DALHOUSIE UNIVERSITY
Inspiring Minds

OCEAN TRACKING NETWORK Newsletter

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Exceptional Year Two

Year two, 2011, saw substantial progress made on all scientific projects and subprojects of the OTN Canada research Network, across all ocean Arenas. OTN Canada, of course, could not function without the tremendous support of the OTN Global Team toward achievement of our mutual and complementary goals. During 2011, OTN Canada focused heavily on increasing networking and delivering outcomes across research themes and Arenas and on applying our science to issues for oceans governance. The Network is dedicated to education and training, and at last count was supporting some 68 students and PDFs.

Our 1st annual OTN Canada Symposium was held in June 2011. It was a tremendous success and generated great momentum on research strategies, new innovations, collaborations, and partnering of projects and students. Workshops also trained participants on new technology, animal handling and tagging, data management, and data analysis and visualization tools.

The 2nd annual OTN Canada Scientific Advisory Committee (SAC) meeting was held in November, 2011. I am pleased to report that the critical reviews and evaluations of the 2011 annual project reports were very good and we are preceding full throttle into Year Three's (2012) research program!

Finally, together with OTN Global, we are chairing a special session: "Integrating Oceanography and Animal Tracking - the Ocean Tracking Network" at the large Ocean Sciences Meeting in Salt Lake City. We look forward to this exciting opportunity.

Sara Iverson,
OTN Canada Scientific Director

Building the Network

The 2010-2011 period was a building year for OTN Global in every sense. From this newsletter, you will see that we have built our operations team at Dalhousie University, built a significant portion of the OTN infrastructure, expanded our original collaborations and built new ones, developed new technologies and fostered the innovative use of existing technologies, and built a great deal of excitement about the science that the network will be and in some cases already is delivering. It is very gratifying to witness the momentum in the global science teams associated with the OTN.

All of this is happening due to the patience, perseverance, and hard work over the last year of the staff and partners of the OTN. I thank you all for sharing the dream. We are well on our way.

Fred Whoriskey,
OTN Executive Director

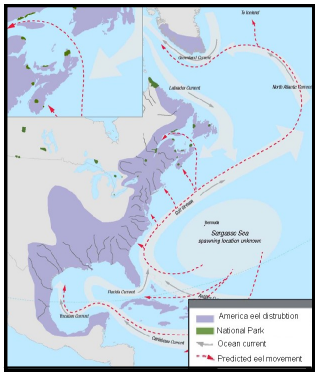
On behalf of the OTN Team, we wish to thank everyone for their efforts over the past year, and wish you all a great break over the holidays! Our very best wishes

Fred and Sara

Atlantic Arena Summary

Grey seal bioprobe collecting data on other marine animals and ocean conditions

Our diverse array of projects have made substantial progress towards achieving their goals, in large part due to the increasing interactions happening between projects and linking with work in the other Arenas. For instance, oceanography researchers are using the flow fields from their North Atlantic model to predict environmental conditions associated with American eel behaviour (e.g., preference for specific temperature ranges or latitudes) and their spatial distributions as a function of time. One aim here is to estimate spawning sites of this poorly understood species.



Estuarine and oceanic migration of the American eel – spawning location

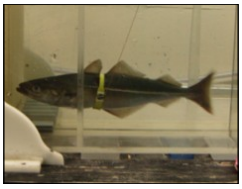
Data collected by grey seal "bioprobes" (carrying Vemco mobile transceivers [VMTs] and other tags) are being used in turn for input into oceanographic modeling, as well as for validation of initial ocean model outputs. Bioprobe data are also providing information on tagged salmon locations in areas where fixed receiver arrays are not present and are informing the Arctic and Pacific Arenas about VMT performance.

Accelerometry Monitors Fish Activity and Growth

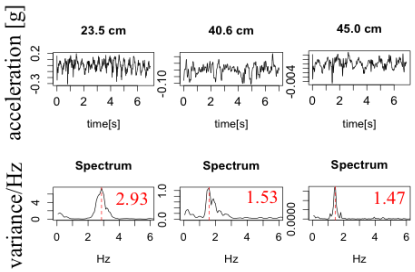
Our group focuses on the remote observation of fish locomotion, behaviour, and physiological characteristics in the wild using novel high-resolution (HR) archival accelerometer tags. Not only can accelerometry be used to quantify activity patterns and energy budgets of aquatic species, it can lead toward the estimation of growth rate in fish in their natural environment and its functional relation to *in situ* temperature.

Dalhousie University PhD student Franziska Bröll and MSc student Andrew Taylor attach an HR accelerometry tag to a shortnose sturgeon

To date we have developed tri-axial micro-accelerometer tags that record high-resolution (~550 Hz) acceleration, achieved in part via collaboration with our industry partner, Vemco. Preliminary analyses of swim trials in a flume tank (various speeds), using pollock of various sizes, demonstrate that the tail-beat frequency (TBF) spectrum (at constant velocity) scales with size (below). We are now analyzing the data to determine acceleration parameters that scale with size, regardless of current velocity.



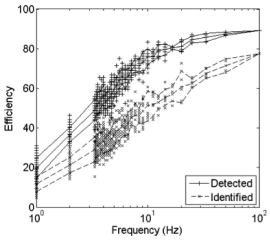
Pollock in flume tank with HR tag (left). TBF extracted by spectral analysis (below)



A new collaboration with Dr. Matt Litvak (OTN Canada Atlantic Arena) increased the scope of the accelerometry project. We are now developing a longer-duration accelerometer tag to be used with pop-up satellite technology for tagging Atlantic sturgeon in the wild. We hope to conduct similar studies on black marlin with colleagues in Australia.

Collaboration between Bröll and graduate students from Japan and England, working at the Friday Harbor Laboratories, Washington, has resulted in a manuscript soon to be submitted to *Ecological Methods* wherein it is shown that it is possible to detect fine-scale behaviour in the great sculpin based solely on acceleration signals.

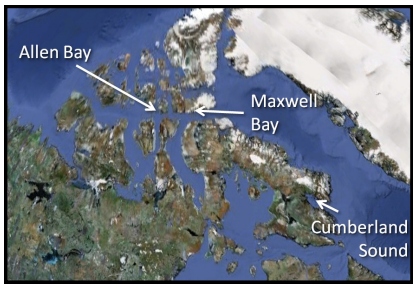
We also show that sampling at >30 Hz is essential to detect and identify great sculpin behavioural events when using accelerometers. A more agile species (salmon, swordfish etc.) may require even higher frequencies.



The research demonstrates that we are able to remotely monitor and identify complex behaviours – something not previously possible using conventional acceleration tags – and we conclude that studies using accelerometry in the lab or field must ensure appropriate sampling frequencies, likely 30 Hz or greater.

Arctic Arena Summary

Our research in Lancaster Sound (Allen Bay, Maxwell Bay) and Cumberland Sound combines technology development, fisheries, marine mammal, and oceanographic projects. Overall, 2011 fieldwork was highly successful.



Key Arctic Arena research areas

Interaction within the broader Network has led us to exciting cross-Arena activities

These interactions are exemplified in our oceanographic and Atlantic/Arctic salmonid movement research plans.

In Cumberland Sound, telemetry tags were deployed on ringed seals, Greenland halibut, Arctic skate, and Greenland sharks. Marine mammal surveys were conducted and biopsies collected. Also, an extensive array of acoustic receivers and oceanographic equipment was tested and deployed. This array represents the first extensive long-term acoustic monitoring study in the Arctic, which is critical given sea ice and large tides.

In Lancaster Sound, Greenland sharks were caught for the first time. Sharks were fitted with satellite and acoustic tags that will provide unique high-resolution data on the vertical diving profiles alongside concurrent work in Cumberland Sound.

Greenland shark tagging

Summer 2011 Field Work in Cumberland Sound

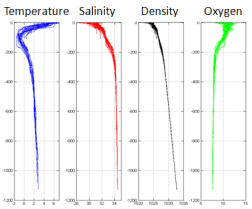
Graduate students and PDFs take a lead in the design and implementation of all Arctic research, including travelling to the Arctic to carry out the research. The following is a description of one student's experience and work.

Summer 2011 field work in Cumberland Sound. Jeanette Bedard, PhD student, U Victoria

Mid-summer found me on my way to spend six weeks in Cumberland Sound, Baffin Island, Nunavut, where we are conducting one of the first systematic oceanographic measurement programs in the Arctic aboard the new Government of Nunavut research vessel *The Nuliajuk*. Large, remote, and not-fully charted, Cumberland Sound has an irregular rocky bottom with deep pools extending past 1100 m separated by sub-surface ridges 200 m deep, and little is known about its physical oceanography.

Most of the summer's research aboard *Nuliaiuk* centered on fish. Greenland shark, turbot, and Arctic skate were tagged, measured, and studied by a diverse group of scientists from the OTN Arctic group, DFO, as well as Memorial University. To further our understanding about the local creatures, my project is aimed at investigating the physical conditions within the sound. My 2011 research focused on the seawater's properties. For data collection, I used a CTD profiler to measure salinity, temperature, depth, and dissolved oxygen by lowering the instrument through the water.

Most days started with pulling up the 600-hook fishing line and processing the fish, a task typically taking until early afternoon. Fishing was followed by 1-2 CTD casts. Re-baiting the fishing line took the rest of the afternoon and early evening; when the line was ready, it was deployed. This daily grind resulted in plenty of fish and 44 CTD casts. Near summer's end, a day was devoted to CTD casts in one location to capture changes resulting from tidal fluctuations.



CTD casts

Early in the field program, along with many acoustic receiver moorings, an oceanographic mooring was deployed. While we fished and casted, salinity and temperature data at 40-m intervals from the bottom (270 m) to 30 m below the surface were collected. The roughest day, with 5-m waves, turned out to be mooring recovery day. The ship's sonar located the mooring and we signalled it to release. As the mooring's orange float bobbed to the surface, I let out a sigh of relief – I would get plenty of data (which is never a sure thing with moorings). After securing the mooring on board, the ship waited out a storm in a sheltered cove. I downloaded the data and redeployed the mooring. With these data, the effects of environmental conditions on tag range and detection will also be examined.

Pacific Arena Summary

The Pacific Arena research program continues its focus on linking behaviour, environment, and physiology of Pacific salmon to better understanding their movement, migrations, and survival.

New findings are being used to inform management and conservation practices.

The program is facilitated through a broad network of investigators that spans several academic institutions (UBC, Carleton, UNBC), government groups (Pacific Salmon Commission, DFO Science Branch), non-government environmental groups (Pacific Salmon Foundation, Canadian Wildlife Federation, Vancouver Aquarium-POST), and private company partners (Kintama, LGL). Collaborations also span several disciplines, including behavioural ecology, physiology, genomics, epidemiology, oceanography, electronic engineering, and fisheries harvest management.

To date, research results have identified mechanisms for reducing mortality of fish that are released by fishers, identified locales of migration mortality, and improved our understanding of the important role of temperature and disease (river and now ocean) in movement and survival patterns.

Identifying Thresholds for Tag Size

Have you ever wondered whether surgical procedures for the implantation of electronic tags or the presence of the tag itself are detrimental to the animal being tagged?

This question should always be asked because tagging procedures or the tag itself can influence behaviour, health, or survival and in turn bias the data collected.

Alison L. Collins, MSc student, UBC

Several studies have challenged the 'rule of thumb' that tag burden (ratio of tag mass to fish body mass) should not exceed 2%.

To address this issue, we conducted a study to identify tag burden and tag size thresholds for salmon smolt. Over 250 hatchery-reared Cultus Lake sockeye salmon were transported to the wet-lab facilities at UBC, Forest Sciences Department, where they were implanted during their pre-smolt phase with one of three sizes of dummy acoustic tag to assess how tag burden (1.3-13.6%) influenced swimming performance, relative growth, survival, and post-surgical wound healing in freshwater and during initial stages in seawater. Tagged fish were compared with surgical shams (surgery but no tag implantation) and non-surgery control groups.

Fish with tag burdens ≥8% had shorter swimming durations than fish with burdens <8%, and fish implanted with the smallest tags had longer swimming durations than fish with the largest tags. We observed no effects on fish growth. Incisions associated with smaller tags healed more quickly than those with the largest tag. Mortality was nil when tag burden was <6%, and survival remained high (≥93%). Survival for all tagging treatments was ≥88% in seawater.

Based on our results, we recommend that tag burdens should not exceed 8% in juvenile, hatchery-reared sockeye salmon. Work is on-going to examine tag burden effects in wild juvenile sockeye salmon, which have different body shapes. These results provide our OTN team and other researchers with a scientifically defensible threshold for tagging, and enable us to retrospectively examine the conclusions of previous telemetry studies that have studied the migration survival and behaviour of sockeye smolt.

The Network Within

OTN is a global, distributed, ocean observatory headquartered at Dalhousie University and focused on the use of sonic and other telemetry technologies (satellite tags, archival tags) to document the survival and movements of marine animals, and the correlates of movements and survival with environmental conditions and changing climate. OTN Global was established as a Canada Foundation for Innovation (CFI) – International Joint Ventures Fund award to deploy Canadian designed and manufactured state-of-the-art acoustic receivers and oceanographic monitoring equipment in key ocean locations off continental coasts around the world. The Natural Sciences and Engineering Research Council of Canada (NSERC) supports OTN Canada, the largest national network of researchers that works with the OTN infrastructure across Canada's three oceans.

OTN also hosts a Data Warehouse that serves as a repository for data collected by OTN researchers, and is developing a web-based data visualization, analysis, and collaboration tool – the Platform for Ocean Knowledge Management (POKM). Ultimately, POKM will be a tool for all OTN researchers to access and query their tracking data, to conduct specialized analyses and visualizations, and to share data, analysis tools, and results across both the Canadian and Global Networks. Together, the mission of these three entities is to create a state-of-the-art, global scientific infrastructure to track the movements of marine animals, and show how these animals and their habitats are affected by the changing physical, chemical, and biological conditions of the ocean.

The OTN Team: Outer circle, clockwise from left: POKM: Ian Jonsen (Data Modeller); OTN Global Administrative Team: Ron O'Dor (Scientific Director), Margie Hall (Project Manager), Fred Whoriskey (Executive Director), Tracy Rounds (Administrative Assistant); Technical Team: Ian Beveridge (Technician), Duncan Bates (Technical Leader); Data Team: Susan Dufault (Data Manager), Brian Jones (Junior Programmer), Lenore Bajona (Portal Manager), Marta Mihoff (Senior Programmer), Bob Branton (Director). Middle: OTN Canada: Sara Iverson (Scientific Director), Daniela Turk (Network Manager), Shauna Baillie (Administrative Assistant), Susan Heaslip (Grad Student Coordinator).

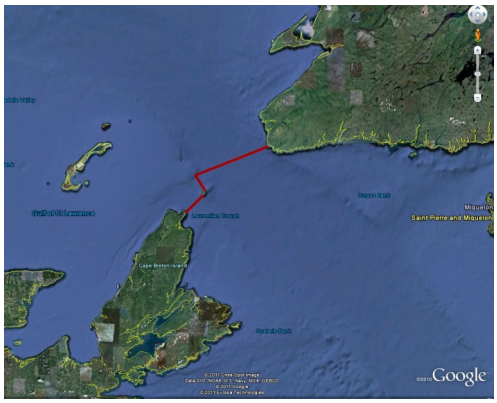
No component of this multifaceted Network could function without the contributions of the many other linked components, nor indeed without the great people that are the drivers behind this Network. It is only through OTN Global, OTN Canada, and POKM teams working together and integrating our programs and activities that we can aspire to become a world leader in the provision of high quality, open-access information on marine animal movements and their environmental drivers, to address serious global threats to marine biodiversity and the socioeconomic benefits that we derive from it.

OTN Expansion: Reaching Milestones in Acoustic Tracking

Expansion of OTN's scope has progressed dramatically over the last six months both close to OTN's home base in Atlantic Canada and on the other side of the globe.

Working in collaboration with the Atlantic Salmon Federation (ASF), in June, OTN added four VEMCO VR4 acoustic receiver stations to the ASF Strait of Belle Isle Line. Dubbed the SOBI Line, this acoustic array has been maintained by ASF every year since 2007. Receivers are generally deployed in the spring and recovered in late summer to track Atlantic salmon migration. OTN's VR4 stations will remain in place throughout the winter, greatly expanding the temporal coverage.

In other exciting news close to home, in October, OTN extended its Cabot Strait Line with 120 new VEMCO VR2W acoustic receiver stations, all the way to Cape Ray, Newfoundland. With a straight line distance of >100 km from its point of origin off Cape Breton Island, the OTN Cabot Strait Line may be the longest acoustic receiver line in the world.



OTN Cabot Strait Line: The longest acoustic receiver line in the world?

This line creates a continuous acoustic curtain across a potentially important migration route between the Gulf of St. Lawrence and the NW Atlantic Ocean, and it is hoped that this will help to clarify the migratory pathway and timing of migration of the elusive American eel.

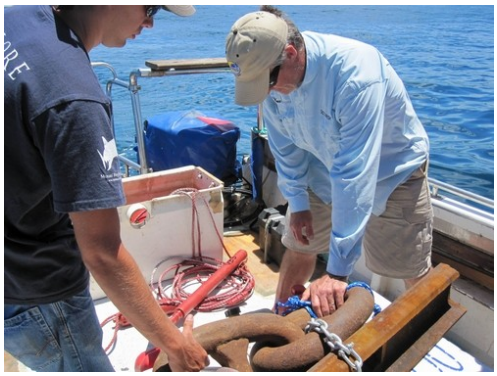
Also close to home, in November, four benthic pod stations were added to the Halifax Line at exisitng acoustic receiver stations. The Satlantic benthic pod consists of a VR4 receiver mounted together in a Romor CROM with oceanographic equipment that measures conductivity, salinity, temperature, dissolved oxygen, and depth to correlate with the animal detection data.

Elsewhere in Atlantic Canada, the recovery of OTN's Minas Passage Line, scheduled for mid-December, is eagerly awaited. The gear will have been exposed to extreme tidal currents for eight months, three months longer than the 2010 deployment. Other ongoing projects in the region are the Antigonish Harbour Trout Project (PI: Aaron Spares, Dalhousie PhD candidate) and Nova Scotia Southern Upland Salmon Project (PI: Edmund Halfyard, Dalhousie PhD candidate) as well as ongoing collaborations with OTN Canada sturgeon, eel, and grey seal research projects.

OTN continued its work in the Canadian Arctic with recovery and redeployment of the Cumberland Sound Array and the addition of a new line of 12 VR4s near the entrance of Maxwell Bay, Lancaster Sound. In addition to acoustic receiver stations, the Cumberland Sound Array has oceanographic monitoring stations and acoustic range detection stations. OTN Canada researchers have tagged Greenland shark, Greenland halibut, and Arctic skate in the area.

Finally, on the west coast of Canada, OTN collaborators at UBC deployed an array of 12 acoustic receiver stations in the Chilko River to track salmon smolts. Each station is equipped with both a 69-kHz and a 180-kHz VEMCO VR2W receiver. The 180-kHz frequency has allowed the development of smaller, lighter tags to track smaller animals.

In news from the other side of the world, November saw the completion of phase I of the OTN South Africa Array. OTN collaborator and Array PI Paul Cowley, from the South African Institute for Aquatic Biodiversity, deployed two receiver lines consisting of 20 stations in Algoa Bay and 14 stations in Mossel Bay off the south coast of South Africa.



Curtis Young and Paul Cowley attach receivers to steel mooring anchors

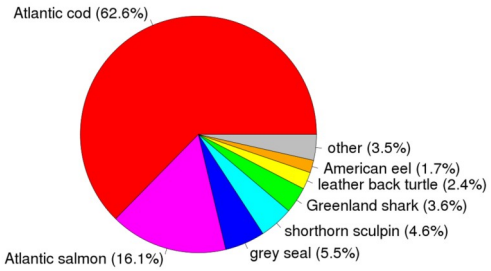
Phase II is slated for the first half of 2012 and will include a receiver line in False Bay to the west of the existing lines as well as several shorter secondary lines to the east.

OTN's first international line, the Perth Line off western Australia (PI: Rory McAuley, Western Australia Fisheries), has been operating since January 2009 with data retrieval and maintenance performed annually. OTN's reach will soon extend to the other side of that continent, with plans completed for the deployment of 72 receiver stations off Tasmania (PI: Barry Bruce, CSIRO).

OTN has also completed plans for a deployment off 24 acoustic receiver stations off Hawaii (PI: Kim Holland, University of Hawaii), and plans are well underway for the deployment of 31 receiver stations in the Strait of Gibraltar (PI: Miquel Canals, University of Barcelona) following an initial test phase.

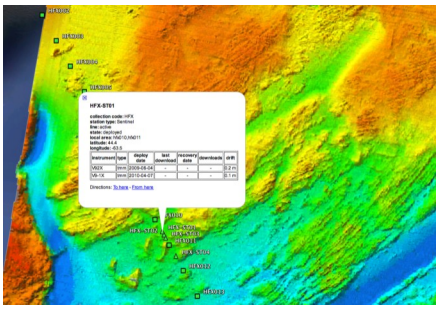
Data Discourse: The Importance of Collaboration

Since our last data update, the number of detection records in the OTN database has increased from 1 million to 5 million. The pie chart to the right shows detections by species, which are currently dominated by Atlantic cod as a result of the intake of data from Fisheries and Oceans Canada researcher John Brattey's long-term cod monitoring project off NE Newfoundland.



http://members.oceantrack.org/data/discovery/byspecies.htm

OTN's GoogleEarth "flyover," showing receiver stations using a variety of symbols and colors, is now operational, with popups of metadata extracted directly from the OTN database. The image on the left shows locations of sentinel tags on the Halifax line overlaid on multibeam bathymetry data from Natural Resources Canada. The popup shows the deployment history.



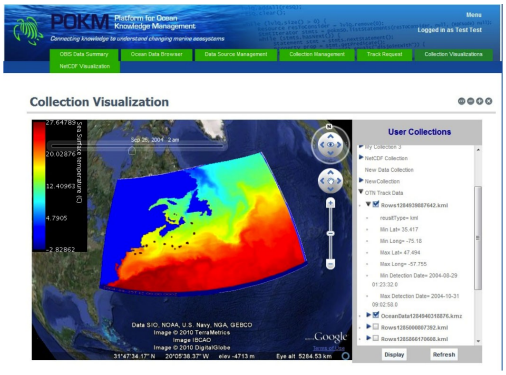
Follow this link to try it yourself:
http://members.oceantrack.org/data/google-earth-and-maps-products

Complete, accurate, and timely descriptions of instruments and associated field activities are critical to the reliability and success of large-scale scientific data processing systems like OTN. This was never more apparent than last year when, while processing detection files from Nova Scotia's Bay of Fundy, Marta Mihoff, OTN's database programmer, determined that multiple tags with nonunique sensor IDs had been deployed by different researchers in this area. After extensive consultation with Denise King at VEMCO, a procedure was developed that involves first matching pinger ID detections with known tag releases. The next critical step is to match these with sensor IDs, a task that is not possible without accurate tag technical specifications. VEMCO and OTN have collaborated to facilitate this process by creating the VEMCO Authorization Form, allowing VEMCO, upon your authorization, to provide an electronic copy of your tag sheet directly to OTN for loading into our database. An added benefit to researchers is that we can generate an OTN standard tagging metadata spreadsheet prefilled with your tag specifications in which you only need to provide details of the animals tagged and tagging process.

OTN encourages all researchers to complete and sign this form as soon as possible, check the "any and all purchases" option, and include the names of all people in your organization making VEMCO purchases. The form is available at http://members.oceantrack.org/data/data-collection/authorization-letter-to-VEMCO, and can be faxed (1-902-450-1704) or emailed to denise.king@VEMCO.com.

Data Visualization

OTN is collaborating with a multidisciplinary team of researchers (Computer Science, Marine Biology, and Oceanography) to develop an innovative E-Science platform that is providing web-based data- and knowledge-management services to the oceans research community. Led by Dr. Raza Abidi (Faculty of Computer Science), the Platform for Ocean Knowledge Management (POKM) is now accessible through the POKM web portal, offering a suite of E-Science services to (a) enable the selection and sharing of multimodal data collected from different geographic sites; (b) perform analytics and simulations, using complex models, to understand various phenomena such as the interactions between marine animal behaviour and biophysical properties of the ocean environment; (c) visualize multiple data layers at a geographic location and results of analytical models via various globe-based, 2D and 3D plots and animations; (d) publish analytical tools for use by the entire community of scientists; (e) interconnect research communities so that they can seamlessly interact and share data, scientific models, experiment results, knowledge resources, and expertise; and (f) enable researchers to design and execute complex analyses by composing specialized online workflows that automate routine aspects of data querying, manipulation, analysis, visualization, and dissemination. The POKM project is funded by CANARIE and it operates on CANARIE's high bandwidth network to handle high volumes of ocean data and to facilitate collaboration among marine scientists across the world.



POKM portal showing leatherback turtle tracking data overlaid on sea surface temperature data

First Smolts Released With Mini Geolocators

In May 2011, >200 Atlantic salmon smolts from Campbellton River, Newfoundland, were tagged using Lotek's latest generation of geolocator technology. The OTN-funded project was led by Dr. Ian Fleming of Memorial University's Ocean Science Center (OSC) in collaboration with Fisheries and Oceans Canada researchers David Reddin, Martha Robertson, and Peter Downton.

At 4.7mm x 8mm x 33.5mm and weighing 1.1g in salt water, the LAT2900 is a miniature descendent of the tag family that was successfully deployed in pelagic fish and seabirds in the Census of Marine Life's TOPP program. Using light-based geolocation, daily position estimates are derived and stored onboard the tag along with SST measurements. The tag was developed with support from ACOA's Atlantic Innovation Fund and the National Research Council's IRAP program.

Open ocean tracking of migratory salmon smolts presents a number of unique technical challenges beyond size reduction in tags. Long-term retention of geolocators has yet to be demonstrated for salmon smolts. The method used was evaluated through experiments on live fish at the OSC. A tethered attachment anchored below the dorsal fin was found to yield the least impact on the animals' health while accommodating growth at sea.

Returns to Campbellton River are expected in summer 2012. Any tagged salmon that return will represent a significant milestone in the collection of track data in areas separate from established lines. In the meantime, Lotek is continuing development efforts to further reduce the size of the tag.

Tech Talk: Advances in Remote Data Offloading

Considerable effort has been spent lately on investigating the characteristics and quality of acoustic communications with the VEMCO VR4-UWM in different environments. This can be affected by many factors including thermoclines, pycnoclines, ship noise, and bottom topography. We tested surface to seafloor acoustic modem communications in different environments around Nova Scotia and the Azores. Whether the water column was stratified or mixed, deep (500m) or shallow, or cold or warm, we successfully established communication with the VR4. Our next test deployment is planned for the Strait of Gibraltar. This is an exciting opportunity to assess VR4 communication and tag performance in a dynamic oceanographic environment.

Given the ability to reliably download receiver data from the surface via acoustic modem, the next step is to couple this capability with a remotely operated mobile platform. In October, OTN partnered with VEMCO, Romor, and Liquid Robotics to test this idea. Liquid Robotics has developed the Wave Glider (seen in the photo on the left), a fascinating vehicle that exploits the energy of waves for propulsion. The difference in wave amplitude between a surface float and a subsurface (7m depth) component propels the Wave Glider, and it can make headway in surprisingly calm conditions. The surface float boasts a solar array that powers communications and steerage as well as supplying a power budget for a host of other electronics and sensors. In theory, the Wave Glider could stay at sea indefinitely.

The results of our sea trials and communications testing were very promising. The glider demonstrated its ability to "fly" holding patterns near a receiver and to fly straight and true between stations. While maneuvering around a VR4 receiver, we successfully offloaded data at ranges up to 800m. This nears the efficiency of a deck box and dunking transducer, at least in the environment just offshore in Southwest Nova Scotia.

Our proof of concept testing involved controlling VR4 communications through the glider via a radiofrequency link from an accompanying vessel. Next steps will be to embed the communication protocols onboard the glider so that a pilot can oversee VR4 uploading remotely. This could save effort and money and reduce risks to crew for lines that are long, extend very far offshore, or are particularly remote, making the potential Wave Glider--VR4 combination an attractive option in some situations.

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