean and the Mediterranean Sea and is a strategic tracking station, as many high-value species including tuna, swordfish, and other commercially important fishes, sea turtles, and several species of dolphins and whales regularly transit through the Strait. The unique characteristics (pycnoclines and thermoclines, strong tidal currents, high volumes of shipping traffic) of this ocean region posed several challenges for our bottom-moored listening stations. We used the trial deployment to study the impacts of the extreme environmental effects on different configurations for our equipment as well as to document species movement and migration. Working with technicians and researchers from the University of Barcelona, the Oceanography Institute (Madrid), and VEMCO, OTN technicians successfully completed several tests of the acoustic communication capability between receivers and surface transducers. We hope to have this line fully deployed by late 2013; however, the current economic climate in Spain is posing significant operations and maintenance support challenges.

Brazil

In the spring of 2012, Brazilian colleagues, in collaboration with the OTN Directors, were awarded a grant to implement the Brazilian-Ocean Tracking Network (OTN-BR), establishing the first presence of OTN in South America and serving as an initial prototype for other regions. OTN-BR plans to address i) scientific problems (habitat use by marine organisms and migration of key species); ii) social issues (management of fisheries resources, and policy and strategies for conservation of the oceans (e.g., marine protected areas)); iii) technological advances (the use and development of acoustic sensors and platforms for ocean observing); and iv) information systems applied to oceanography. The lead researchers in Brazil are from the Federal University of Rio Grande (FURG) and Universidade do Vale do Itajai (UNIVALI).

Martha Crago (Dalhousie) and José Muelbert (FURG) with research student Priscila Orozco at the 2nd Brazil–Canada Joint Workshop on Ocean Science and Technology in Victoria, British Columbia, Canada in June 2013.


Matt Casselman

Canadian Research and Operations

OTN Canada Arenas and Animal Tracking Initiatives

OTN Canada investigators are generating important information related to Canada's three surrounding oceans. For the initial three and a half years, OTN NSERC-funded Canadian researchers were organized primarily around the network's Atlantic, Arctic, and Pacific Arenas. However, a major focus of OTN Canada since its inception has been to continually increase integration of research questions and strategies, and of HQP, both within and across Arenas. OTN Canada has also been strongly committed to advancing the sharing of research tools, programs, and findings. Our researchers have accumulated an outstanding track record of first-rate science and have developed an integrated Canada-wide research network with ever-increasing international reach.

Through to this report year, the Canadian network has engaged 27 principal investigators (PIs), who have formally collaborated with an additional 60 researchers and have jointly trained over 130 HQP. The natural scientists that participate in the Canadian network have been especially committed to partnering with OTN social scientists to examine governance frameworks to directly interact with stakeholders, and to suggest ways to weave stronger conservation and management strategies for species in light of increasing scientific information. As a result, many of the peer-reviewed publications emerging from the Canadian-led work are directly related to conservation and management.

Les Harris, OTN Arctic Arena collaborator, observes acoustically tagged fish in a recovery pen before release.

OTN Social Science Activities

OTN social science researchers have an active interest in determining how data from telemetry studies can be used to implement legislative and regulatory reforms for better oceans management. OTN specialists in oceans law and governance are investigating how to make better decisions for ocean governance, especially as it pertains to ecosystem-based management, indigenous rights, and the role of regional agreements in managing fisheries, and protecting the marine environment and biodiversity. OTN social scientists are also investigating how the federal Species at Risk Act has affected Canada's marine resource sectors such as the offshore oil and gas industry and aquaculture operations, comparing Canadian approaches to those used in other national jurisdictions such as Australia and the U.S., and aligning with proposed international jurisdictions such as the International Sargasso Sea Alliance. Integration of social sciences across the OTN scientific research framework and activities has fostered interdisciplinarity and brought synergy to the network both nationally and internationally. Collaborations between social and natural scientists include, among others, projects on Atlantic sturgeon, American eel, grey seals and cod, Pacific salmon, Greenland shark, and bluefin tuna. This summer, the *Journal of International Wildlife Law & Policy* published the first of two issues featuring case studies by OTN social scientists: "Tracking and Protecting Marine Species at Risk: Scientific Challenges, Sea of Governance Challenges".

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

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Atlantic Arena

Studies in the Atlantic Arena are varied and multidisciplinary. Work in the Northeast Atlantic has included tracking the movements and survival, including causes of mortality, of keystone and threatened species such as Atlantic salmon, American eel, Atlantic sturgeon, and cod. OTN oceanographers are "immersed" in ocean chemistry and physics, and have developed sophisticated, time-varying, 3-D current and hydrography models that are becoming reliable tools to link environmental conditions with animal movements.

The development of novel and innovative techniques has also been a major focus of investigators and has led to the development of the world's smallest data storage tags for use in salmon smolts; development of accelerometer tags by HQP for studying fine-scale behavior, growth, and energetics of fish; beta testing and validation of the first Bluetooth-enabled combined tags and receivers (VEMCO mobile transceivers) to study predator-prey and predator-predator interactions using grey seals as a model system; development of proof of concept for the use of a Wave Glider as a mobile receiver platform; and determination of detection efficiencies of tracking instruments and deployments for all of OTN. Finally, a key focus has involved development of new statistical methods for analyzing animal tracking data, survival estimates, and integration with ocean characteristics.

Mélanie Beguer and Julian Dodson (Université Laval) outfit an American eel with a satellite tag to track its movements through the Gulf of St. Lawrence, Canada.

Atlantic cod outfitted with accelerometer tags, developed by OTN HQP Franziska Broell and Andre Bezanson, in the Dalhousie University Aquatron. Franziska and Andre have since started their own biologger development company, Maritime bioLogger, in Halifax.

Highlights from 2012–2013:

- Detections from the Halifax Line suggest that marine animals moving north and eastward from the Gulf of Maine do so almost exclusively in June–July at a time when the southwest Nova Scotia current is weakest. Detection patterns indicate that numbers of animals crossing the Halifax Line are lowest in areas of highest current velocity.
- Algorithms have been developed to estimate parameters from accelerometry tag records that can classify fine-scale behaviour with a success rate of approximately 80%.
- Researchers obtained the first estimates of the migration routes and duration, and thus speed, of American eels in the Gulf of St. Lawrence heading out towards the Sargasso Sea. They have also quantified the effect of physical ocean conditions on eel migration distributions, and have discovered strong evidence of heavy predation by porbeagle sharks.
- Proof-of-concept studies established that predators (seals) fitted with Bluetooth-enabled VMT and GPS tags can provide important information on other species' locations in areas where fixed receiver arrays are not present, and allow new insights into the nature of predator-prey and predator-predator interactions in the open ocean.

OTN Atlantic Arena Leaders:
Katja Fennel, Dalhousie University
Ian Fleming, Memorial University of Newfoundland

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Headquartered at Dalhousie University, Canada

Arctic Arena

The Arctic Arena is literally pushing the boundaries of OTN. Arctic investigators are making significant contributions to the understanding of Arctic ecosystems and species distributions and movements in the region. This information is critical for the management of Arctic fisheries resources as governments in the Canadian North turn to the development of new fisheries for subsistence and commercial benefits. Target species for fisheries are Greenland halibut and Arctic char. Elucidating the seasonal movements and habitat use of these species as well as keystone prey like Arctic cod and skate, and keystone predators like Greenland shark (also a significant bycatch species), is essential for implementing sustainable fisheries management to support local fishing communities. Ringed seals carrying satellite tags are also providing insight into movements relating to ice flow and oceanographic conditions. These data, coupled with oceanographic measurements, are providing the first large-scale, multidisciplinary research program in the Canadian Arctic.


Steve Fields


Steve Fields


Jean-Sébastien Moore

Left to right: OTN investigators implanting acoustic tags in a Greenland shark, Arctic halibut, and lake trout.

Steve Kessel

Highlights from 2012–2013:

- Arctic OTN investigators have established the first extensive long-term Arctic acoustic monitoring studies, identified seasonal movement patterns of Arctic char and Greenland halibut, and established the first-ever acoustic tagging efforts of Arctic cod and Greenland sharks.
- Oceanographic studies by OTN Canada in Resolute Bay and Cumberland Sound, Nunavut, are collecting some of the most comprehensive oceanographic data ever undertaken for difficult-to-access regions in the Canadian Arctic.
- Arctic OTN investigators are also concerned with changing ocean conditions which may affect the movements and migrations of these keystone Arctic species as a lack of data means these changes are poorly understood and hard to predict. Forty-two conductivity-temperature-depth (CTD) casts were made to capture water movement in and out of Cumberland Sound. These data, and additional nutrient and oxygen samples, will help establish baseline conditions and contribute to simulations on how the ecosystem in the Sound could be affected by climate change.
- More than 50 CTD casts were also conducted throughout Resolute Bay (the last known CTD measurements in the Canadian Arctic were made in the 1950s). Monitoring here was also carried out to categorize water movement, ice movement and formation, and zooplankton production. These data will be used to help interpret fish and marine mammal movement data from the OTN Arctic arrays.

OTN Arctic Arena Leaders:
Aaron Fisk, University of Windsor
Svein Vagle, University of Victoria

OTN HQP Matt Drenner gently restrains a coho salmon for measurments and tagging.

Pacific Arena

OTN Pacific Arena research is primarily focused on studies surrounding Pacific salmon, especially sockeye salmon originating in the Chilko River system. OTN scientists are using a myriad of tools including gene expression, acoustic telemetry, and accelerometry to characterize fish behaviour and survival during most of the animals' life stages. Pacific OTN investigators and their students also continue to lead research on best-handling techniques to improve telemetry procedures and animal care, especially regarding tag-size limits for juvenile salmon. These are critical to inform all OTN studies as poorly implemented procedures can alter fish behaviour nullifying the goals of the research work.

Pacific Arena investigators use acoustic stations placed in the tributaries and main stem of the Fraser River watershed, in addition to the OTN west coast marine deployments in the Juan de Fuca Strait, the Northern Strait of Georgia, Queen Charlotte Strait, and Prince William Sound. Receivers are also deployed on oceanographic buoys operated by Ocean Networks Canada in the Juan de Fuca Strait.

Highlights from 2012–2013:

- West coast OTN investigators successfully conducted the largest study to date on the thermal regimes experienced by freely migrating salmon at sea. Temperature loggers in several hundred specimens revealed that salmon actively sought temperatures that coincided with their metabolic thermal optima during migration.
- In a significant laboratory study, sockeye salmon were outfitted with novel depth-sensing acoustic accelerometer tags that determined the relationship between swimming speeds and energetics during migrations and are now being compared with field studies.
- In an ambitious *in situ* experiment, over 1,500 juvenile sockeye salmon were tagged to identify mortality during out-migration. This is the first, large-scale study on Canadian wild juvenile Pacific salmon and the first to use novel V5 and V6 (5 and 6mm long, respectively) miniature tags. Data from 2012 showed that, similar to previous years, Chilko Lake smolts faced significant mortality during the first 100 kilometres of their 650 kilometre freshwater migration. Overall, out-migrating smolts had a paltry 3-7% survival rate from their release post-tagging to detection on acoustic receivers at the mouth of Chilko Lake.

OTN Pacific Arena Leaders:
Steve Cooke, Carleton University
Scott Hinch, University of British Columbia


Matt Drenner

Matt Drenner

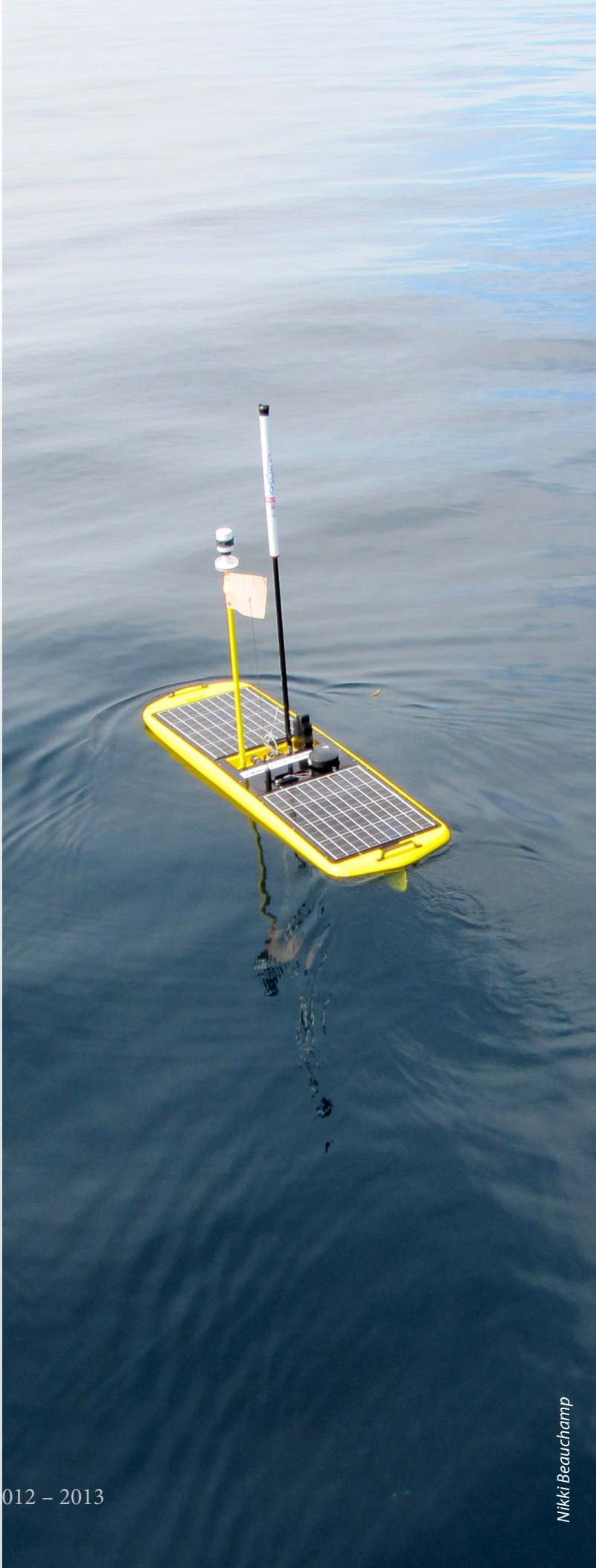
Innovation

Autonomous Marine Vehicles

OTN's ocean gliders had a landmark year collecting more than 67 million oceanographic records on nine missions covering the length of the Halifax acoustic receiver line—over 200 kilometres to the Scotian Shelf. Oceanographic data collected by gliders help contextualize animal tracking data from the line and provide a venue for oceanographers and biologists to merge thinking, results, and models that help describe the phenomena behind animal movements, survival, and habitat use.

In May 2013, OTN purchased the first Wave Glider in Canada. The glider, built by ocean engineering firm Liquid Robotics, is equipped with a VR2C acoustic receiver to detect acoustically tagged animals on its trajectory. Its primary purpose, however, is to remotely offload data via hydrophone from bottom-moored acoustic receivers. This will result in a far more cost-effective means of recovering acoustic telemetry data, but will also reduce the risk to technicians and other personnel where retrieval would otherwise require prolonged stays at sea.

In April 2012, in the waters of a popular surfing destination in South Africa, champion bodyboarder David Lilienfeld lost his life as a result of a tragic encounter with a white shark. The OTN Wave Glider, nicknamed "DL", is a reminder to scientists everywhere that their research has real-world impacts—by characterizing the movements of ocean animals, we can protect both animals and people.

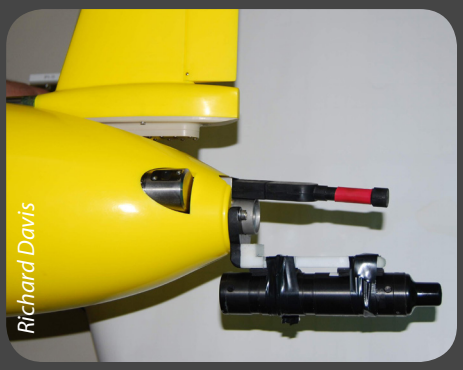


Nikki Beauchamp

Grey seal carrying satellite tag (head) and VEMCO mobile transceiver (back). Inset top: VMT unit. Courtesy of VEMCO. Below: VMT mounted on an ocean-monitoring glider picks up animal detections as it surveys the marine environment.

VEMCO Mobile Transceivers (VMTs)

VMTs are the result of intense collaborations between OTN members and Canadian telemetry equipment manufacturer VEMCO. VMTs act simultaneously as acoustic transmitters and receivers. The advent of this technology is allowing researchers to expand the ranges of detections beyond fixed arrays and to examine species interactions by outfitting large marine animals with these units as they swim. These tags can also be coupled with oceanographic sensors, allowing large animals to essentially act as roving "bioprobes". In the past year, further collaboration among OTN, VEMCO, and the Sea Mammal Research Unit (Scotland) has seen the creation of Bluetooth-enabled VMTs. Detections stored in the VMT are sent to the animal's satellite tag, which then transmits the information back to researchers via satellite in real time. The Bluetooth configuration was validated in 2012–2013 and allows VMTs to be deployed on large marine animals (such as seals, sharks, and sturgeon) without having to retrieve the unit manually for data collection. By sending such data via satellite, ship time and field costs of research can be further reduced and innovative methods for data collection are created. VMTs can also be deployed on ocean gliders which carry a suite of environmental sensors to record oceanographic properties further enhancing insights into relationships between animal movements and oceanographic conditions.



OCEAN TRACKING NETWORK

Headquartered at Dalhousie University, Canada

Technology Partnerships

OTN's partnerships go beyond universities and research institutions; OTN is finding unique opportunities to collect global oceanographic and animal tracking data by reaching out to members of industry, environmental NGOs, and others.

The Halifax acoustic telemetry line, which begins near the shore just south of Halifax, Nova Scotia, was fully deployed in the last year and now runs over 200 kilometres to cover the width of the continental shelf. This is the most ambitious and longest acoustic telemetry line on the planet.

Extensive consultations with fishing groups were carried out prior to this line's deployment to avoid potential fishing gear conflicts and to incorporate the knowledge of fishermen into the design of the line.

The line is providing valuable information on the North-South movements of migratory fishes between U.S. and Canadian waters, on seasonal patterns in species distributions, and on oceanographic and ecosystem changes across the entire continental shelf. By working with the user groups to place the nearly 260 stations of the line, gear conflicts were minimized, no equipment was lost to fishing operations, and OTN had 100% recovery of data from all stations over the operating year.

"VEMCO has been a proud partner of OTN since its inception. We are pleased to have been able to provide the innovative technology and infrastructure to help OTN researchers achieve their study objectives and dramatically increase their understanding of the oceans' inhabitants."

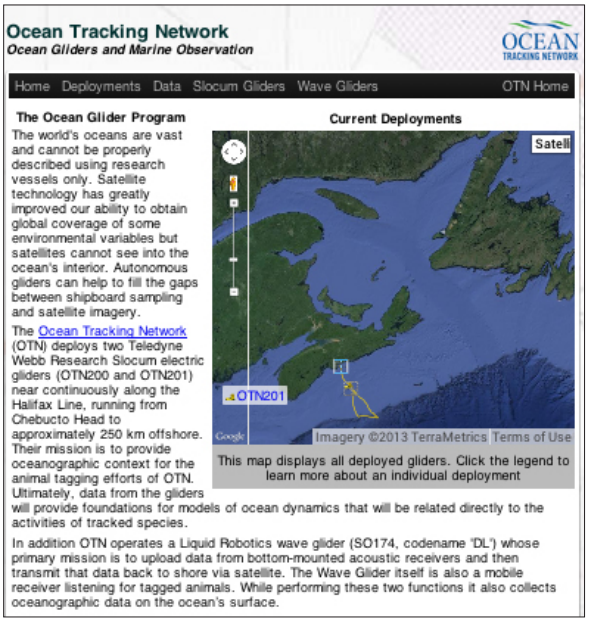
Mark Jollymore
President and CEO, VEMCO

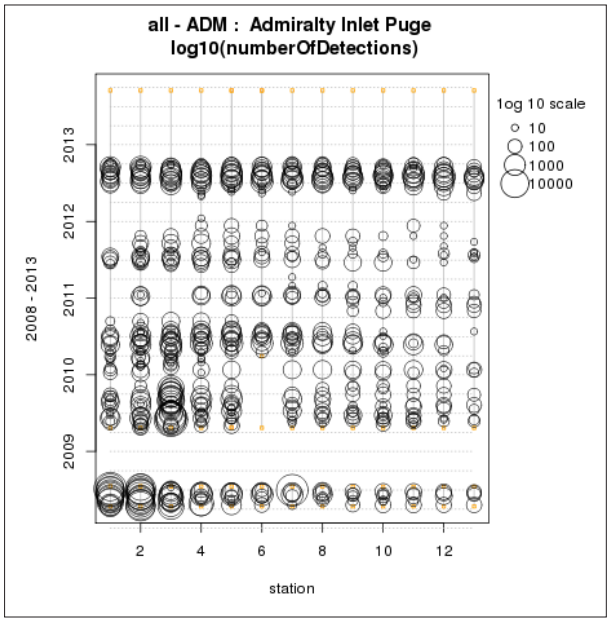
Information Technology and Data Analysis

Database Expansion

The OTN database is the repository for all globally collected OTN tracking data. As of mid-2013, the OTN database held more than 53 million animal tracking records. This is in addition to the millions of oceanographic records obtained from OTN's three gliders. Tracking data submitted to the OTN database are first quality controlled by OTN's team of skilled data managers and programmers. Once the information is loaded into the database, metadata are accessible to interested parties. Access to tracking records on individual fish is guided by the terms of the OTN data policy. The OTN database serves as a point of connection between investigators and groups wanting to share information across platforms, disciplines, and political/geographical boundaries.

The OTN data policy and database structure have served as models for the international scientific community. OTN data staff participated in the development of the new U.S. Integrated Ocean Observing System animal tracking exchange standard and are working to harmonize OTN's database with that of AATAMS. OTN is currently working with investigators in South Africa to establish a database for the African continent, and a Northeast Pacific Node has been established in the OTN database for the historic and current records generated by the OTN west coast lines.





Left: The OTN glider page containing background information on the OTN glider program that includes two Slocum gliders and one Wave Glider. The site hosts oceanographic data collected by the gliders including sea temperature, oxygen saturation, and irradiance.
Right: Plotting detection frequency over time on the OTN Admiralty (U.S.) acoustic telemetry line.

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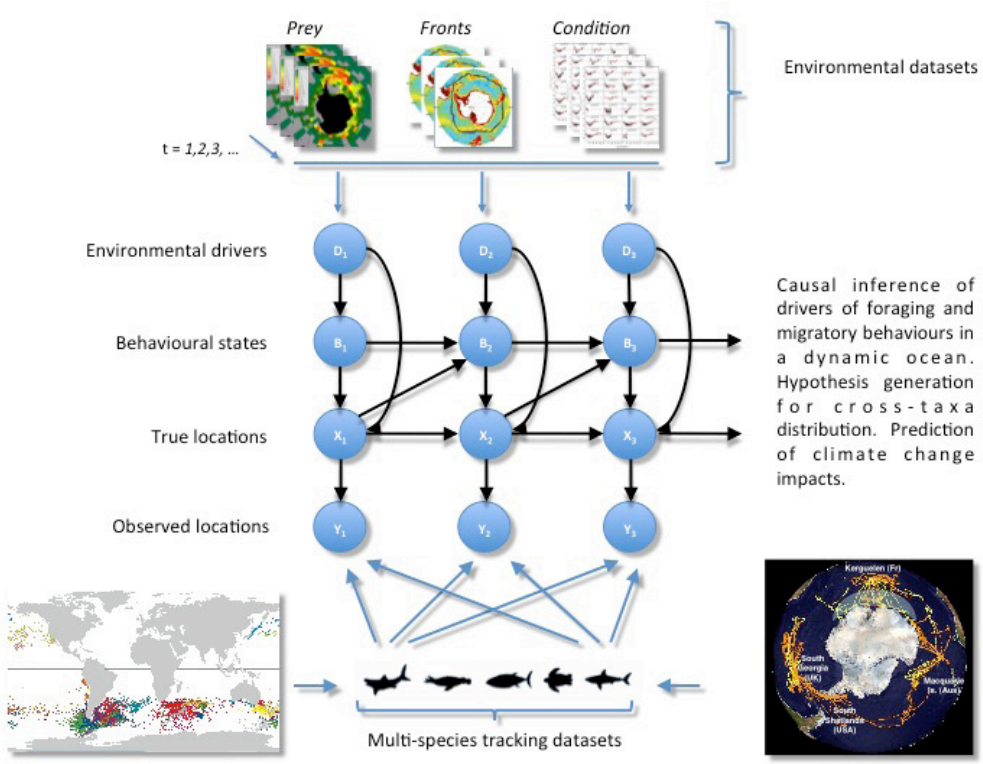
Data Visualization and Modelling

Visualization is a key 21st century research skill that provides insight into complex datasets like those being collected by OTN. Visualization provides a means of seeing this complexity in a dynamic and integrated fashion. Modelling is crucial for designing effective tracking studies, is necessary to draw inferences about species interactions, integrating animal movements with environmental data, and is critical for providing conservation and management advice.

There are three objectives within the modelling and visualization component of OTN. The first is to bring together OTN trainees (HQP) and international experts in data visualization and statistical modelling to i) develop visualization tools tailored to complex marine observations and related OTN research objectives and ii) develop the modelling tools necessary to analyze OTN tracking studies with particular emphasis on estimating migration survival and species' interactions in an environmental context. The second objective is to create a repository of documented shared code and freely available software that will be made available to OTN researchers and the broader scientific community. The third objective is to facilitate the exchange of HQP across Canada and internationally, as resources permit, to foster stronger collaboration on visualization and modelling tools useful to many OTN and outside projects.



Schematic depicting an approach for incorporating environmental data into state-space models of marine animal tracking data. These models can be used to generate improved location estimates, to estimate unobserved behavioural states (e.g., migrating vs resident or foraging behaviours), and to infer how particular movements or behavioural states may be associated with environmental drivers (e.g., temperature, productivity, currents). Ian Jonsen, Joanna Mills-Flemming.

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Communications

In the News

Over 100 stories involving OTN were distributed through international media channels in 2012–2013. From seals to sharks to robot submarines, national and international media followed a variety of success stories coming out of OTN. Some of the reporting was regional in nature, reflecting the relevance of OTN results to local stakeholders who depend on the oceans for their livelihoods. Other stories of broader interest were carried nationally and internationally. We are still "riding the wave" as researchers continue to mark firsts and push boundaries of oceans research and technology innovation.

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Merkel visits Dalhousie

Joint research project. Halifax institute, German association agree to work together

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Researcher tracks, tags — and, yes, would also eat — Toronto Harbour fish

Jodee Brown | 13/03/02 5:33 PM ET
More from Jodee Brown | @Jo_Brown_1

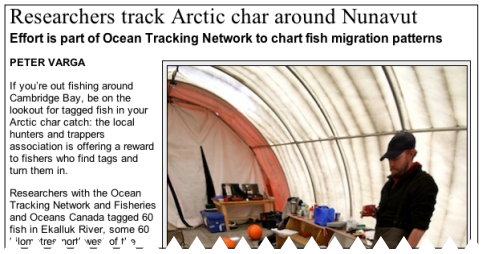
Student fish-tracking collaboration makes a splash

Advancing the tracking of marine species

Nikki Comeau - September 10, 2012

Franziska Broell holds one of the accelerometer tags that she developed with Andre Bezanson. (Danny Abriel photo)

Like 2 people like this.



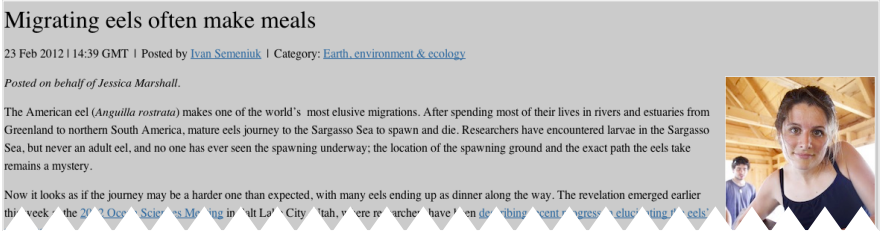
Researchers track Arctic char around Nunavut

Effort is part of Ocean Tracking Network to chart fish migration patterns

PETER VARGA

If you're out fishing around Cambridge Bay, be on the lookout for tagged fish in your Arctic char catch: the local hunters and trappers association is offering a reward to fishers who find tags and turn them in.

Researchers with the Ocean Tracking Network and Fisheries and Oceans Canada tagged 60 fish in Ekalluk River, some 60



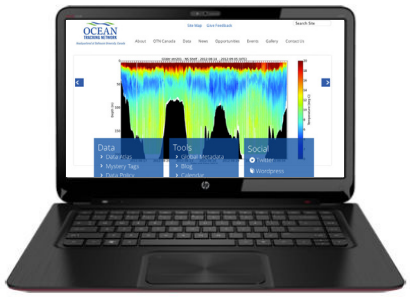
Migrating eels often make meals

23 Feb 2012 | 14:39 GMT | Posted by Ivan Semeniuk | Category: Earth, environment & ecology

Posted on behalf of Jessica Marshall.

The American eel (*Anguilla rostrata*) makes one of the world's most elusive migrations. After spending most of their lives in rivers and estuaries from Greenland to northern South America, mature eels journey to the Sargasso Sea to spawn and die. Researchers have encountered larvae in the Sargasso Sea, but never an adult eel, and no one has ever seen the spawning underway; the location of the spawning ground and the exact path the eels take remains a mystery.

Now it looks as if the journey may be a harder one than expected, with many eels ending up as dinner along the way. The revelation emerged earlier



Website

OTN's website has undergone significant redesign to make it easier to communicate network activities, submit and view data projects, and share the latest research and technology developments. The web address continues to be oceantrackingnetwork.org

OCEAN TRACKING NETWORK

Headquartered at Dalhousie University, Canada

2013 OTN Symposium

Connections and collaborations: the Canadian network and beyond

In June 2013, the Canadian OTN research network brought together over 120 of its members at Dalhousie University for the third annual OTN Symposium. OTN Canada PIs and students presented results from the Arctic, Pacific, and Atlantic Arenas from more than 50 individual projects. These annual symposia are funded through the NSERC research grant and provide a synergistic environment that fosters inter-Arena studies and multidisciplinary approaches to marine animal and oceanographic studies.

This year, thanks to additional support from OTN partners, industry, Dalhousie University, and fundraising activities, OTN was able to evolve this symposium to include the OTN International Scientific Advisory Committee (ISAC) and other international collaborators.

The theme of the 2013 symposium, Canada and Beyond, was a nod to the network's growth in national and international research, technology developments, and industry partnerships. ISAC members presented global perspectives on telemetry research, data, and policy. Day 1 of the symposium was, for the first time, open to members of the public, who are taking increasing interest in OTN activities.

Additionally, OTN hosted a successful and informative panel discussion as part of Halifax Oceans Week, which has grown to become a major national celebration of Canada's link to the oceans. The panel provided a compelling discussion of the present academic-industry model for oceans research and suggestions for future models. Panelists included Ian Thompson, Associate Publisher of The Chronicle Herald; Christine Penney, VP Sustainability and Public Affairs, Clearwater Seafoods; Aaron Fisk, Canada Research Chair, University of Windsor; Susanna Fuller, Coordinator, Ecology Action Centre; and Linda Panozzo, award-winning environmental author.

OTN Canada HQP during the closing reception of the 2013 OTN Symposium.

Future Meetings

During the report year, OTN was selected to co-host a session on acoustic tagging at the annual International Council for the Exploration of the Sea conference to be held in September 2013 in Reykjavik Iceland, and to host a session on OTN at the American Association of the Advancement of Science conference to be held in February 2014 in Chicago, Illinois.

During the 2nd International Conference on Fish Telemetry (ICFT), hosted by the South African Institute for Aquatic Biodiversity, it was announced that OTN would host the 3rd ICFT in 2015 in Halifax, Nova Scotia.

Preparations are underway to provide a unique and exciting venue at which to gather the leading marine, acoustic telemetry, social, and oceanographic scientists from around the world to share experiences, report on findings, and generate significant collaborative linkages. The Great Lakes Fishery Commission will be organizing a special session on the use of telemetry in fresh water for this conference.

Paul Cowley (SAIAB) and Fred Whoriskey attend the science and technology briefing to international communities at the Canadian High Commission in South Africa.

OCEAN TRACKING NETWORK

Headquartered at Dalhousie University, Canada

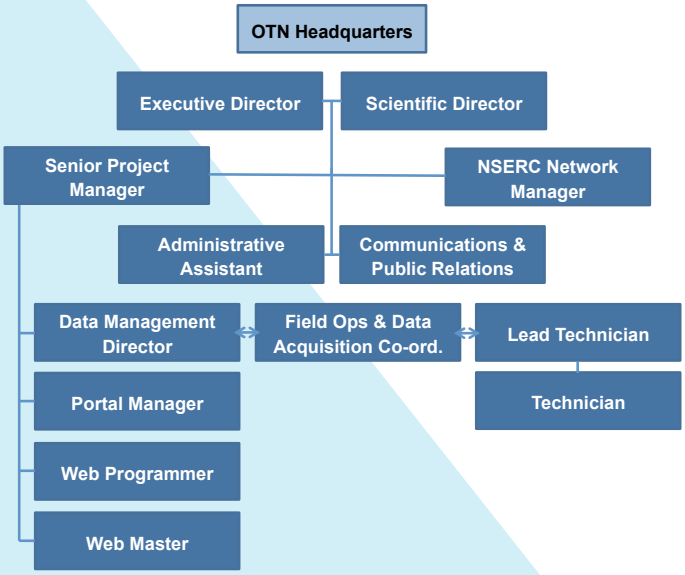
Our People

OTN Headquarters

It takes special people to build a new complex global ocean observing network. OTN's dedicated staff is overseeing network development with enthousiasm, pride, and competence. People are our most valuable network resource.

OTN headquarters includes:

Lindsay Algee (Co-op student)
Lenore Bajona - Portal Manager
Duncan Bates - Technical Lead
Nikki Beauchamp - Communications and Public Relations (joined June 2012)
Ian Beveridge - Technician (left May 2013)
Bob Branton - Director of Data Management
Susan Dufault - Field Operations and Data Acquisition Coordinator
Katerina 'Kat' Fupsova (Intern)
Sara Iverson - Scientific Director
Brian Jones - Database Programmer
Ian Jonsen - Data Visualization
Sue L'Orsa (Volunteer)
Kyle McKenzie - OTN Canada Network Manager (joined June 2012)
Marta Mihoff - Database Developer
Kathryn 'Kes' Morton - Senior Project Manager (joined June 2012)
Joe Pratt – Technician (joined June 2013)
Tracy Rounds - Executive Administrative Assistant
Fred Whoriskey - Executive Director



OTN Council

The mandate of the OTN Council is to provide independent, external stewardship of OTN on behalf of Dalhousie University, CFI, and other OTN stakeholders. A new Council was formed in 2012, comprising Canadian and international industry, research, and policy leaders who are lending their considerable expertise to assist in strategic planning, management, growth, and positioning of OTN. Three committees fall under the purview of the OTN Council. They are the OTN Management Committee, the OTN Canada Scientific Advisory Committee, and the OTN International Scientific Advisory Committee (formerly the OTN Global Coordination Committee).

OTN Scientific Advisory Committee (SAC) and OTN International Scientific Advisory Committee (ISAC)

The SAC and ISAC's roles are to guide, advise, and, where possible and desirable, integrate the planning of Canadian and international research projects, respectively. These groups assist in ensuring that science undertaken in Canada and around the world is consistent with strategic direction and funding priorities.

OTN Council:

Bill Casey - Former member of parliament for Cumberland-Colchester, Nova Scotia
Martha Crago - VP Research, Dalhousie University
Albert Fischer - Director of the GOOS Project Office of the Intergovernmental Oceans Commission; Head, Ocean Observations and Services Section at IOC/UNESCO
Dave Gillis - Director General, Ecosystems and Oceans Science Sector, Fisheries and Oceans Canada
Jim Hanlon - CEO, Halifax Marine Research Institute
Peter Harrison (Chair) - Professor and Stauffer Dunning Chair, School of Policy Studies, Queen's University
Nigel Lloyd - Former executive VP of NSERC
Chris Moore - Dean of Science, Dalhousie University
Leo Muise - Executive Director, Fisheries and Aquaculture, Province of Nova Scotia
Ian Smith - CEO, Clearwater Seafoods
Zdenka Willis - Director, Integrated Ocean Observing System, National Oceanographic and Atmospheric Administration
Nancy Hayter (non-voting) - Interim Director, Research Grants and Contracts, Research Services, Dalhousie University
Sara Iverson (non-voting) - Professor, Dalhousie University and OTN Scientific Director
Kyle McKenzie (non-voting) - OTN Canada Network Manager
Kes Morton (non-voting) - OTN Senior Project Manager
Doug Wallace (non-voting) - Professor and Canada Excellence Research Chair, Dalhousie University
Fred Whoriskey (non-voting) - OTN Executive Director

OTN ISAC:

Kim Aarestrup - Senior Scientist, Danish Technical University
Steve Cooke - Professor and Canada Research Chair, Carleton University
Paul Cowley - Senior Scientist, South African Institute for Aquatic Biodiversity
Aaron Fisk - Professor and Canada Research Chair, University of Windsor
Robert Harcourt (Chair) - Professor and Director of Marine Science, MacQuarie University
Kim Holland - Senior Scientist, University of Hawaii
John Kocik - Senior Scientist, National Oceanographic and Atmospheric Administration
Joanna Mills-Flemming - Professor, Dalhousie University
Svein Vagle - Senior Scientist, Fisheries and Oceans Canada; Adjunct Professor, University of Victoria
Kyle McKenzie (non-voting) - OTN Canada Network Manager
Kes Morton (non-voting) - OTN Senior Project Manager
Sara Iverson (non-voting) - Professor, Dalhousie University and OTN Scientific Director
Fred Whoriskey (non-voting) - OTN Executive Director

OTN SAC:

Chris Barnes - Former Project Director, NEPTUNE Canada
Steve Cooke (Chair) - Professor, Carleton University
Katja Fennel - Professor, Dalhousie University
Aaron Fisk - Professor, University of Windsor
Ian Fleming - Professor, Ocean Sciences Center, Memorial University of Newfoundland
Michelle Heupel - Professor and ARC Future Fellow, James Cook University
Scott Hinch - Professor, Department of Forest Sciences, University of British Columbia
Svein Vagle - Senior Scientist, Fisheries and Oceans Canada, Adjunct Professor, University of Victoria
Alain Vezina - Acting Regional Director of Science, Fisheries and Oceans Canada
Dale Webber - Scientist, VEMCO
Nikki Beauchamp (observer) - OTN Communications and Public Relations
Sara Iverson (non-voting) - Professor, Dalhousie University and OTN Scientific Director
Alison Janidlo (non-voting) - Senior Program Officer, NSERC
Kyle McKenzie (non-voting) - OTN Canada Network Manager
Kes Morton (non-voting) - OTN Senior Project Manager
Tracy Rounds (observer) - OTN Administrative Assistant
Fred Whoriskey (non-voting) - OTN Executive Director

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DALHOUSIE UNIVERSITY
Inspiring Minds

Cover image: an OTN ocean monitoring Slocum Glider is launched near OTN headquarters in Halifax Harbour, Nova Scotia. Gliders collect oceanographic measurements and can be equipped with acoustic tracking devices to capture data from marineanimals carrying acoustic tags. Image courtesy of Richard Davis (OTN)

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NSERC CRSNG

Social Sciences and Humanities Research Council of Canada
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Canada