Ocean Tracking Network (OTN) Canada

Annual Reports Year 2 (2011)

NSERC Strategic Network Grants Program: NETGP 375118 – 08

S.J. Iverson et al.

"Understanding Species Movements, Interactions, and Environmental Variability across Canada's Three Oceans"

Index

Projects Page

Ocean Tracking Network (OTN) Canada Network Overview

1. Network Objectives

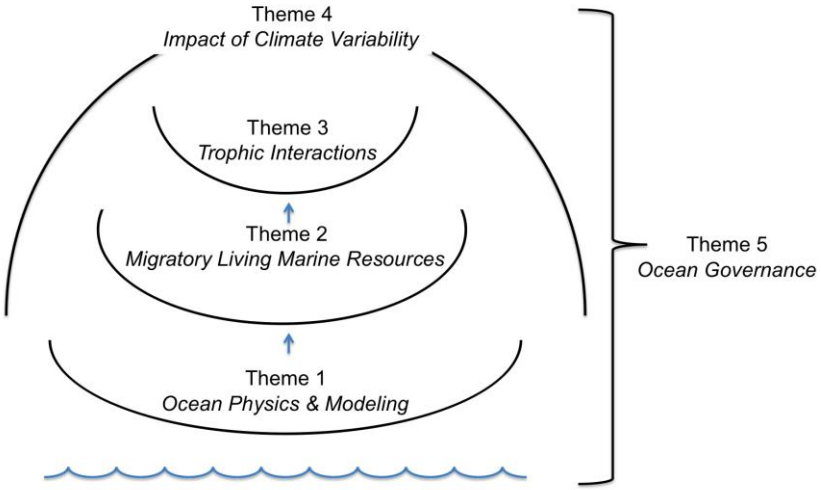
Overall objectives of the network

The paramount objective of the OTN Canada Network is to better understand changing ocean dynamics and their impact on ocean ecosystems, animal ecology, and ocean resources, with the aim to address critical issues in resource management and implications for ocean governance.

Within this context, OTN Canada has three overarching questions:
1) What are the physical, chemical, and biological oceanographic linkages that determine the population structure, dynamics, movement and critical habitat of marine organisms? 2) How will climate variability, change and anthropogenic activities affect the distribution and abundance of marine organisms? and 3) What are the ocean governance implications, including social, economic and legal dimensions, of OTN findings?

Under the umbrella of these larger issues, OTN Canada research will directly address one key, integrative question across the entire Canadian continent and its three ocean Arenas (the Atlantic, Arctic and Pacific): What are the movements of continental shelf marine animals, how do these movements affect species interactions, and what are the consequences of environmental variability/change and human activities on these species' distributions and abundance?

OTN Canada is organized around five key research themes within and across Canada's three Ocean Arenas (the Atlantic, Arctic and Pacific).



We are focusing our investigations on key species of interest and on sharing and integrating research strategies, expertise and emerging technologies to understand changing marine ecosystems across Canada. To assure comparison across the Arenas, included for each Arena are measurements of

oceanographic characteristics and variability at various spatial and temporal scales, movements of key species at several trophic levels, and analysis of key acoustic "bioprobes" (animals that carry tags which record locations visited, ocean conditions and interactions with other tagged animals) and "roboprobes" (remotely controlled gliders that measure physical, biological and chemical conditions) to complement measurements from fixed OTN curtains. Ultimately, information obtained will be exploited to address socioeconomic and resource management issues.

2. Progress and Integration of the Network

Substantial progress has been made on all scientific projects and sub-projects of the OTN Canada Network, both within and across Arenas. These are described in detail in each of the individual reports that follow the Network Overview.

Integration of the Network within and across Themes and Arenas has proceeded through directed workshops and meetings, data exchange and joint publications and presentations, plans for exchange of HQP, and integrated field exercises. As expected, most efforts in the first year and a half of a research Network must be to organize, populate, and develop a working strategy that will ensure the success of the individual scientific projects. However, the Network has already established substantial integration and networking strategies and outcomes.

2.1 Meetings/Symposium/Special sessions

First Annual OTN Canada Symposium in Halifax, June 2011

In June 1-3, 2011, we held the First Annual OTN Canada Symposium in Halifax, NS. The purpose of this symposium was to bring together all students, PDFs, and eligible PIs to present projects and results, discuss research strategies, and focus on integration of the OTN Canada Network and sharing of research tools and programs within and across Arenas. *A full description of this symposium follows below*.

The first day of the Symposium started with welcome and introductory remarks by S. Iverson. This was followed by keynote talks from three of the six Theme Leaders representing each of the three Arenas: K. Fennel (Atlanic), S. Hinch (Pacific) and A. Fisk (Arctic). These presentations were followed by an update of the social/legal projects by R. Apostle and D. VanderZwaag. Keynote talks were followed by 17 oral presentations by HQP from all Arenas that addressed a wide variety of topics including oceanographic modeling and observations, tracking migration of Pacific and Atlantic salmon, American eel, Atlantic sturgeon, Arctic skate, and grey seals. All presentations were impressive and demonstrated the high quality of research and great progress accomplished already in the first year of the Network program. Following the keynote talks, and in parallel with the HQP presentations, the first meeting of the partnership of core social/legal researchers was held, with attendance from participating natural scientists. Day 1 of the symposium ended with a late-afternoon/evening poster

and wine and cheese reception for both the natural and social scientists, primarily show-casing further HQP scientific research projects, but which also included social science posters and displays from OTN Canada industry representatives and collaborators Vemco, Satlantic and Lotek. This session was very well attended and fostered excellent interactions, new connections and increased interest in OTN Canada research from both OTN participants as well as the wider community attending Dalhousie Oceans Week.

The second day of the symposium consisted of five workshops. An Animal Tagging Workshop (led by S. Cooke and K. Murchie, with participation of Dalhousie's head veterinarian (Dr. S. Craig) representing the CCAC and issues of animal handling) and a Technology Workshop (led by R. Vallee and D. Webber) were held in the morning. The Oceans Governance Workshop (led by R. Apostle and D. VanderZwaag) continued to run in parallel, but this session focused on participation of the natural scientists, issues of concern, and moving forward with plans for Theme 5; key case studies were identified and investigators targeted for putting together chapters for a planned book or dedicated journal issue. In the afternoon, the social/legal scientists joined the natural scientists for a Data Visualization Workshop (led by I. Jonsen and J. Mills Flemming), followed by a Data Management Workshop (led by B. Branton and L. Bajona). All workshops were very well attended, interactive and raised a number of new questions and ideas and ways to move forward. The Animal Tagging Workshop covered topics on the importance of pre- and post-operative care, choice of anesthetics, sterilization, wound closure, tag size relative to fish size, and training. The workshop also explored the role of veterinary professionals in tagging studies and discussed more generally the ethics and practice of tagging animals including marine mammals and invertebrates. Dr. S. Craig gave a presentation summarizing the issues that need to be considered in terms of meeting the requirements of the CCAC (Canadian Council of Animal Care) and institutional animal care committees. Her discussion was well balanced in that it addressed the 3Rs (reduction, refinement, replacement) pertaining to animal use, but also incorporated an understanding of the unique difficulties of fieldwork. OTN Canada is working to create a summary document of the powerpoint presentations from this workshop to post on the website to serve as a stand-alone reference and guide for all OTN animal users. The Technology Workshop featured presentations from Vemco and Lotek and discussions on passive and active acoustic technology, how to use the equipment effectively, as well as problems regarding deployment methods, experimental design, and identifying unknown codes. The Data Visualization Workshop introduced OTN Canada researchers to a new web-based environment for scientific collaboration, data visualization and analysis: the Platform for Ocean Knowledge Management (POKM) and explored the various data analysis and visualization needs of OTN Canada researchers. The Data Management Workshop outlined the who, what, when and where of OTN data management, with particular attention to roles and responsibilities of OTN Canada collaborators regarding preparation, uploading, viewing and downloading of collection metadata, instrument log files, detection records and discovery metadata. The latest OTN Website and Portal features were also demonstrated. The Oceans Governance Workshop began with a short summary and discussion of the previous day's discussions followed by the consideration of the various ways social sciences can utilize and benefit from OTN products. Natural scientists were invited to provide their reviews on possible case studies for inclusion in the planned book/journal issue.

On the second day, OTN Canada students also held a lunchtime meeting. After S. Iverson provided introductory remarks and potential ideas and examples for their directions, the HQP met alone and

brainstormed about the ways in which they could most benefit from the Network (training, communication, website profiles, etc.). They discussed ways of improving interactions and networking, such as establishing a student forum, additions to the OTN Canada web site that would be dedicated and maintained by students (e.g., newsfeeds, listserve, FAQ), visits and student exchange between the different labs etc. The possibility of workshops was addressed and some of the topics suggested included: data analysis and experimental design, the use of software (e.g. POKM) and the opportunity to observe surgical techniques and tag placement. In addition, student contacts for each arena were established: Jordan Matley for the Arctic, Susan Heaslip for the Atlantic, and Alison Collins for the Pacific.

The third and last day of the symposium was devoted to a networking session led by S. Iverson and assisted by a panel of the Theme Leaders present (K. Fennel, I. Jonsen, S. Hinch, S. Cooke, A. Fisk). The session started with S. Iverson outlining the objectives of the session, emphasizing the importance of integration both within and across Themes and Arenas, how best to achieve this, and how best to demonstrate successes. This was followed by a presentation by Atlantic student representative S. Heaslip summarizing the student lunch meeting (see above). Comments from the panel and audience followed. K. Thompson suggested that the new annual reports begin to incorporate a component from the HQP summarizing their work, interactions, and communications. Students were very enthusiastic about this with regards to this additional networking and organizing opportunity, especially given the difficulty that sometimes arises when communicating through their supervisors. B. Hatcher proposed the idea to students to form their own research hypotheses independent of PIs and to present them to the Network. S. Iverson added that the secretariat could facilitate conference calls for students. S. Cooke proposed the potential participation of students in graduate courses at different institutions. D. Turk suggested the potential of planning an International OTN summer school in later stages of the Network, possibly with OTN Global and including international lecturers. J. Cullen also stressed the extremely important roles of many technical staff in the work and training of HQP, and the encouragement to include technical staff activities in the annual reports. The session continued with short presentations from each individual project leader on their current and envisioned integrations with other projects and ways of presenting such information in annual reports. C. Taggart and S. Iverson highlighted the importance of documenting deliverables (i.e. outcomes other than publications) to granting agencies for Networks and C. Taggart volunteered to produce a template for reporting on these, which would help facilitate the ongoing documentation of events for annual reports. One of several international conferences in 2012 were suggested as good venues for presentation of OTN Canada research and interactions with the international community – in particular, a special session entitled “Integrating Oceanography and Animal Tracking- the Ocean Tracking Network” had then been submitted (by S. Iverson, D. Turk and several OTN Global members) to be held at the 2012 Ocean Sciences meeting, 20-14 Feb, Salt Lake City. (*Addendum: this special session has now been accepted and abstracts submitted; final planning is underway*.) The symposium ended with concluding remarks from S. Iverson, and very positive comments from attendees on the scope, outcomes and organization of the event. It was emphasized that this symposium provided one of the first opportunities for many of the HQP to meet, as well as the first time for some of the PIs to meet each other. A lot of excitement and momentum was generated as a result.

Most of the networking ideas discussed are already being implemented and are included in the following sections of this report.

Special session at the ocean Sciences Meeting 20-24 February 2012

We received 20 submitted abstracts (8 from OTN Canada researchers) for our accepted session: "Integrating Oceanography and Animal Tracking - the Ocean Tracking Network" for the Ocean Sciences Meeting (a large venue for scientific exchange across broad marine science disciplines, co-sponsored by AGU, ASLO, TOS) in Salt Lake City. This will be an exciting opportunity to introduce OTN to a very large group who may be largely unaware of OTN.

2.2 Joint research, publications/presentations and data exchange

Selected examples of the activities within and among Themes and Arenas are highlighted bellow as illustration of the integration and networking that has been initiated. More extensive lists are contained in the individual reports.

Atlantic 1 and Atlantic 2-4

- Research has recently been carried out by principal investigator K. Thompson and Dalhousie graduate student S. Shan (project I.1.3) on using the flow fields from the large-scale North Atlantic model to examine the effect of animal behavior (e.g., preference for a specific temperature range or latitude) on their spatial distribution as a function of time. This work is motivated primarily by project I.2.2 (Estuarine and oceanic migrations of the juvenile and reproductive stages of the American Eel). Specific goals are to estimate spawning sites and also animal behavior from the model flow fields and knowledge of the spatial distributions of the marine animals. A presentation on ways of modeling the migration of the American eel from the St. Lawrence River to the Sargasso Sea will be given at the Ocean Sciences meeting in 2012 by M. Beguer.
- Atlantic project I.1.2 PIs and HQP met with PIs and HQP of project I.2.4 and 1.2.5 *Biopobes and Design Principles* to discuss the use of bioprobe data (specifically, the temperature, depth and salinity ocean profiles being collected by the tagged grey seals) for input into oceanographic modeling as well as the transfer of first sets of ocean model outputs (course resolution) to the I.2.4/5 investigators for interpreting animal movement and foraging. A joint abstract based on this work was submitted for presentation at the Ocean Sciences meeting: Iverson, S.J.; Lidgard, D.C.; Bowen, W.D.; Jonsen, I.D.; Mills Flemming, J.Fennel, K., "Bioprobes and receivers in the Ocean Tracking Network (OTN): Grey Seals as biological and oceanographic samplers".

Atlantic 2-4 and Social/Legal

- The Atlantic eel project (I.2.2) is collaborating with social scientists and lawyers (IV, Theme 5) within OTN who are working on the governance dimensions of the eel fishery. Following a summer meeting between J. Dodson and R. Apostle, they initiated a search for information to build a socio-economic impact assessment of eel restoration measures and actions taken by countries having habitats for eel.

Pacific, Atlantic 2-4, Arctic, Social/Legal

- One of the key among-Arena activities led by one of the Pacific Arena PIs was the development and submission of a paper to a high profile fisheries journal that summarizes the objectives and players in OTN Canada for an international fisheries audience. Co-leader for the Pacific Arena (S. Cooke) was lead on this paper. S. Cooke assembled a team of OTN coauthors from across the country and together with S. Iverson co-led the team in the development of an interdisciplinary perspective on OTN Canada - this paper represents one of a series examining networks of research within Canada. Cooke, S.J., S. J. Iverson, M. J.W. Stokesbury, S. G. Hinch, A. T. Fisk, P. Smith, D. VanderZwaag, J. Brattey and F. Whoriskey. 2011 Ocean Tracking Network Canada: A network approach to addressing critical issues in fisheries and resource management with implications for ocean governance. Fisheries. In press.
- S. Cooke (Pacific Arena) worked with A. Fisk (Arctic Arena) and S. Hinch (Pacific) to develop a presentation called "To tag or not to tag – ethical and stakeholder perspectives on animal tagging" given at the 1st International Conference on Fish Telemetry, Sapporo, Japan. This presentation is intended to be developed into a paper for the SSHRC special journal issue being led by D. VanderZwag and R, Apostle (Dalhousie).

Pacific and Atlantic

- T. Clark (Pacific Arena) provided acceleration data collected using biologgers on sockeye salmon to F. Broell (Ph.D. student at Dalhousie in the Atlantic Arena, I.1.1) to facilitate the development of algorithms for measuring fish growth via acceleration data. Additional biologger data are currently being collected by G. Raby (M.Sc. student, Pacific Arena) on coho salmon and that will also be shared with Ms. Broell. The students have been interacting via email and telephone and it is anticipated that there will be a lab exchange within the next year. Largely as a result of interaction at the June 2011 Symposium, F. Broell also began collaborations with investigators from the Atlantic sturgeon project (I.1.3) to apply the novel research under I.1.1 to sturgeon and was given to opportunity to conduct field work with the sturgeon team in the summer of 2011.

Arctic and Atlantic 2-4

- Preliminary discussions with OTN-Atlantic collaborators I. Fleming and F. Whorisky on collaborative research on Atlantic salmon and arctic charr interactions were initiated. Fisherman are reporting Atlantic salmon in northern Quebec rivers where previously only charr were caught. Plans for a new OTN acoustic line in northern Labrador to monitor charr and salmon, and tagging of these species in this area, are being planned. Arctic charr project will span the Canadian Arctic and into the northern reaches of the Atlantic region.

2.3. HQP exchange

Again, a few examples of HQP exchange are highlighted bellow with more extensive lists contained in the individual reports:

• M. Beguer (HQP, I.2.2 American eel project) from the Université Laval will spend time at Dalhousie (with K. Fennel's group, project I.1.2) in fall 2011 to become more familiar with model products and gain basic modeling skills directly applicable to her project.

• S. Cooke hosted a M.Sc. student from the Atlantic Arena (from the M. Stokesbury Lab, project I.2.3) to learn blood sampling of sturgeon and field physiology techniques. S. Cooke has also shared equipment with the student and is participating on the academic committee of the student.

3. Training of Highly Qualified Personel (HQP)

The following table summarizes the HQP who have been supported by the Network during Oct 2010-Sep 2011.

Table 1. Summary of the number of Highly Qualified Personnel (HQP) trained within the scientific program of OTN Canada by Arena.

	Atlantic Arena		**Arctic Arena**		**Pacific Arena**	
HQP	**Total**	Supported completely by grant	**Total**	Supported completely by grant	**Total**	Supported completely by grant
Undergraduate	10	6	1	1	3	2
MSc	9	6	3	3	7	4
PhD	11	5	2	1	5	3
Post-Doctoral Fellows	6	3	4	1	3	1
Research Associates	3	2	-	-	1	1
Technicians	6	1	1	-	5	-
Total	**45**	**23**	**11**	**6**	**24**	**11**

The integration of research activities among projects within and across Arenas from University, and Government Agencies has proven to be invaluable in terms of allowing HQP access to varied expertise across multiple fields of ocean sciences. The Networking Session of the OTN Canada June 2011 Annual Symposium also provided an impetus for future activities. Appendix A, assembled with the assistance of S. Heaslip (Atlantic student representative and project I.2.4), provides a complete summary of student names within projects and examples of work within the Network. Complete descriptions of HQP involvement are contained in the individual project reports.

4. Participation of key partners

Government.

The involvement of Department of Fisheries and Oceans (DFO) occurs in all levels of research and

coordination, including the transfer of research results within the Network and to the general scientific community. DFO has two voting members (A. Vezina, DFO representative, and S. Vagle, Arctic Arena representative) on the SAC and ten of the twenty-eight Network PIs are university adjunct professors from DFO. Since many of the DFO scientists that are either co-PIs or collaborators are also adjunct faculty, they have a significant involvement in both student and postdoctoral training. The details on involvement of partners in individual projects are described in section 10 of each individual report.

There has been a concern in the Network regarding the limited DFO travel permission to attend OTN Canada meetings, as several key DFO investigators in the Network were unable to attend the OTN meetings because they did not receive travel authorization or support. Unfortunately, this will be on ongoing issue, given DFO's fiscal situation and the Network's inability to provide travel costs for DFO through NSERC funding. Nevertheless, the contributions made by DFO investigators have been, and continue to be, absolutely critical to the progress and success of the Network and its research programs.

Canadian Foundation for Innovation (CFI).
None of the research programs of the OTN Canada Network could take place without the significant contribution of infrastructure support from CFI. The OTN Global Network, through the CFI funding, has in fact bent over backwards to make OTN Canada work – through deployment of fixed receiver arrays throughout areas of the Atlantic, Arctic and Pacific Arenas and according to the needs of the OTN Canada PIs, through the purchase of acoustic tags and use of gliders, through the servicing and uploading of data that must be obtained from receiver lines, and finally through access to the data management support that is part of the infrastructure.

Industry.
OTN Canada has a number of industry collaborators. These industry collaborators, such as Vemco, Satlantic, Kintama, Lotek, and others, have been integral in helping it solve problems, develop new technology, construct needed equipment, and brainstorm about better ways to use it. Examples are many and are included in individual project reports, but include working with OTN PIs to miniaturize tags and subsequently test their success, to allow deployments in the smallest fish to date (salmon smolts, I.2.1) and collaborating with bioprobe PIs to develop the next phase of Vemco Mobile Transceiver (VMT) tags. Through discussions with VEMCO and the Sea Mammal Research Unit (SMRU), St Andrews, Scotland, work has begun to develop a VMT that can communicate, via Bluetooth technology, with a satellite tag for transmission of detection data and thus eliminate the need to recover tags. This would make it possible to use VMT technology in the Arctic and Pacific Arenas, where it is not possible to recover tags on large bioprobes.

Universities and other research institutions.
The many universities and research institutions with whom the OTN Canada PIs and collaborators are associated provide the further infrastructure and support, including personnel support, to conduct the Network's research, sponsor HQP, and host various other activities. These are apparent throughout, and detailed in, individual project reports.

5. Dissemination and other contributions

Publications and presentations.

See individual reports for details.

Newsletter and Web site.

Jointly with OTN Global we are producing a bi-annual OTN Newsletter. The first addition was completed in June 2011 and distributed to OTN Canada and Global researchers at the 1st OTN Canada Symposium, to a wider audience at the Dalhousie Oceans Week events, to our sponsors and collaborators, and relevant Dalhousie and other university departments. The newsletter was very well received. Work on the 2nd combined newsletter for OTN Global and OTN Canada is underway and with the plan for it to be issued with the holiday season in December.

The OTN Canada website (otncanada.org) has been an important source of information for OTN Canada researchers and Global community. It continues to be populated and expanded. Students and other HQP are working on substantial improvements for HQP presentations and exchanges.

Data management/sharing.

It is OTN's intention to publish all Discovery Metadata on a web portal that is currently under development. The OTN Canada metadata can be found online at http://members.oceantrack.org/data/discovery/new2/OTNCanada.htm. This metadata allows data to be discoverable via the internet and provides users with a contact point to learn more about the data. The metadata will also be used in things like the GoogleEarth application. Further information on OTN Data Policy is available online (http://www.marinebiodiversity.ca/OTN/policies/otn-data-policy-ver-11-oct-30).

A Data Management workshop was held at the 1st OTN Canada Symposium in June 2011, led by Bob Branton and Lenore Bajola**.** The workshop focused on who, what, when and where of OTN data management, with particular attention to roles and responsibilities of OTN Canada collaborators regarding preparation, uploading, viewing and downloading of collection metadata, instrument log files, detection records and discovery metadata. The latest OTN Website and Portal features was also demonstrated. Given that data are just now really beginning to flow in through OTN Canada's research programs, this will be a major focus for organization in the next year.

Other contributions and deliverables.

The OTN Canada Network as a whole has made huge contributions to various outputs such as productions of webpages, radio and television appearances, and documentary filming. There have also been many outputs of newspaper and magazine stories, technical reports, invited conference and

public presentations, and input into public advisory meetings and documents, including providing expert advice and consultation. PIs have also used OTN Canada research programs to leverage additional funding support through submissions of new proposals for complimentary funding, student support, and access to new technologies and research spin-offs. These are far too numerous to describe here and are detailed in the individual reports which follow.

6. Changes, Reprofiling, and Delays

Deviation from the original overall research objectives.

There have been no significant deviations to the overall objectives of the Network. Within the specific projects, adjustments have been made where required to maximize the productivity toward stated goals (in response to new personnel expertise and changes in logistical support). Many projects experienced some initial delay in recruiting suitable graduate students and post-doctoral fellows, but these are now well underway.

SAC and TLC composition change

*Science Advisory Committee (SAC)***:** It became clear after our first year's experience with OTN Canada that we needed to streamline parts of our management structure. The primary concern is over the amount of administrative burden and number of required research decisions currently placed on the three Arena leaders. This was discussed with both CFI and NSERC, within the OTN Management Committee, and with the Chair of the SAC. The SAC structure was altered to include two co-leaders for each Arena, instead of a single individual. The co-leaders both sit as voting members on the SAC - and have equal say and control in the directions and fund allocations of their Arena. This provides continuity in case a theme leader has to step down, and divides the workload into something more manageable. It is also more inclusive, which should improve performance and communication within each Arena. SAC member Terry Dick (U Manitoba) has officially resigned from all OTN Canada (and Global) activities and has been replaced by Svein Vagle (U Victoria, DFO-IOS). The current composition of the Arena leaders on SAC includes two members from each Arena representing 6 institutions: Atlantic: Ian Fleming (Memorial) and Katja Fennel (Dalhousie), Arctic: Aaron Fisk (U Windsor) and Svein Vagle (U Victoria, DFO-IOS), Pacific: Scott Hinch (UBC) and Steve Cooke (Carleton U).

Theme Leaders Committee (TLC): I. Jonsen stepped down from the TLC due to his current research commitments and I. Flemming is appointed as acting member from the Atlantic arena.

Reprofiling and Budget Implications

As recommended by the SAC, we have established a Reprofiling Sub-committee to deal with ongoing changes to programs and funding, projects facing problems, and to make recommendations on these to the SAC. "Reprofiling" is meant to encompass issues, such as investigators proposing a deviation of >20% of their approved budget, investigators who have proposed to conduct certain work but are not performing this work, Arena Leaders or the Theme Leaders Committee (TLC) raising concerns about the progress of specific projects and suggesting possible solutions or new directions.

This Sub-committee is comprised of a core of three members (currently A. Fisk (chair), J. Cullen, and S. Hinch) to be supplemented with additional specific expertise as needed. If one of the three members of this committee is the requester, NSERC has approved that S. Iverson serves as their replacement on the committee for that request. The committee would be called to meet only as issues and needs arise. The committee will review, make recommendations, and report to Sara Iverson, the OTN Canada Scientific Director, who will then report to the SAC and NSERC. In this manner due process should be carried out in fairly making any such decisions.

Two requests were received during the 2011 report year by I. Flemming and A. Fisk and were unanimously approved by the Sub-committee and the SAC. In submitting budgets and justifications for approval for yearly budgets during the time of annual reports, such requests will necessarily be a part of the SAC's review and approval of the projects' budgets. The most significant of these will be the reallocation resulting from T. Dick's resignation from OTN activities. A Fisk (U Windsor) has stepped in as replacement for T. Dick on OTN Council, and S. Vagle (U Victoria, DFO) has stepped in as 2nd Arctic theme leader and SAC member. All of the funds T. Dick has held at U Manitoba and proposed in the future will be held and managed by A. Fisk at U Windsor (pending approval by the SAC), but with the planned Arctic program to essentially remain in place, and in fact should run more smoothly. All Arctic PIs are working very closely together to make this happen.

Technical issues

As the equipment issues can be a significant difficulty (e.g., delivery, malfunctioning, etc) in some of the projects, the SAC and NSERC recommended the establishment of a technology Sub-committee that will monitor, inform and advise researchers on issues and developments related to technology. The technology Sub-committee of the SAC is now established with the following membership: M. Stokesbury (chair, Atlantic), S. Vagle (Arctic), and S. Cooke (Pacific). Due to perceived potential conflict of interest and for consistency with the involvement of other industry collaborators. A Technology Workshop was held at the 1st OTN Canada Symposium in June 2011 to help increase the awareness of technology and issues. Technical issues are addressed within each individual project's annual report.

SAC also discussed the possibility of a dedicated person at VEMCO who would be available to answer technical questions from researchers during field experiments. However, VEMCO currently does not feel the need to dedicate a person to this, as there seem to be few issues with their support regarding equipment failure, and when there is, it is always treated on a case-by-case basis. VEMCO should be notified via email about the timing of equipment testing, so their representative can be ready to help if issues arise.

Atlantic Arena I.1.1

1. Project Number: I.1.1

2. Project Title: Integrated Interdisciplinary Observing and Modeling Platform – Observing Component

3. Project Leader(s): John Cullen (Dalhousie), Christopher Taggart (Dalhousie), Peter Smith (DFO)

Collaborator(s): Blair Greenan (DFO), Dave Hebert (DFO)

4. Training of Highly Qualified Personnel:

a) List of the HQP and level of their salary support by SNG.

Personnel	*Title*	*%Time involved in project*	*%support from SNG*	*Dates*
Mathieu Dever	PhD	100	100	1 Jan 2011 – 30 Sep 2011
Matthew Beck	MSc	100	100	1 Oct 2010 – 30 Sep 2011
Adam Comeau	Research Technician	100	100	1 Oct 2010 – 30 Sep 2011
Richard Davis	Research Technician	75	0	1 Oct 2010 – 30 Sep 2011
Jon Pye	Research Technician	75	0	1 Oct 2010 – 30 Sep 2011
Franziska Bröll	PhD Student, Oceanography	100	100	1 May 2010–30 Sep 2011
Andre Benzanson	PhD Biomedical Engineering	10	see below	1 Sep 2010–30 Sep 2011
Amy Ryan	RA	25	0	1 May 2011–31 Aug 2011

Clarification: Richard Davis and Jon Pye are provided considerable support from OTN CFI funding (see Sec. 10b).

b) Explain the role, activities and opportunities for training of technical staff in your project.

Mathieu Dever is a PhD. Student jointly supervised by Drs. Jinyu Sheng, Peter Smith, Blair Greenan, and David Hebert. His role is to assemble, process, validate and interpret physical data from the Halifax Line, for ultimate comparison with contemporaneous biological and fish detection data.

The Ocean Glider Group focused its efforts on the development of procedures for routine deployment of the three ocean gliders, delivered November 2011. This required a great deal of training and the development of many procedures, including instrument preparation and calibration, software development, and logistics (including facilities and techniques for deployment and recovery). Troubleshooting was also an important component of the work. Team members encountered and met many challenges, developing potent capabilities in the process.

Richard Davis is the lead technician for the glider component. His primary role is to ensure that all safety procedures are followed in the lab and aboard vessels, minimizing the chance for injury. Other activities include supervising Adam Comeau and Jon Pye, overseeing data analysis and providing quality control on collected data, requisitioning and purchasing equipment, coordinating activities with other research groups, managing the budget, and training graduate students. Adam Comeau is the primary field technician. He maintains and operates the gliders, maintains and operates the OTN Zodiac boat, maintains and operates field equipment, and performs data analysis. Jon Pye is an Information Technology specialist. He creates and maintains databases, creates and maintains websites, programs missions for the gliders, and maintains computer hardware. Graduate student Matt Beck became involved with day-to-day activities of the glider group once his classes were completed in the spring of 2011 and he is developing software skills as well as gaining technical familiarity with the glider systems. Overall, the group is developing a capability that is central to modern oceanography and all involved are gaining the skills and knowledge to help others to use this research approach.

Ryan was trained by Bröll to assist in the fish tagging procedure and conducting flume-tank accelerometer trials on pollock during the summer of 2011 and played a crucial role in laboratory data collection using storage and tether accelerometer tags, especially while Bröll was studying and carrying out acceleration experiments at the Friday Harbor Laboratories at University of Washington.

Benzanson has been responsible for electronic design and construction of our HR-tether and HR-archival tags. It is not possible to calculate his percent support.

5. Progress towards Objectives/Milestones (1 Oct 2010 – 30 Sep 2011)

a) Please provide brief description of the overall objectives of this project (max ½ page).

The overall objective of this project is to provide observations in support of a general purpose observation/modeling platform that will provide historical reconstructions of the time-varying, 3D physical, biological and chemical conditions of the ocean and projections of future states. In Phase I, the project focuses on the northwest North Atlantic Ocean and adjacent continental shelves. The reconstructions will be used to interpret the movement of marine animals monitored by OTN's acoustic receivers, and also project how their movement may change in the future. In addition to this

observing project, the theme contains of two other components: 2) integrated modeling and 3) data assimilation.

The main objective of this component is to develop and calibrate new ocean observation technologies, including interdisciplinary sensor systems on ocean gliders and accelerometers on fish as a powerful and cost effective capability for surveying essential physical, chemical, biological and ecological processes and interactions in coastal waters and shelf seas. It will also provide validation data sets for the integrated modeling component and time series for data assimilation. In Phase I this component will:

(1) Develop a system for integrating bottom pod, ADCP and glider data to provide a physical description of the system;

(2) Develop procedures for deploying gliders and obtaining optical data products;

(3) Develop new optical data products to provide biological and physiological information;

(4) Develop new approaches to modeling biological-optical-physical interactions;

(5) Validate that acceleration metrics in a fish are a function of size-at-time;

(6) Determine key parameters from the acceleration frequency spectrum and/or other relevant statistics that scale with size at age;

(7) Demonstrate that similar acceleration metrics will provide estimates of activity of marine animals (fish, sea turtles, seals etc.).

(8) Demonstrate that acceleration metrics will provide *in situ* estimates of feeding activity and energy budget estimation.

b) Describe progress towards meeting the project's objectives and specific milestones for the project.

HEADER KEY

OO: Ocean observations **OG: Ocean gliders** **AC: Accelerometry**

OO:

Mooring data: Three OTN moorings, carrying ADCP (current profiles) and MicroCat (T,S,O_2) sensor systems and spanning the Nova Scotia Current (100-180m isobaths), have been deployed on the Halifax Line continuously since April 2008. Since that time, data recovery from these instruments has exceeded 93% overall, with roughly the same amount of data loss from each instrument type.

ADCP analysis: HQP Mathieu Dever has performed the initial processing of the ADCP data, including tidal analysis, rotary cross-correlation between currents and wind observations in Halifax Harbour and

on Sable Island, and transport time series from selected portions of the record interpolated across the array. As expected, the annual transport record (Fig.1) shows maximal negative values in December/January, despite exceptionally high variability.

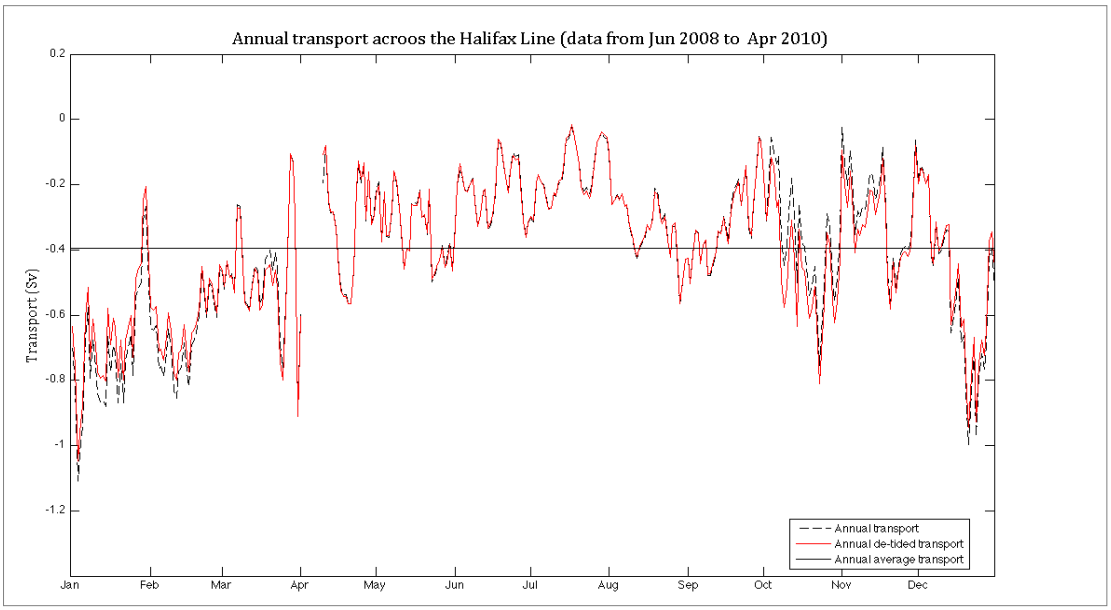


Figure 1: Annual transport time series across the Halifax Line using data from June 2008 to April 2010. The transport is consistently negative (i.e., to the SW) with an annual average value of roughly -4X10^5 m^{3}s^{-1}.

OG:

Four project personnel (the Dalhousie glider group: Matthew Beck, Adam Comeau, Richard Davis and Jon Pye) attended a 4-day training class at glider manufacturer Teledyne Webb in late October 2010. Immediately after, they travelled to Rutgers University and spent a day with the highly experienced glider team there, gaining valuable insight and establishing a working relationship.

Two Teledyne Webb slocum gliders were delivered in November 2010.

High quality space provided to the Dalhousie glider group by BIO was refurbished and equipped to act as a laboratory for glider ballasting.

After extensive preparations, field trials of the two gliders started in March 2011, consisting of several days operating the gliders in Bedford Basin.

The first successful operational deployment of glider 200 started in June 2011, with 4 missions following until end of September 2011.

During this period, development of procedures for data management and analysis began, and the group is now producing plots of results from glider transects (Fig. 2a,b).

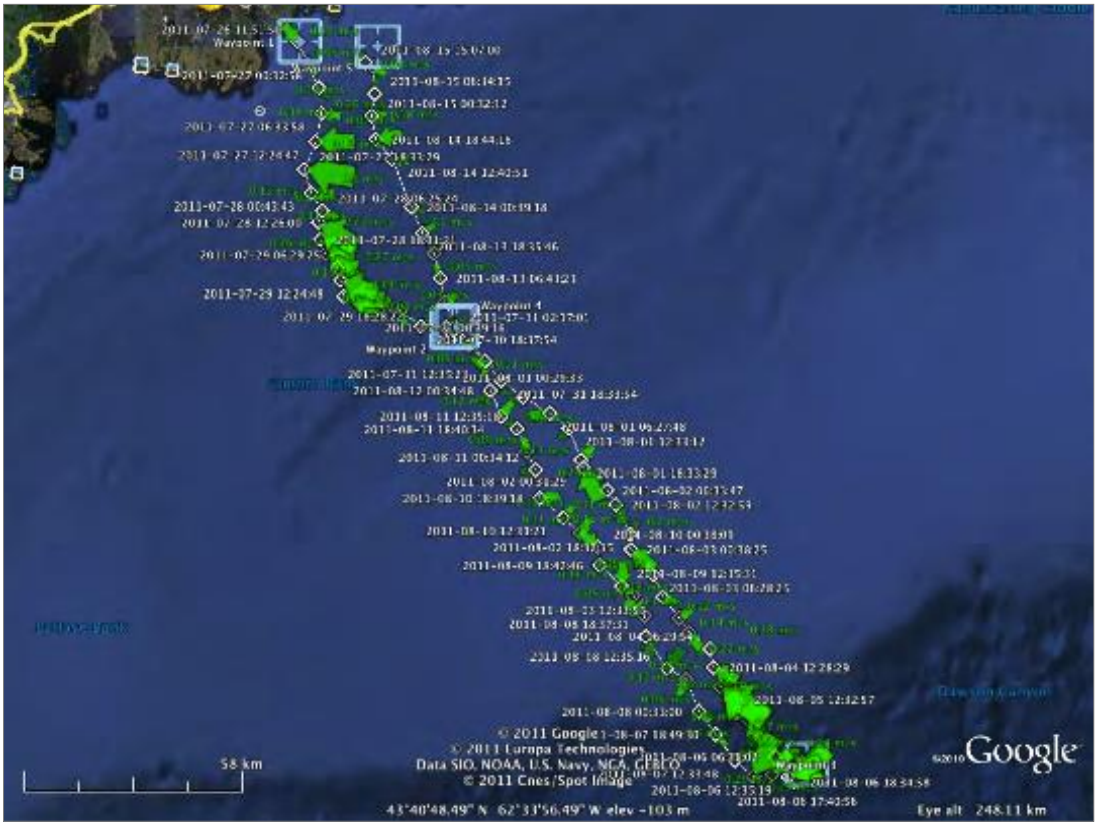


Figure 2a: Google map showing the glider locations whenever it surfaced on the way out and back. The green arrows are estimates of the mean current between surfacing.

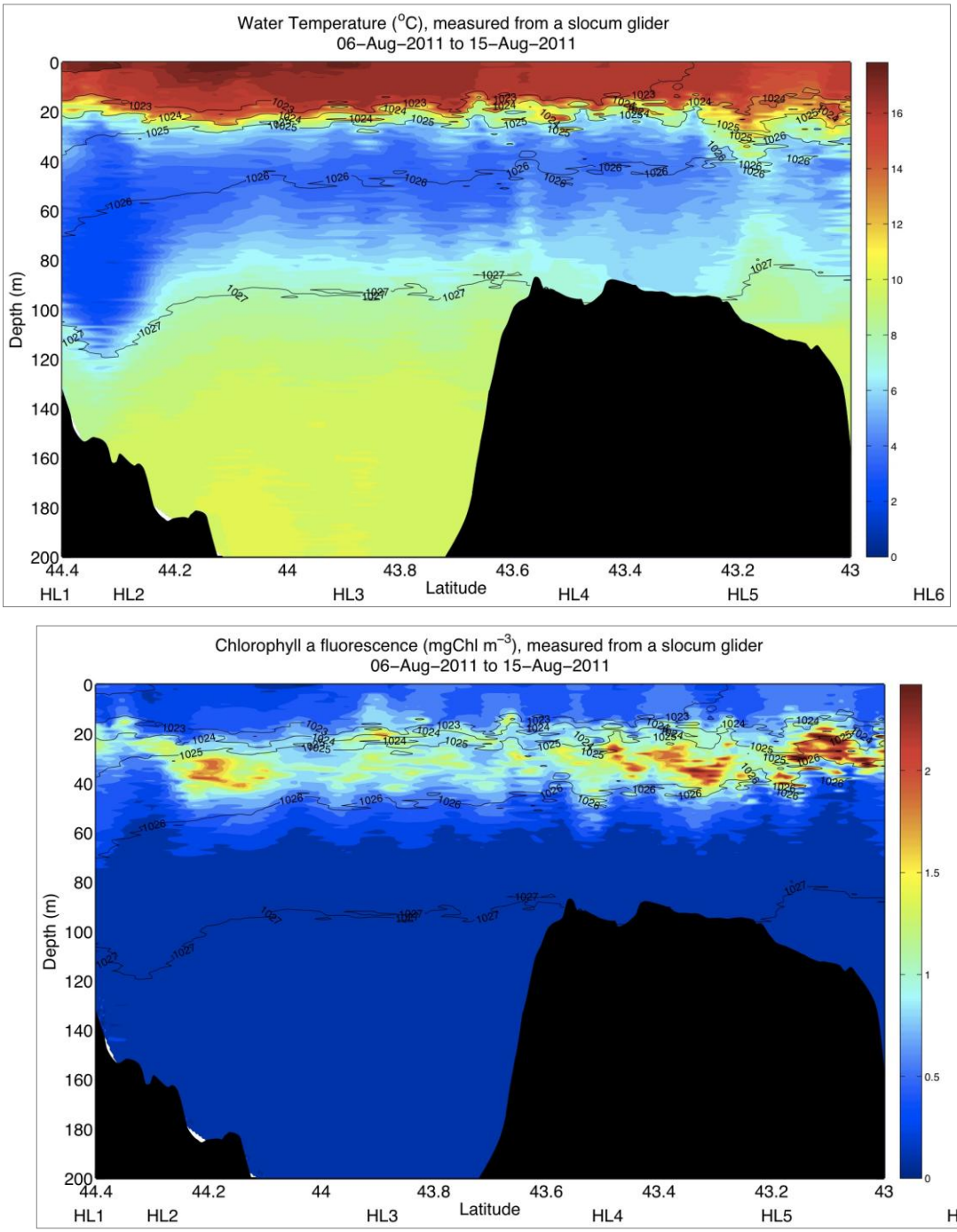


Figure 2b: Results from an ocean glider transect, August 06-15, 2011, demonstrating the resolution of the sampling technology and capabilities for presenting the data that have been developed as part of this project. The distribution of chlorophyll (here estimated with fluorescence), relative to light and the density structure of the water column (shown here with contours), shows pattern that is readily interpreted but not easily predicted in detail. Comparison of these records with model predictions will be an essential activity of the network project. Regular, subsurface observations of these oceanographic properties with such high spatial resolution would not be available were it not for the glider program.

AC:

The high-resolution (HR; 500 Hz) tether-tag and mounting mechanism was improved and used beyond that achieved in 2010. A new HR archival-tag and mounting mechanism was developed and successfully used in 2011.

The HR tether- and archival-tag trials in a controlled flume tank (various speeds) were successfully carried out in 2011 using 13 pollock of various sizes. Preliminary data analyses have been conducted to establish a scaling parameter between size and acceleration as well as showing that the tail-beat frequency spectrum (in constant current) scales with size.

The HR archival-tags were successfully used to validate the intraspecific relationship between acceleration and size-at-time with shortnose sturgeon at the Mactaquac Hatcheries in a new OTN collaboration with Dr. M. Litvak and PhD candidate A. Taylor (Mount Allison; see 5e). Twenty seven sturgeon of various sizes (55 to 150 cm) in a large free-swimming pool were used. The data are being analyzed to identify the scaling parameter(s) between size and acceleration. This was an important contribution to test the relationship between acceleration and size within and across species. Additionally, free-swimming behaviour was observed/recorded and is being used to quantify activity patterns, including tail beat frequency that also scales with size. The analyses will be used to design a field experiment with Litvak where we will use the required sampling frequency (determined from the above trials) to allow for longer duration tags using a combination of pop-up satellite tags and the HR-archival tag.

HR-archival tags from Japan (also in-house-development) were used on great sculpin at the Friday Harbor Lab by Bröll in collaboration with researchers and PhD candidates from Kyoto University (Japan), CEFAS (UK) Istituto per l'Ambiente Marino Costiero (Italy) and Denmark (Uni. Copenhagen (Denmark). One research focus was the detection of fine-scale behaviour and the effect of sampling frequency and the results are currently being compiled into a manuscript to be submitted in 2011 by Bröll, F., Noda, T., Wright, S., Domenicic, P., Steffensen, J., Taggart, C.T. *"Fine-scale behaviour finfish: acceleration signatures and the effect of sampling frequencies."*

Based on academic excellence (A-grades in all 4 grad courses) and research progress, Bröll's Advisory Committee unanimously recommended transfer to PhD candidature. That was achieved in Sept. 2011. Bröll was co-awarded the Kathy Ellis Memorial Prize for obtaining the best course marks in the Department of Oceanography with another OTN graduate student, Anna Katavouta.

c) Describe and justify any significant deviations from the original objectives or plans, including any revised goals, new projects, or deleted projects.

OO:

Excessive delay in deploying benthic pods (and hydrophone moorings) was caused by manufacturing delays due to withholding of funds. This storm has been weathered and technical staff are making great efforts to get back on schedule.

OG:

From the beginning, it was appreciated that it would take time to develop the capability for routine deployment of ocean gliders in a nearly continuous program of surveys on the shelf. Technical problems with the gliders (discussed below) forced us to spend more time on solving problems then on sampling, but technical challenges were expected, and the original plans and objectives for the glider program remain the same.

d) *Describe how the work of the project's co-investigators and collaborators was coordinated and integrated*.

OO:

The ocean observing group also coordinates closely with the modeling component under Drs. Sheng and Thompson, using models to understand and interpret the physical data, while helping to validate the model results.

OG:

The Dalhousie glider group collaborates with researchers at BIO, primarily Dr. Dave Hebert, who provides significant guidance and expert advice on the deployment of autonomous vehicles and the processing of the oceanographic data. Also, the glider group has established a working relationship with Dr. Keith Thompson and his group whose forecasts of current conditions off the coast of Nova Scotia from the DALCOAST model are helpful in planning glider missions. In return, glider position and data from the on-board sensors for conductivity (salinity), temperature and depth will help refine predictions from the DALCOAST model. Finally, during June 2011 the glider group deployed the OTN Global glider in the Gulf of St. Lawrence with a VEMCO acoustic receiver attached in support of Dr. Fred Whoriskey's salmon tracking efforts. The plan was to fly the glider in a strategic location in the hope of receiving signals from tagged salmon smelts. Unfortunately the glider lost communications and was not recovered.

AC:

Dr. Webber (VEMCO), Dalhousie's Biomedical Engineering (Benzanson), Aquatron Staff (Batt and Eddington) and Animal Care (Narayanan) continue to provide substantial support to the HR accelerometry work. VEMCO continues to be actively involved tag technology and we envision that the involvement will increase once we have demonstrated the value of the accelerometry tag (detailed

below). Bröll continued to work closely with Benzason in the Engineering electronics lab to improve the tags (detailed below)

The 1st Annual OTN-Canada Symposium meeting resulted in new collaborations with M. Litvak (Mount A.), S. Cooke (Carleton) and with the Ocean Governance group (Apostle, VanderZwaag).

e) Describe the benefits of conducting this research as part of a network rather than as a separate project (e.g., scope of the research, cross disciplinary collaborations, new synergies and research opportunities, access to ship time, planning and coordination of research activities, exchange of information and data, benefits to students and technical staff).

OO:

OTN NW Atlantic Regional Meeting held at BIO on 7 Feb. 2011 – Discussions centred on evolving technology (Vemco), OTN data policy and management, and social networking. In that context, NSERC SNG research was presented and discussed as a means to understand species movements, interaction and environmental variability across Canada's three oceans. This sort of meeting greatly supports regional mono- and cross-disciplinary collaborations and synergies, both within and outside of the OTN community.

OG:

The glider project was conceived as a crosscutting activity, comprising both support for oceanographic analysis and modelling, and original research on the development of new data products. It is inherently a network activity: making observations without applying them make no sense; in turn, modelling without validation is not the OTN modelling group's chosen path, with good reason. Our commitment to the development and evaluation of new data products is guaranteed to be a stimulus for the introduction and testing of more effective modelling approaches, and the reality of trying to make models and observations match will surely provide strong guidance for the scientific effort to identify and validate appropriate data products for use in models. These strong conceptual underpinnings ensuring the network approach permeate our activities.

AC:

On 20 May 2011 we convened a half-day workshop at VEMCO with Dr. D. Webber (R&D), Dr. R. Vallee (Sales & Marketing), Dr. B. Oakley (VP, R&D) and D. King (Director of Market Development). Taggart, Bröll and Benzanson presented our advances with the HR accelerometer tags and discussions centered on future collaborations between VEMCO and the accelerometry group and the advancing technology. It is clear that archiving known parameters drawn from accelerometry data can be incorporated into

existing VEMCO transmitter tag technology as soon as we have determined the nature of the parameters and the minimum sampling frequency required.

Collaboration with Dr. Matt Litvak (5b above) increased the scope of the accelerometry project with a new species for lab and field application. We collected HR accelerometer data on activity, swimming and burst acceleration that are being used to determine optimal sampling frequencies for shortnose sturgeon in the field and for determining the parameters of interest (size-at-age scaling, and activity for use in growth, behavioural, and energy budget determination in the wild). Based on these analyses we can develop a longer-duration tag with the optimal sampling frequency and likely parameter archiving in the field when tagging Atlantic Sturgeon in the St. John River using pop-up satellite tags (PSAT; Desert Start Systems, LLC) in combination with our accelerometer tags to assess activity patterns and movement in this species. This will contribute to the PhD research of A. Taylor as well as Bröll. Additionally, the same PSAT tags can be re-used for similar experiments with black marlin in Australia in collaboration with ANU (see below).
We have begun a collaboration with scientists from Australia National University to use our HR accelerometer tags in combination with PSAT tags to investigate post-tagging fine-scale behaviour and vertical and horizontal movement of black marlin in 2012 and with our collaborators have applied for an Australia Museum 2012 – LIRS Peter Teakle Sustainable Fishing Research Grant entitled "Accelerometry: estimating size, activity, energy, habitat and post-release effects in black marlin" (Roche, D., Binning, S., Bröll, F., Taggart, CT, Domenici P.) and we envisage a research connection with OTN-Australia to evolve.

We have discussed collaborative initiatives with Dr. Steve Cooke (Carleton, OTN Pacific) that would combine our HR accelerometer tags with ECG data-loggers to identify and quantify stress levels during net-entanglement of coho salmon

The development of our HR tag and technology has now been transferred and further advanced and successfully deployed to research focused on leatherback turtles with PhD Candidate T. Tapics working in Taggart's lab in collaboration with Dr. M. James. This non-OTN development of a high-resolution archival inertial-navigator tag (3-axis accelerometer, magnetometer, and gyroscope) was funded by Taggart's Discovery and CWF grants.

f) Describe the scientific and/or engineering significance of the results to date.

OO:

Recent detections on the first 60 km of the Halifax Line suggest that the animals are passing the line, almost exclusively, in the June/July period, and their numbers may be diminished in the core region of the Nova Scotia Current.

OG:

The glider group has developed a capability to operate ocean gliders routinely, troubleshoot their operation, and to retrieve, manage, and display oceanographic data (Figure 2a, b). This capability is highly significant for the OTN observations component.

AC:

The Bröll et al. work at Friday Harbor (ms in prep.) shows that a >30Hz sampling frequency is essential to detect fine-scale behaviour events in a less-than-agile fish species (great sculpin) when using accelerometers (Fig. 3). More agile species (salmon, gadids, swordfish, tuna etc.) will likely require even higher frequencies. Therefore, studies using accelerometer tags in the field to identify various activities, and to estimate energy expenditure (some published and very likely compromised), must ensure appropriate sampling frequencies. Bröll developed algorithms to estimate parameters from the acceleration record that are able to identify activity events and classify fine-scale behaviour (e.g., feeding event, Fig. 3) with a detection rate of ~80%. The algorithm examines the standard deviation of the acceleration vector norm (**Φ**) to differentiate between spontaneous movements and fast-starts such as escape response or feeding strike, and then a set of parameters (acceleration maximum, range, and variation in the lateral and forward direction, autocorrelation within the event, and correlation between lateral and forward acceleration) to determine **Ω** that differentiates between an escape response and a feeding strike.

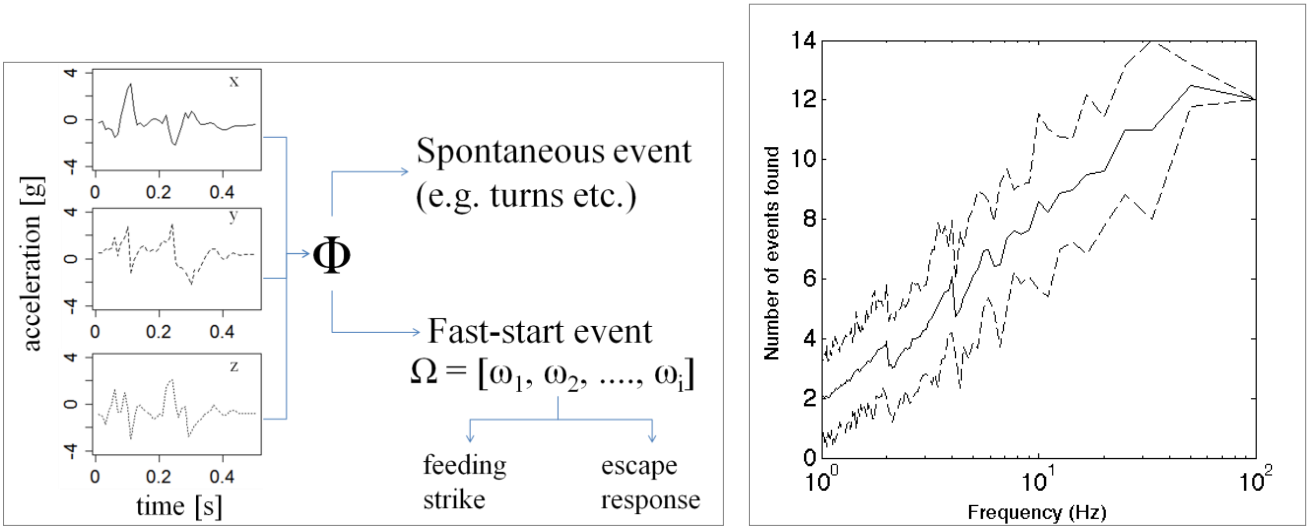


Figure 3. Detection of fine-scale behaviour based on x, y, z, 100 Hz acceleration, parameter Φ and parameter set Ω (left panel), and the number of successful detections (n=14 events) with confidence intervals as a function of sampling frequency (Bröll et al., in prep.)

Preliminary data analyses of the HR tether-tag and HR archival-tag data in controlled flume tank (various speeds) trials with pollock of various sizes in 2011 demonstrate that the tail-beat frequency spectrum (at constant velocity) scales with size (Fig. 4). We are in the process of analyzing the data to

determine how acceleration, regardless of velocity, scales with size. Early indications suggest it is possible. Regardless, activity estimates are clearly possible as shown above.

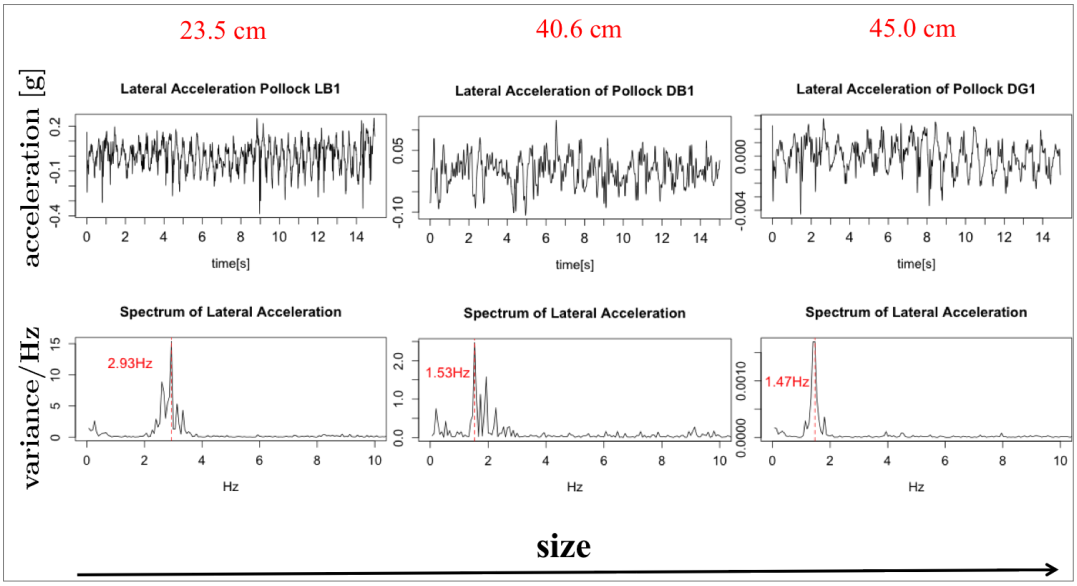


Figure 4. Tail Beat frequencies extracted by spectral analysis from three pollock of different length swimming against a constant 0.4 cm•s^{-1} current.

AC: - Engineering significance:

Our novel accelerometer tags (Bröll and Benzanson) now include: 1) a 1000Hz tether-tag for use in a flume, swim tunnel or respirometer etc., 2) a short-duration (10 hr) 500 Hz storage tag developed for use field studies or free-swimming laboratory or enclosure studies, and 3) an advanced 100 to 500 Hz inertial navigator tag (tri-axial accelerometer, magnetometer and gyroscope) or short-duration field use. All three tags have been successfully tested and deployed in the lab and field.

6. Difficulties encountered

a) Identify the main difficulties encountered in carrying out the research during the reporting period from the list below:

- ❑ Scientific problems/difficulties
- **X** Equipment and technology issues (e.g. delivery and malfunctioning of equipment)
- ❑ Personnel problems
- **X** Involvement of partners
- ❑ Other (specify): _____
- ❑ No problems occurred during this instalment of the grant

b) For each checked box, describe the difficulties identified above and the steps taken to resolve them

OG:

Significant and time-consuming technical problems were encountered with both OTN gliders (s/n 200 and s/n 201), and some were severe. All could be traced to either defective parts or components incorrectly configured by the manufacturer. Some problems required a great deal of time to uncover, and each of the OTN gliders developed a leak (at least one around a sensor), forcing the glider team to motor offshore for recovery. Many weeks were consumed in troubleshooting, and consequently, the number of routine transects completed so far is less than we had hoped. It is disappointing that the gliders were much less reliable than we expected, based on the experience of users to date. The manufacturer is well aware of the problems and committed to rectifying them; they have been very cooperative. Progress on the project has been slowed, but the glider group has gained a great deal of expertise and we are confident that the manufacturer will work with us to ensure that future operations are much smoother.

Finally, a glider purchased for OTN Global, s/n 121, was lost in the Gulf of St. Lawrence. After making contact on schedule for 27 hours, the glider failed to communicate further. The reason for this catastrophic loss is unknown but may be due to either ship strike or a failure related to the flooding issues encountered by gliders 200 and 201, as glider 121 was also equipped with WET Labs sensors, at least one of which is known to have leaked.

AC:

Equipment: We had several technical issues with flume tank set up and motor-related noise generation (frequency filter eventually installed) plus delays in accelerometer development that led to fewer swim trails having been conducted than planned. Progress should be swift in the remainder of 2011 and 2012, since remaining experimental set-up and tag development phase for laboratory tags is expected to be concluded in 2011 (new pressure-case via Benzanson).

Partners: It would be of some value if we could increase our involvement with VEMCO and we are working on doing so, and understand their corporate responsibilities come first. Our new results above, and there are more to come, are expected to increase R&D enthusiasm within VEMCO

7. Networking and outreach

Discuss the extent of networking and outreach by the project, both within the OTN Canada Network and with the broader community, by co-PIs, collaborators and HQP. Describe how the project's research has been impacted by, and contributed to, the research carried out by other projects from across the Network. This is a critical section! Please review the comments on your last year's report.

a) Intra-Network Collaboration and Partner Meetings

OO:

Scientists at Fisheries and Oceans Canada are interacting with the glider group at Dalhousie University to incorporate a subset of the vast quantities of data in the Atlantic Zone Monitoring Program. During this past year, the two groups are working together to understand the different types of data collected, the sampling strategies and operational constraints placed on the glider and the method to transfer the subset to the Ocean Data and Informational Services group at the Bedford Institute of Oceanography.

A group of DFO scientists (led by Will Perrie) has approached HQP Mathieu Dever, seeking to use the OTN ADCP and MicroCat data to validate their ocean model (NEMO-OPA) for the purpose of estimating long-term climate change on the Scotian Shelf and in the Gulf of Maine. Discussions are underway to help facilitate this process.

OG:

The Dalhousie glider group has made several connections within the OTN Canada Network and the broader community. We are providing metadata and data to the OTN Canada data management group. We are in discussion with Dr. Whoriskey to obtain VEMCO receivers to be mounted on the gliders during all missions, essentially enhancing and extending the line of bottom pod receivers and providing highly detailed oceanographic observations associated with tracking encounters. We have access to output from the DALCOAST model as operated by Dr. Keith Thompson's research group. In return, the position of the glider and data from the CTD can be used to refine the model's output. We work extensively with the AZMP group at BIO, sharing data and expertise.

As measurements are coming on line and both modelling and analysis projects are being developed, network members have established a Shelf Observations Group to facilitate interaction among network members. Communication links have been established, and a first group meeting, with presentations and discussions with modellers, is being scheduled for early December.

AC:

Taggart and Bröll have ongoing discussions with K. Thompson and A. Katavouta, PhD candidate (project I.1.1) about combining information from data assimilative ocean models with the accelerometer data from tagged fish. The objective it to determine fish paths from the model output, and tag-data records (accelerometry, temperate, depth, time; TDR) The main elements in the inversion of the model output and tag data to recover the fish paths are as follows:

1. Fish tracking generally provides location and time at release, crossing receiver curtain(s), and recapture. The problem is that we don't know the horizontal position of the fish at intermediate times.
2. The tag delivers time, temperature, depth and acceleration data (the latter can be combined to give situ estimates of size at time, i.e., growth). The same data can also be used to obtain estimates of activity and swimming at time (tail beat frequency, swimming velocity, size etc.) as well as energy expenditure, maximum swimming velocities, etc.
3. The model delivers estimates of temperature at *x,y,z* and *t*.
4. The inversion involves the determination of the "most likely" paths that the fish took (*x,y,z*) during the intermediate times. Essentially, the model temperature, interpolated to the possible positions of the fish at time *t*, is combined with the tag data and a cost function is minimized over all possible paths to identify the one most likely taken.
5. The above approach can be expanded to include physiologic and energetic (e.g. maximum swimming speed) constraints that may change with time/size.

(See 5e above). Bröll, Dr. Taggart, Dr. Litvak and A. Taylor (Mount Allison University, OTN Atlantic) jointly carried out a series of accelerometer swim trials on shortnose sturgeon at the Mactaquac Hatchery (DFO, New Brunswick) in May/June 2011. This work could not have been accomplished without the collaborative effort. Bröll would not have had access to these animals and facilities otherwise. Litvak also provided a field assistant during the swim trials, while Bröll provided the necessary accelerometer equipment, expertise of equipment usage and experimental protocol. The high-resolution accelerometer data on activity, swimming and burst acceleration collected will be used to determine optimal sampling frequencies for shortnose sturgeon for certain parameters of interest (size-at-age scaling parameter, parameters for activity patterns and energy budgets). Based on these analyses we can develop a longer-duration tag with the optimal frequency for the field to be used for tagging Atlantic Sturgeon in the St. John River. For this future collaboration between Litvak, Bröll, Taggart and Taylor we aim to use Pop-up Satellite Tags (Desert Start Systems, LLC) in combination with accelerometer tags to assess activity patterns and movement in this species. These PSAT tags (valued at $2900/piece plus $400/accelerometer) will be obtained by an NSERC RTI grant. If the RTI grant application is successful, these tags will be used for field trials on shortnose sturgeon, can also be used for similar experiments with black marlin in Australia in collaboration with ANU (see below). If the RTI grant application fails, Taggart and Litvak will purchase at least one tag each from other funds to facilitate this collaboration. This is essential as OTN-SNG does not permit the purchase of tags. While Bröll's studies will greatly benefit from the collaboration to test the size-at-age and acceleration hypothesis as well as the relations between acceleration and activity/energy budgets, Litvak's and Taylor's studies will benefit from this novel application by adding information to sturgeon behaviour that was previously limited to migration routes, and location detection. With the use of accelerometers

more in-depth behavior (swimming, bursting activity, feeding, spawning etc.) can be associated with migration routes.

Discussions have taken place with S. Cook and PhD candidate G. Raby (OTN Pacific) on collaborating with the use high-resolution accelerometers in connection with electrocardiogram/accelerometer (ECG/acc.) data-loggers to address stress levels during net entanglement of coho salmon. As the ECG/acc data-loggers used in these studies sample at lower frequencies and only record averaged values of acceleration, we have collectively recognized that the research will benefit with the addition of a HR-accelerometer tag. Bröll will thus have the opportunity to expand her research by addressing relationships between heart rate and acceleration and at the same time determine the relation between size and acceleration metrics across a range of sizes of coho. Bröll's expertise in time-series analysis will also be of value in the analysis of ECG data.

A new initiative involving Taggart and Bröll, led by R. O'Dor (Dal) along with S. Adamo (Dal), G. Lyon (PhD candidate, Belfast) and VECMO, is currently getting under way to address growth, swimming, activity, energetics, and visual physiology/responses with cuttlefish, and possibly squid, in both the laboratory swim-tunnel respirometer along with tags and in the field with tags. Our involvement will be the use of our new HR-tags to first address size-at-time using the accelerometry metrics and parameters and secondly to determine the activity detection metrics and parameters that can be incorporated into metabolic and energy budget estimation.

On 15 Sep 2011, Taggart met in a short research workshop with S. Iverson and the soon-to-be-appointed NSERC Industrial Research Chair holders Glenn Crossin and Jeremy Goldbogen, and VEMOC (IRC sponsor) representative D. Webber. The discussions revolved around collaborative research initiatives that could evolve in the near future given their mutual interests in the development and deployment of advance tag technology for eco-physiological research on fishes and large marine animals (whales and turtles).

In June 2011, Taggart met with the OTN-Governance group workshop led by R. Apostle, and D. VanderZwaag, who are working along with C. Nochi (U. Maine) and J. Duff (U. Mass) on ocean governance issues, and they invited Taggart (who agreed) to participate given his science applications to policy issues, particularly his expertise in addressing shipping and fishing-gear threats to right whales and the successful policies in place and developing to mitigate such threats.

b) Interaction/Outreach to Broader Community

OO:

On 8 Feb. 2011, results and highlights of the OTN regional meeting were reported by Dr. Smith to the ICES working group, WGNARS, meeting at BIO. The session, entitled "Ecosystem indicators and climate/environmental drivers", was attended by ~45 marine scientists/stakeholders from the ICES community (mainly US and Canada).

OG:

Interactions with the broader community and outreach were primarily associated with deliverables listed below (Section 8, e.g., invited lectures and visits to other laboratories), and spinoff activities (Section 12, discussions with MetOcean.

AC: TBA

8. Dissemination of information and results

List refereed journal articles (accepted/published, submitted) and conference presentations (invited, contributed). All other dissemination is included in section #9 (Other contributions and deliverables).

Note: Deliverables from collaborators are listed in their respective reports and not repeated here.

Refereed Journal Articles (1 total)- *Submitted*

Cullen, J.J., R.F. Davis and Y. Huot. 2011. Spectral model of depth-integrated water column photosynthesis and its inhibition by ultraviolet radiation. Global Biogeochem. Cycles., submitted in 2010 and revised with new analyses in 2011.

Contributed Conference Presentations (7 total)

Bröll, F. Submitted . Fine-scale behaviour in fish: acceleration signatures and the effect of sampling frequency. CCFFR, Jan 2012. Contributed oral presentation.

Bröll, F. Submitted. Fine-scale behaviour in fish: acceleration signatures and the effect of sampling frequency. ASLO 2012. Contributed oral presentation

9. Other contributions and deliverables

Radio or television interview or contribution to a programme/documentary, etc.

- Dr. Cullen was interviewed for a documentary for the Weather Network, with a short piece, "Climate Science: Oceans," excerpted and presented at the annual CMOS meeting. It included interviews with Ken Denman and John Cullen. It was intended to be shown regularly on the Weather Network.

Invited or contributed open-to-public presentation/contribution.

- Dr. Cullen was one of the weekly invited speakers in Lamont Doherty's Earth Science Colloquium. The lecture is posted by Lamont as a video. Cullen, J.J. "Chlorophyll *a* as the measure of phytoplankton biomass: Time to move on." Lamont Doherty's Earth Science Colloquium: March, 2011.
- In July, Cullen presented a similar invited talk at the C-MORE Symposium at the University of Hawaii. Both lectures described innovations in modeling approaches that are being developed as part of the OTN Network research.
- Cullen, J.J. "Chlorophyll *a* as the measure of phytoplankton biomass: Time to move on." C-MORE Symposium: "Using 21st Century Technology to Address the Big Questions of 20th Century Oceanography." University of Hawaii, Manoa, July, 2011.
- Cullen, J.J. "Optical observations of the ocean" and "Measurements and models of phytoplankton biomass and primary productivity." C-MORE Summer Course on Microbial Oceanography, University of Hawaii, June 2011.

Invited or contributed presentation/contribution at a workshop.

Comeau, A.J., J. Pye, R.F. Davis, M. Beck, and J.J. Cullen. Ocean gliders for autonomous underwater surveys of physical, chemical, and biological conditions on the Scotian Shelf. OTN Symposium, Halifax, June 2011.

Cullen, J.J., C. Taggart, and P.C. Smith. Advanced observing component. OTNC Atlantic Arena Meeting, 19 April, 2011.

Bröll, F. and C.T. Taggart. 2011. Accelerometry: the key to monitoring temperature-dependent fish growth and activity in the wild. 1st OTN Canada Symposium, Dalhousie University, 1–3 June 2011. Invited oral presentation.

Bröll*, F. and C.T. Taggart. 2011. Accelerometry: the key to monitoring temperature-dependent fish growth and activity in the wild. Friday Harbor Laboratories, Washington, August 2011. Workshop presentation.

Dr. Smith was invited to co-chair and present OTNC plans at the first meeting of the NW Atlantic Region at the Bedford Institute of Oceanography on 7 February, 2011. Two days later he presented similar information at the WGNARS meeting at the same venue.

Invited or contributed presentation/contribution at a seminar series.

- See section above.

Data reports, technical reports, manuscript reports, advisory documents, briefing notes, handbook or guide, checklist, barcode, CTD casts, Glider runs, and/or data deposition to an agency/database (e.g., MEDS, GenBank, OBIS, etc.), as well as a contribution to a larger piece of work in any of the former.

- There have been 5 successful operational glider runs during this reporting year, from May to the end of September 2011. The data from these runs resides at Dalhousie but has been made available to researchers at BIO. The data is also available to anyone within OTN Canada who makes a request.

Invited or contributed consultation with an agency; public or private

- Bröll, Taggart, Benzanson were invited to a half-day workshop at VEMCO to present advances in high-resolution accelerometer tag development and to discuss future collaborations.

Anything else that isn't a primary publication that has you communicating (specify) with others (specify).

- Dr. Cullen was invited to present a series of 5 lectures on ocean observation and prediction, at institutions in China during October, 2011. This has included discussion of future collaborations that have been going on for months.

Leveraging your research/funds in order to make a new contribution to another initiative

OO/OG:

- The observations components of the OTN SNG formed a foundation for the Marine Environmental Observations, Prediction and Response (MEOPAR) Networks of Centres of Excellence proposal, including its Observations Core. This $25M initiative represents very substantial and long-term leveraging of the observations and modelling activities of OTN.

AC:

- (5e above). We have begun a collaboration with scientists from Australia National University to use our HR accelerometer tags in combination with PSAT tags to investigate post-tagging fine-scale behaviour and vertical and horizontal movement of black marlin in 2012
- (5e above). Our HR tag and technology has now been transferred and further advanced and successfully deployed to research focused on leatherback turtles
- (7 above). We embarked on a a new initiative with O'Dor et al. to address growth, swimming, activity, energetics, and visual physiology/responses with cuttlefish, and possibly squid.

A spin-off from the research that provided a new opportunity or new initiative

OO:

- A group of DFO scientists (led by Will Perrie) has approached HQP Mathieu Dever, seeking to use the OTN ADCP and MicroCat data to validate their ocean model (NEMO-OPA) for the purpose of estimating long-term climate change on the Scotian Shelf and in the Gulf of Maine. Discussions are underway to help facilitate this process.

OG:

- The glider group is in discussions with MetOcean, a local marine technology company, to plan a collaborative consultation about new technology.

AC:

- (see 5e above). The development of accelerometer tags has motivated the interest from scientists in Australia and Italy to collaborate and apply for funding to estimate fine-scale behaviour post-tagging in black marlin.

A new technology, method, protocol, measure, analytical technique, algorithm, operational or numerical model, or predictive tool. Include the validation of any of the former and their practical application.

OG:

- Dr. Cullen and colleagues have developed a new framework for modeling the dynamics of phytoplankton without relying on measures of the photosynthetic pigment, chlorophyll *a*. See citations of the two invited public lectures, above.

AC:

- (see 5f above) We have developed novel tri-axial accelerometer tags: one for laboratory use that is a 1000Hz tether tag being used in laboratory (flume) studies (Bröll and Benzanson)

and the other for field use that is a short-duration (order 10 hours) 500Hz archival tag developed for use in short-duration field studies or free-swimming enclosure (Bröll and Benzanson).

- (see 5e above) The technical advances in tag development above led to the development (independent funds and outside OTN) of a short-duration (10 hour, tri-axial accelerometer, magnetometer and gyroscope) inertial navigator tag (Tapics and Benzanson).

A proof of concept in relation to any of the above

AC:

- All of the above accelerometer tags have been successfully deployed.

Baseline measures (e.g. reference for change), empirical relations (e.g. rates and states), or mapping products (e.g. range expansion or contraction) especially if of use to other scientists and the organizations listed above.

OG:

- Physical and biological measurements collected from the gliders include temperature, salinity, oxygen concentration, chlorophyll and dissolved organic matter fluorescence, optical backscatter at 4 wavelengths, and downwelling irradiance at 4 wavelengths. This data will be added to the extensive data collected by the AZMP program at BIO and ultimately will be made available to the public.

AC:

- We have established baseline measures (e.g., reference for change), empirical relations (e.g. rates and states), and critical sampling frequencies related to aliasing of value to other scientists and the organizations listed above.

Other

OG:

- The Dalhousie glider group assisted Dr. Jaime Palter at McGill University by providing advice on purchasing Teledyne Webb gliders. We regularly interact with researchers and technicians at Rutgers University.

10. Collaborations with Industrial and Government Partners

a) Please describe which partners are actively involved in management, research, and knowledge transfer within the network and the specifics of their involvement.

OG:

The Dalhousie glider group has committed to data sharing with researchers at BIO. This collaboration will benefit the network in two direct ways. First, government researchers working on the AZMP project will have incentive to share their vast knowledge and experience with the glider group, an immense advantage in planning missions and ballasting gliders. These researchers will be able to enhance their current sampling regimes by acquiring data during times when they normally wouldn't and with spatial resolution that is otherwise unattainable. Second, the data from the gliders will ultimately be incorporated into the AZMP database, making the observations accessible to a much wider community.

AC:

VEMCO via D. Webber are involved in HR-accelerometer tag development.

b) Cash and in-kind contributions from partners for year 2.

Name of supporting organization: **DFO**	**Year 2** 2011
Cash contributions to direct costs of research	---
In-kind contributions to direct costs of research	---
1) Salaries for scientific and technical staff	12,000
2) Donation of equipment, software	---
3) Donation of material	---
4) Field work logistics	---
5) Provision of services	2,800
6) Other (specify): _____	35,000
In-kind contributions to indirect costs of research	49,800
1) Use of organization's facilities	
2) Salaries of managerial and administrative staff	1,200
3) Other (specify): _____	
Total of all in-kind contributions	51,000

Name of supporting organization: **CFI**	**Year 2** 2011
Cash contributions to direct costs of research	
In-kind contributions to direct costs of research	
7) Salaries for scientific and technical staff	80,833
8) Donation of equipment, software	436,529
9) Donation of material	
10) Field work logistics	
11) Provision of services	
12) Other (specify): _____	
In-kind contributions to indirect costs of research	
4) Use of organization's facilities	
5) Salaries of managerial and administrative staff	
6) Other (specify): _____	
Total of all in-kind contributions	517,362

Name of supporting organization: **VEMCO**	**Year 2** 2011
Cash contributions to direct costs of research (*NSERC/Discovery*)	7,000
In-kind contributions to direct costs of research	
13) Salaries for scientific and technical staff	7,000
14) Donation of equipment, software	2,000
15) Donation of material	
16) Field work logistics	6,000
17) Provision of services	2,000
18) Other (specify): _____	
In-kind contributions to indirect costs of research	
7) Use of organization's facilities	3,000
8) Salaries of managerial and administrative staff	3,000
9) Other (specify): _____	
Total of all in-kind contributions	23,000

11. Expenditures and Support

Expenditures and support for Atlantic I.1-3 are reported and explained in a singular financial budget at the end of this Oceanography report (please see page 72).

Atlantic Arena I.1.2

1. Project Number: I.1.2

2. Project Title: Integrated Interdisciplinary Observing and Modeling Platform – Physical and biological modeling component

3. Project Leader(s): J. Sheng (Dalhousie U), K. Fennel (Dalhousie U)

Collaborator(s): K. Thompson (Dalhousie U), J. Cullen (Dalhousie U), P. Smith (DFO-BIO), B. Greenan (DFO-BIO)

4. Training of Highly Qualified Personnel:

a) List of the HQP and level of their salary support by SNG.

Personnel	*Title*	*%Time involved in project*	*%supported from SNG*	*Dates*
Jorge Urrego-Blanco	PhD	40	40	October 1, 2010 - present
Shiliang Shan	PhD	40	40	October 1, 2010 - present
Dr. Kyoko Ohashi	PDF	100	100	October 1, 2010 - present
Dr. Daisuke Hasegawa	PDF	20	20	May 1, 2011 – September 30, 2011
Dr. Laura Bianucci	PDF	100	100	Sept 20, 2010 – present
Karl Lagman	PhD	100	100	Nov 1, 2010 – present
Paul Mattern	PhD	20	0	Sept 1, 2011 – present

b) Explain the role, activities and opportunities for training of technical staff in your project.

No technical staff is supported by this project.

5. Progress towards Objectives/Milestones (1 Oct 2010 – 30 Sep 2011)

a) Please provide brief description of the overall objectives of this project (max ½ page).

Point measurements of the passage of tagged animals across fixed lines of underwater acoustic receivers must be interpreted in the context of physical, biological and chemical ocean characteristics. This requires a synthesis of physical, biological and chemical measurements by OTN, along with other

available data streams, in order to generate a dynamically consistent, time varying, three-dimensional view of the ocean. In this project advanced physical, biological and chemical models are developed for predicting this time varying, three-dimensional structure of physical (e.g., currents, temperature and salinity), biological and chemical variables (e.g. oxygen, nutrients, phytoplankton abundance and other measures of the state of lower trophic levels). This modelling work is part of a larger, general purpose Observation and Modeling Platform that also supplements existing observational capabilities (within OTN and other sustained monitoring programs) with new observation tools (project I.1.1 *Advanced Observing Component*), and develops effective methods for combining the models developed here with observations, i.e. data assimilation, (project I.1.3 *Data Assimilation Component*). This project directly supports projects I.2.1 *Atlantic Salmon*, I.2.2 *American Eel*, I.2.4 *Grey Seals* and I.2.5 *Sea Turtles* by providing validated model hindcasts. In addition, this project will use bioprobe data collected by project I.2.4 *Grey Seals.*

b) Describe progress towards meeting the project's objectives and specific milestones for the project.

The specific project deliverables are listed followed by a description of progress toward each of these deliverables:

1. Nested-grid ocean circulation models for the Atlantic arena, some coupled with biological models and O_2 dynamics, that can be used in hindcast, nowcast and forecast mode. The system will be generic to facilitate application to the other OTN arenas.

   Jorge Urrego-Blanco (PhD student) and Dr. Jinyu Sheng completed the setup for the outer-most and coarse-resolution (¼ degree) sub-model (domain MD1 in Fig. 5 of the OTN proposal) of the multiple nested-grid modelling system, using a coupled ocean-ice model based on NEMO (Madec, 2008). The model domain of MD1 covers the northwest Atlantic Ocean between 33^{o}N and 55^{o}N and between 80^{o}W and 33^{o}W (Urrego Blanco and Sheng, 2011). Using the atmospheric forcing taken from the atmospheric reanalysis data produced by Large and Yeager (2004) and specifying model open boundary conditions based on the global ocean reanalysis data produced by Smith et al. (2011), sub-model MD1 was integrated for 18 years from the beginning of 1987 to 2004 to reconstruct the time-dependent, three-dimensional (3D) circulation and hydrography over the northwest Atlantic (Fig. 1).

   Dr. Kyoko Ohashi (PDF) and Dr. Jinyu Sheng continued to work on the specification of freshwater runoff from the St. Lawrence River, St. John River and several small rivers along the northern shore of the Gulf of St. Lawrence (GSL) in sub-model MD2 (see Fig. 5 of the OTN proposal). One of the challenges we faced during the report period is the undesirable effect of the seasonal spectral nudging implemented in MD2 on the estuarine plumes associated with freshwater runoff from rivers. After many model sensitivity runs, we decided not to use the spectral nudging method in the

model. The other important modifications for MD2 include (a) extension of the model domain to include the whole bay of Bundy and the Gulf of Maine; (b) calculation of net sea surface heat and freshwater fluxes using atmospheric fields taken from the North American Regional Reanalysis (www.emc.ncep.noaa.gov); and (c) specification of large-scale circulation at the open boundary using the model results produced by MD1. Figure 2 shows the comparison of the sea surface salinity and currents produced respectively by the default version and the new version of MD2 over the GSL and eastern Scotia Shelf. The new version of MD2 performs better in simulating circulation and salinity fields in the St. Lawrence Estuary and over the northwest GSL.

Dr. Daisuke Hasegawa (PDF) and Dr. Jinyu Sheng developed a new two-way nesting technique and tested this new technique in simulating 3D barotropic tidal circulation in the Bay of Fundy (Daisuke et al., 2011). We are currently testing this two-way nesting technique in simulating the 3D baroclinic currents, temperature and salinity in the Bay of Fundy. We plan to use this two-way nesting technique in our multiple nested-grid modelling system.

Shiliang Shan (PhD student) and Dr. Jinyu Sheng recently started to apply a nested-grid modelling system developed early by Shan et al. (2011) to a limited area of the Scotian Shelf to examine main physical processes operating over the region. The first focal area selected for the study is the Gully at the shelf break of the Scotian Shelf (Fig. 3). The Gully contains a rich diversity of marine habitats and species, including deep-sea corals and the northern bottlenose whale. We will use this nested-grid modelling system to investigate the general circulation in the Gully and quantify the influence of the low-salinity estuary water from the Gulf of St. Lawrence and relatively cold and fresh Labrador Current.

Dr. Laura Bianucci (PDF) and Dr. Katja Fennel developed an implementation of the Regional Ocean Modeling System (ROMS) with biological component for the northwestern North Atlantic shelf and adjacent deep ocean (domain MD4 in Fig. 5 of the OTN proposal). Necessary steps included the creation of bathymetry, initial and boundary conditions, and forcing files. Initial and boundary conditions of the physical variables are based on the northwest Atlantic NEMO model (MD1) mentioned above. The ROMS model was then run with different formulations for the treatment of the boundary conditions and for varying horizontal and vertical resolutions and evaluated against observations. An optimal baseline configuration has been determined. With respect to initial and boundary conditions for the biological variables nitrate has been identified as a crucial variable. Since nitrate observations in the deep ocean adjacent to the shelf are scarce the World Ocean Atlas climatology was tested as a possible source. However, serious flaws were found in the horizontal interpolation underlying the World Ocean Atlas for our study region making it an inadequate choice. Instead, individual nitrate profiles from the World Ocean Database are now used to define initial and boundary conditions.

Simulated velocities and sea surface temperatures (SST) after one year of simulation are shown in Fig. 4. The shelf break current transporting cold, fresh and nutrient rich water southeastward is

clearly visible. The model also captures the large scale nutrient gradients accurately as can be seen in the two selected transects of nitrate concentration in Fig. 5. The nutrient transect across the Grand Banks (SEG) shows a nitrate maximum at the shelf break illustrating the importance of the shelf break current in supplying nutrients to shelf ecosystems. Also note the much higher nutrient concentrations in the Labrador Sea at the Bonavista (BON) transect.

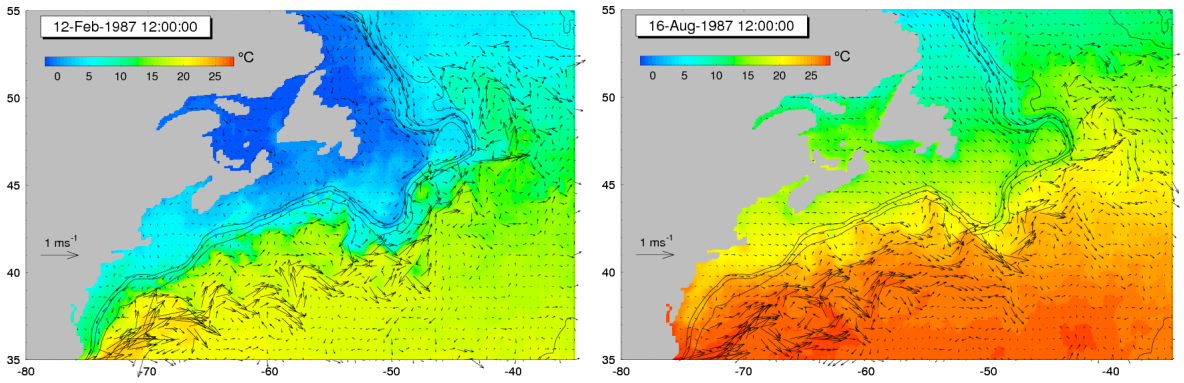


Figure 1: Sea surface temperatures and currents over the northwest Atlantic Ocean produced by the outer-most component (MD1) of the nested-grid modelling system on (a) February 12, 1987 (left) and (b) August 16, 1987 (right).

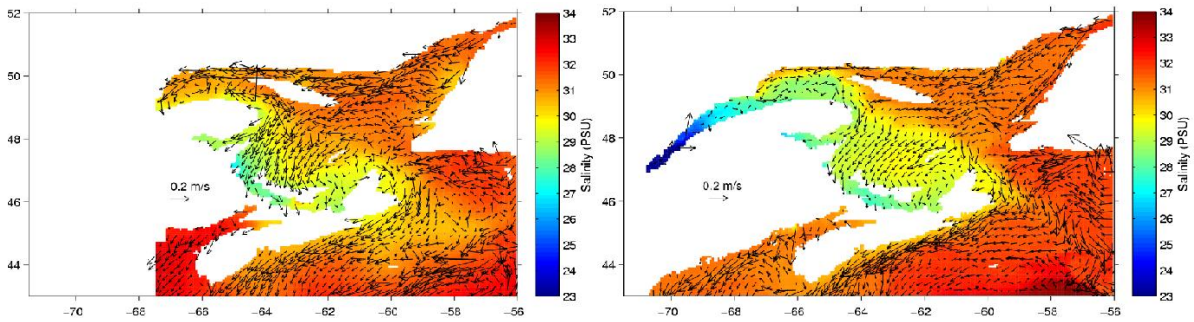


Figure 2: Monthly mean sea surface salinity and currents over the Gulf of St. Lawrence and eastern Scotian Shelf produced by (a) the default version (left) and (b) the new version (right) of sub-model MD2 of the nested-grid modelling system in November 2000. Please note the model domain in the new version of MD2 was extended to include the whole Bay of Fundy and the Gulf of Maine.

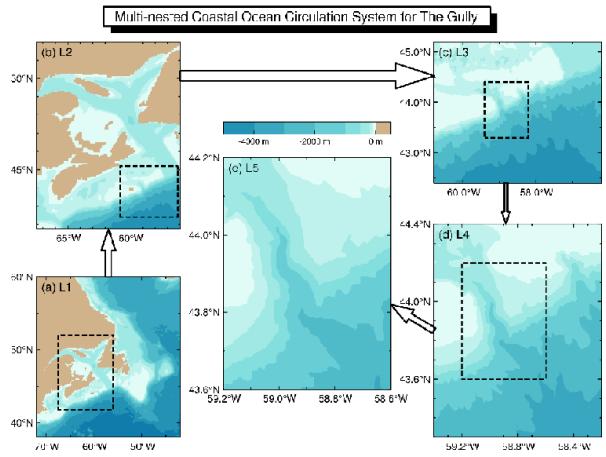


Figure 3: Domains and major topography of a multiply nested-grid modelling system for the Gully of the Scotian Shelf.

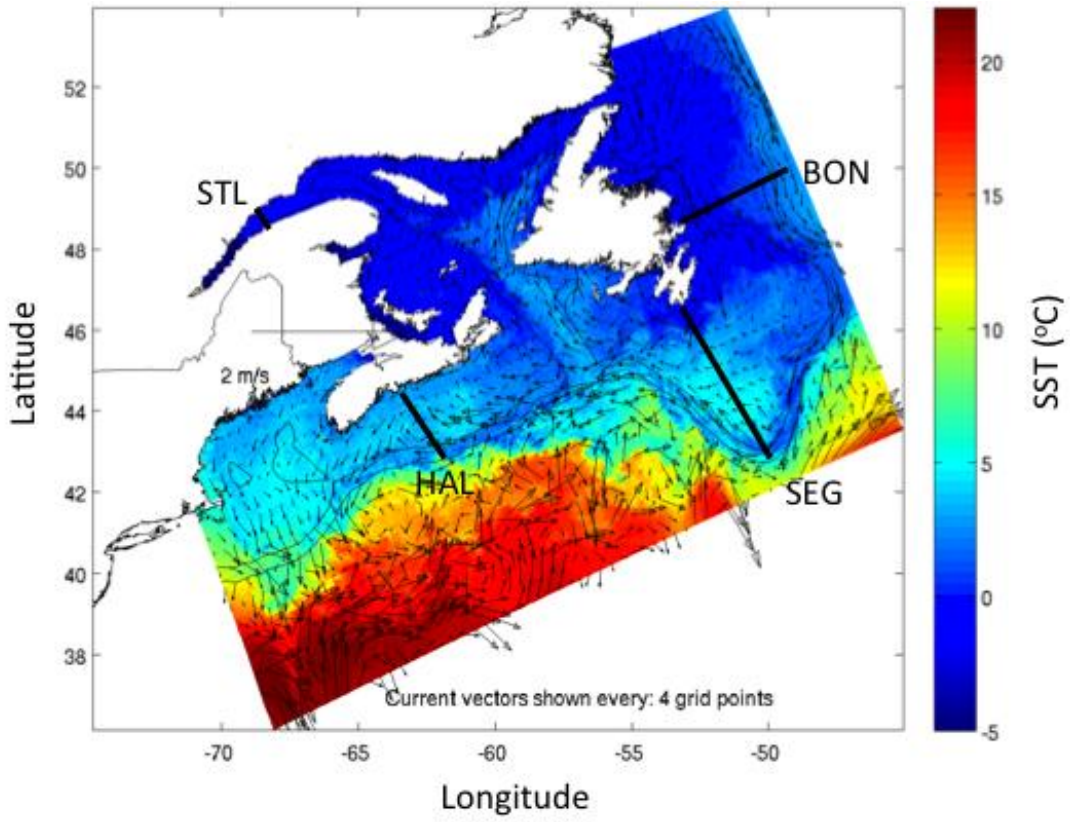


Figure 4: Model domain of MD4. Sea surface temperature is shown in color; arrows depict surface currents on December 29, 1999 (after one year of simulation). Black lines show the location of transects SEG, BON, STL and HAL.

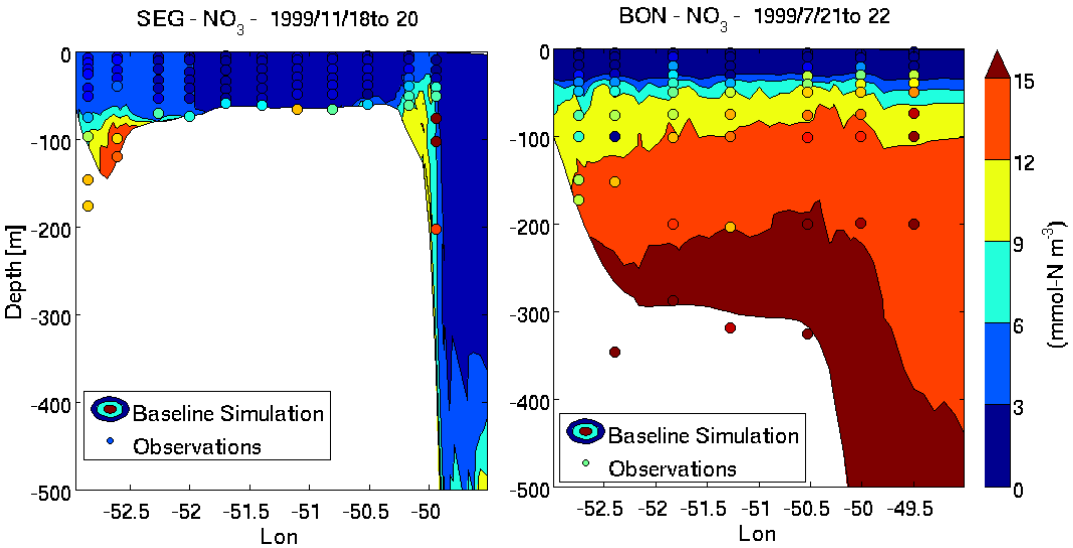


Figure 5: Simulated nitrate distributions (contours) in comparison with observations from the Atlantic Zone Monitoring program (colored dots). Left: transect through the Southeast of the Grand Banks (SEG) in November 1999. Right: transect east of Newfoundland (BON) in July 1999. Locations of transects SEG and BON are shown in Fig. 4.

2. Assessment of performance of the different models using a wide array of observations.

Performance Assessment of sub-model MD1 was made by comparing surface geostropic currents calculated from simulated time-mean sea surface elevations and the currents calculated from time-mean sea surface topography (MSST) constructed from satellite remote sensing data by Higginson et al. (2011). Figure 6 demonstrates that sub-model MD1 reproduces very well the altimetry-derived surface geostrophic currents, particularly the intense surface geostrophic currents associated with the Gulf Stream after its separation point at Cape Hatteras. MD1 also performs reasonably well in simulating the strong poleward geostrophic currents associated with the North Atlantic Current in the deep waters to the east of the Grand Banks and over the northeast corner, and equatorward geostrophic currents associated with the inshore and offshore branches of the Labrador Current over the Labrador Shelf.

Figure 7 presents comparisons of vertical structure of observed and simulated horizontal flow across a transect at the southwestern Newfoundland Slope. The observed currents are the time mean absolute geostrophic velocity normal to the transect calculated by Pickart and Smethie (1998) based on measurements made with the CTDs and acoustic transport floats and measured dissolved oxygen and chlorofluorocarbons between 1983 and 1995. The simulated currents are calculated from model results between 1988 and 2004. Both the observed and simulated currents feature equatorward currents associated with the upper Labrador Sea Water (ULSW, centered at about 800 m) originating from the western Labrador Sea, the classical Labrador Sea water (CLSW, at about 1500 m) originating from the central Labrador Sea, and the Denmark Strait Overflow (DSO, at about 3500 m). Figure 7 also shows the poleward Slope Water Jet (SWJ) cross the transect, which separates the Gulf Stream from the shelf break and from Labrador Sea Water in the top 500 m (Pickart and Smethie, 1998). The SWJ flows in the upper ocean with eastward velocities of the order of 3 cm s^{-1} and extends down to a depth of about 300 m in the northern side and from the surface to about 500 m in its offshore side. Sub-model MD1 reproduces reasonably well the general features of the eastward SWJ and the westward Labrador Current in the upper and intermediate continental slope.

Figure 8 shows simulated and observed monthly mean sea surface temperature (SST) anomalies (with the seasonal cycles removed) over the Scotian Shelf and Slope. The observed SST anomalies were estimated from the satellite remote sensing data by Shadwick et al. (2010). Sub-model MD1 reproduces reasonably well the cooling trend from 1999 to 2005 over the Scotian Shelf. It should be noted that more research work is needed to improve the model skill over the slope water region, where circulation and hydrography is affected significantly by non-linear processes (Urrego-Blanco and Sheng, 2011).

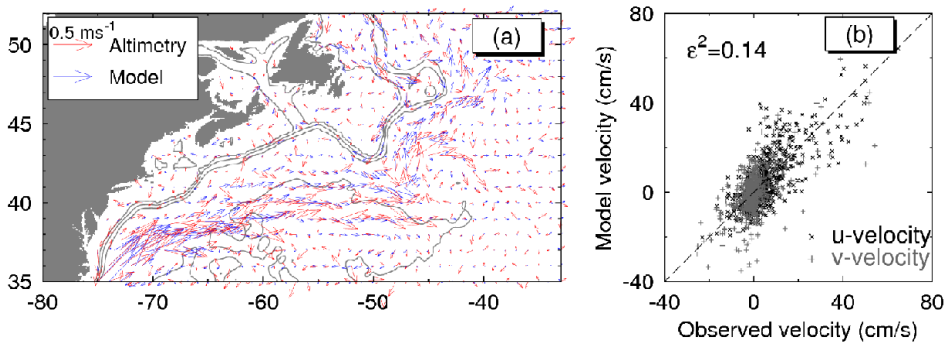


Figure 6: (a) Comparison of time-mean surface geostrophic currents in the 5-year period 2000-2004 calculated from simulated (blue) and altimetry-derived (red) time-mean sea surface elevations (Higginson et al., 2011). (b) Scatterplot of altimetry-derived and simulated time-mean surface geostrophic currents.

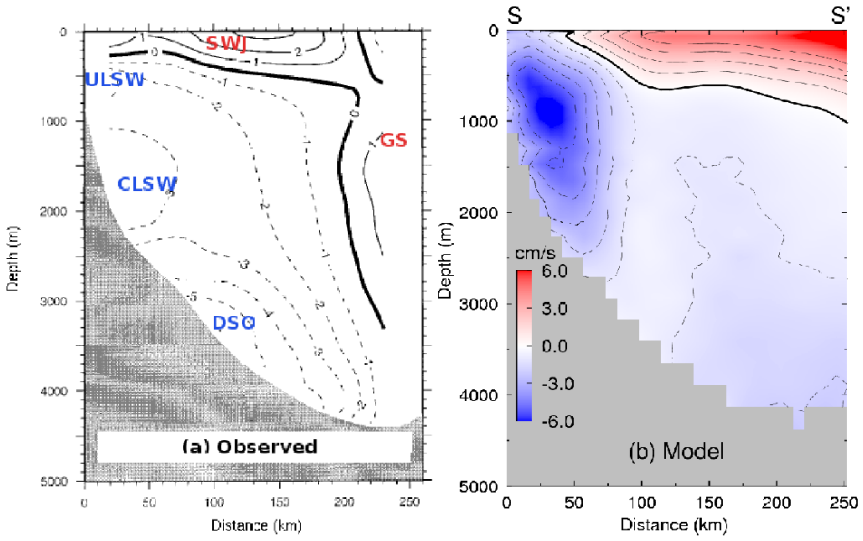


Figure 7: (a) Absolute geostrophic currents estimated from time-mean hydrographic observations at a transect off the southwestern Newfoundland Shelf at approximately 55◦W (Pickart and Smethie, 1998). (b) Time-mean currents normal to the transect computed from model results between 1988 and 2004. Black contour lines indicate velocity contours spaced every 1 cm s^{-1} with the thick black line indicating the zero velocity contour. Abbreviations are used for the Slope Water Jet (SWJ), Upper Labrador Sea Water (ULSW), Classical Labrador Sea Water (CLSW), Denmark Strait Overflow (DSO) and the Gulf Stream (GS).

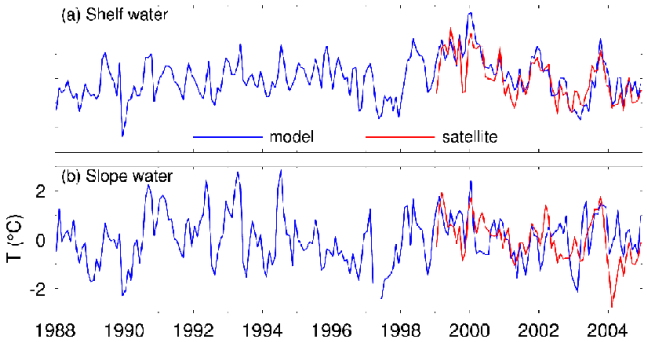


Figure 8: Monthly mean anomalies of sea surface temperature derived from satellite remote sensing data (Shadwick et al., 2010) and calculated from model results for (a) an area over the central Scotian Shelf centered at 44°N and 64°W and (b) an area over the slope Water region centered at 42°N and 60°W.

Initial validation of the physical variables in the ROMS MD4 model by Karl Lagman (PhD student) included comparisons of simulated temperatures and salinities against observations from DFO's Atlantic Zone Monitoring Programme (AZMP). Since the model has 30 vertical layers, the simulated salinity was interpolated to the depths at which observations were made. Quantitative assessment included calculation of the bias and RMSE (smaller absolute values imply better model/data agreement) as well as the correlation coefficient R^2 (values closer to 1 imply better agreement). Figure 9a shows the comparison for the year 1999. There is a slight over-estimation of the observed salinity by the model (bias of 0.19), the RMSE of 0.69 is small and the R^2 of 0.76 is encouraging. Representative spatial components are shown in Figure 9b. There is good agreement for the Halifax transect (HAL) where the model slightly under-estimates the observed salinities. In the Gulf of St. Lawrence estuary (STL) the observed salinity is over-estimated by the model (bias of 3.18), which is a direct consequence of the lack of river input in the current model version. Including river inputs will be one of the next steps.

For validation of biological variables several data sets were obtained including observations from AZMP and satellite products of surface chlorophyll and particulate organic carbon (POC). The satellite observations include data from SeaWiFS and MODIS and were made available by Dr. Kimberly Hyde of the U.S. Northeast Fisheries Science Center (Ecosystem Assessment Program). In addition to these traditionally used data sets, bioprobe data from project I.2.4 *Grey seals* is being analyzed by Karl Lagman with the goal of inferring phytoplankton biomass from light attenuation coefficients. If this avenue proves successful it would provide an important additional data set for model validation and for assimilation into the models.

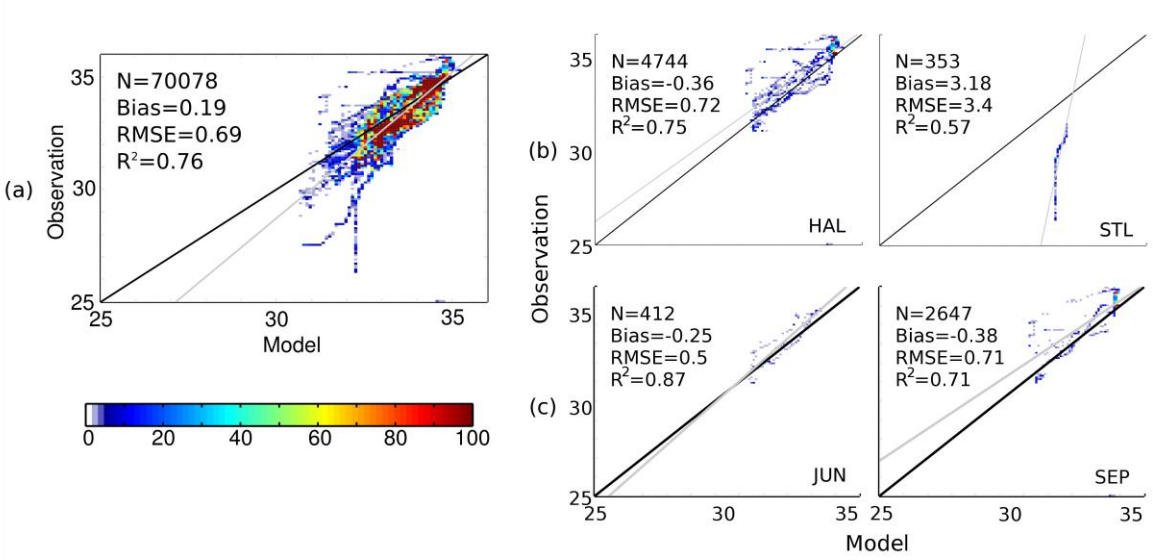


Figure 9. Comparison of simulated salinity from ROMS MD4 model with AZMP transect observations for 1999. All salinity data are shown in (a); data from the Halifax (HAL) and St. Lawrence estuary (STL) transects only are shown in (b); data from the Halifax line for June and September are shown in (c).

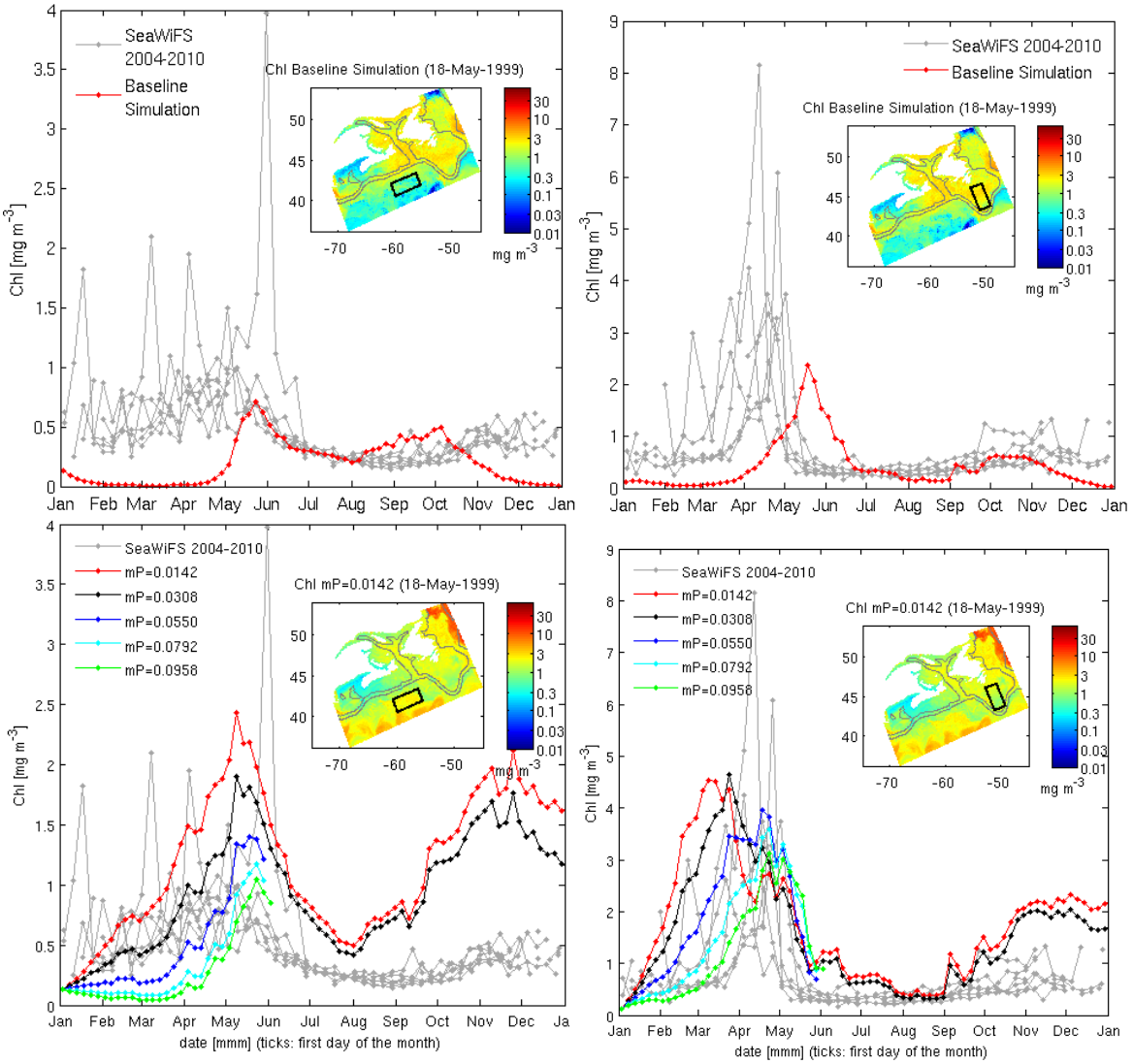


Figure 10: Chlorophyll time series averaged spatially over the area shown as black box in each inset. Red line in top panels: baseline simulation for year 1999. Gray lines: satellite data from SeaWiFS for years 2004 to 2010. The insets show the surface chlorophyll field for the baseline simulation in May 18, 1999. The colored lines in the bottom panels or for different values of phytoplankton mortality (m_P) in units of 1/d.

Initial comparisons between validation data sets and model output were performed for biological variables by Dr. Laura Bianucci (see examples in Figs. 4 and 10). These comparisons revealed an important issue with current biological models in high latitude systems like ours, namely a systematic underestimation of surface chlorophyll in winter. This problem has traditionally been explained as excessive mixing in the physical model. In our case satellite chlorophyll observations are relatively stable in winter at about 0.5 mg m^{-3}, while simulated chlorophyll levels are near 0.01 mg m^{-3} (see left panel in Fig. 10). The reason is that current ecosystem models function according to the 'Critical Depth Hypothesis' of Sverdrup (1953), which is a pillar of marine plankton ecology and assumes that blooms start when stratification reaches a critical depth such that growth

exceeds phytoplankton losses. Moreover, losses are assumed constant with depth and time. Although evidence questioning the generality of this hypothesis has existed for sometime (e.g. Townsend et al. 1992), only recently has a new hypothesis been suggested to could explain phytoplankton winter blooms (Behrenfeld 2010). A systematic study will be carried out to assess the underlying reasons in our model and suggest appropriate model modifications (see below under 4). It is anticipated that results will fundamentally affect the formulation of current biological models.

2. Time-dependent, 3D currents and temperature, salinity, nitrate, ammonium, phytoplankton biomass, chlorophyll and O_2 fields from a non-assimilative hindcast from 2002 to date (~2012) for the Atlantic arena (to be used directly by projects ***I.2.1*** *Atlantic Salmon****, I.2.4*** *Grey Seals, and* ***I.2.5*** *Sea Turtles*).

   Time-dependent, 3D currents, temperature and salinity fields from MD1 are available to all OTN investigators. The model results from sub-models MD2 and MD4 will be available to other OTN investigators soon.

3. Studies of key physical and biological processes over the eastern Canadian shelf seas and of the dynamic interactions of shelf processes and deep water circulation of the northwest Atlantic Ocean (to be used directly by project ***I.2.2*** *American Eels*). Sensitivity studies to changes in initial conditions, surface fluxes and open boundary conditions (e.g. variation in freshwater input from the St. Lawrence estuary).

   Sub-model MD2 has been used in examining the effect of the variation in freshwater discharge from St. Lawrence River on the circulation and hydrography over the GSL and Scotian Shelf. Preliminary model results demonstrate that salinity and currents in the upper ocean over the western GSL and eastern Scotian Shelf are affected significantly by the changes in freshwater discharge from St. Lawrence River.

   As mentioned above, Shiliang Shan and Dr. Jinyu Sheng started working on an application of a 5-level nested-grid circulation modelling system (Fig. 3) in the study of main physical processes operating over the Gully at the shelf break of the southeastern Scotian Shelf. The model results to be produced by this modelling system will be discussed in the next report.

   As mentioned above under 2) we have identified a general problem with current biological models for high latitude systems, namely a systematic underestimation of phytoplankton biomass in winter. The 'Dilution-Recoupling Hypothesis' of Behrenfeld (2009) suggests that the key for biomass accumulation is the coupling and decoupling of predators and prey (i.e., zooplankton and zooplankton). He suggests that the encounter rate between predators and prey is low in a deeply mixed water column, due to the dilution of phytoplankton and zooplankton. Therefore, the grazing pressure on phytoplankton decreases and, although phytoplankton growth decreases due to reduced light availability in winter, positive net growth rates can be achieved. Other working

hypotheses exist. We are addressing this issue in the ROMS MD4 model using an emulator approach as in Mattern et al. (submitted). This approach will allow us to constrain phytoplankton net growth rate through time. A first indication that this approach will be successful is given in the bottom two panels of Fig. 10, where chlorophyll is shown for varying mortality rates (see values of m_P in the panel legends). It is obvious that for smaller loss rates the model is able to reproduce the observed chlorophyll concentrations in winter, yet overestimates chlorophyll in summer as expect (phytoplankton mortality is higher in summer). Products from the glider/optical measurements (project I.1.1) and from the seal bioprobes (project I.2.4) will be used as well in elucidating this issue. This work could lead to a breakthrough in biological modelling of high latitude systems.

4. Derived products that include suitable habitat with respect to O_2 conditions and a characterization of food supply (plankton biomass) for migratory fish (to be used directly by project ***I.2.1*** *Atlantic Salmon*).

Progress is on track to producing these products in year 4.

c) Describe and justify any significant deviations from the original objectives or plans, including any revised goals, new projects, or deleted projects.

None.

d) *Describe how the work of the project's co-investigators and collaborators was coordinated and integrated*.

The projects co-leads Dr. Sheng and Dr. Fennel are working together closely in all aspects of model implementation and validation. For example, the ROMS MD4 model implemented in Dr. Fennel's group is using output from the NEMO models produced by Dr. Sheng's student Jorge Urrego Blanco.

Both, Dr. Sheng and Dr. Fennel, collaborate closely with Dr. Thompson (lead of project I.1.3 *Assimilation Component*) and his group and held joint meetings including the three investigators and their HQP. Karl Lagman, PhD student with Dr. Fennel, has begun the implementation of a data assimilation method for the biological ROMS model and will work closely with Dr. Thompson. In addition to these meetings and individual interactions, a working group involving HQP from this project and Dr. Thompson's project was set up to develop an OTN toolbox which will include available data sets and scripts for validation and comparing of the different model products that are emerging.

Dr. Sheng and Dr. Fennel, also collaborate closely with collaborators from project I.1.1 Advanced Observation Component, specifically with Dr. Cullen on the use of glider data in model validation and Dr. Smith and Dr. Greenan in the analysis and interpretation of ADCP observations from the OTN

moorings on the Halifax Line. In fact, Dr. Sheng and Dr. Smith are co-supervising MSc student Mathieu Dever who is funded through project I.1.1 and Dr. Fennel is a member of his supervisory committee. Dr. Dever and others will participate in activities (including meetings) of the newly instituted Shelf Observations Group (see report of project I.1.1).

e) Describe the benefits of conducting this research as part of a network rather than as a separate project (e.g., scope of the research, cross disciplinary collaborations, new synergies and research opportunities, access to ship time, planning and coordination of research activities, exchange of information and data, benefits to students and technical staff).

The research in the project could not be carries out without the collaboration with projects I.1.1 *Observing Component* and I.1.3 *Assimilation Component*. Cross-disciplinary collaboration between this project and projects I.2.1 *Atlantic Salmon*, I.2.2 *American Eel*, I.2.4 *Grey Seals* and I.2.5 *Sea Turtles* would not be possible without the network. It should be noted that there is a two-way interaction between this Theme 1 project and projects in Theme 2. On the one hand, model output will be used by Theme 2 investigators. On the other hand, information from Theme 2 guides model design decisions (e.g. which level of spatial resolution is to be used for the innermost model nests) and provide observations for model validation and improvement (e.g. bioprobe observations of temperature and light, the latter as a proxy of phytoplankton biomass).

The benefits to students and postdoctoral fellows are tremendous. For example, Mélanie Beguer (I.2.2 American Eel) from the Université Laval will spend time at Dalhousie this fall to become more familiar with model products and gain basic modeling skills directly applicable to her project. Students and PDFs from this project learned about tagging technology and best practices during workshops held in conjunction with the Annual OTN Meeting in June 2011.

f) Describe the scientific and/or engineering significance of the results to date.

Development of the suite of coupled physical-biological models for the northwest Atlantic Ocean is of scientific significance for understanding the effects of physical, biological and ecological conditions on animal migrations. These models are state-of-the-art research tools for use by the OTN community and beyond.

Products are already available from the MD1 model, namely an 18-year reconstruction of the 3D physical conditions of the Northwest Atlantic Ocean, and are of scientific importance not only for this project but also for the broader research community.

6. Difficulties encountered

a) Identify the main difficulties encountered in carrying out the research during the reporting period from the list below:

- ❑ Scientific problems/difficulties
- ❑ Equipment and technology issues (e.g., delivery and malfunctioning of equipment, etc)
- ❑ Personnel problems
- ❑ Involvement of partners
- ❑ Other (specify): _____
- ❑ No problems occurred during this instalment of the grant

b) For each checked box, describe the difficulties identified above and the steps taken to resolve them.

None.

7. Networking and outreach

Discuss the extent of networking and outreach by the project, both within the OTN Canada Network and with the broader community, by co-PIs, collaborators and HQP. Describe how the project's research has been impacted by, and contributed to, the research carried out by other projects from across the Network.

Intra-Network Collaboration and Partner Meetings

PIs, collaborators and HQP attended the Atlantic Arena Meeting in April 2011 in Halifax. The meeting brought together most PIs working in the Atlantic arena and their HQP. The format included brief presentations from all seven Atlantic Arena projects (including this) updating participants about the current status and results obtained so far. Talks were followed by extensive discussions about project integration and synergies. Several important avenues were identified.

PIs, collaborators and HQP attended the Annual OTN Meeting in June 2011 in Halifax as well as some of the OTN workshops that were held in conjunction. Dr. Fennel gave one of the three plenary talks at the meeting and all HQP on this project presented their work. Many opportunities for informal discussions arose as well.

The PIs and HQP on this project and project I.1.3 *Data Assimilation* met in September 2011 in order to review progress and refine plans for collaboration. The meeting was led by HQP who gave short presentations followed by extensive discussions. One noteworthy outcome of this meeting was the

formation of a Group for Model Validation consisting of HQP from different projects. The aim of this group is to develop an OTN Modeling Toolbox to be made available to collaborators.

PIs met with PIs and HQP of project I.2.4 *Grey Seals* to discuss use of bioprobe data for modeling as well as the transfer of first sets of model output (course resolution) to the I.2.4 investigators.

Discussions are ongoing with PIs and HQP on project I.2.2 American Eel and a visit by student Mélanie Beguer (from I.2.2) to Dalhousie University is planned for the fall of 2011.

Meetings with the PIs of projects I.1.1 and I.1.3 occur frequently and PIs from all three Theme 1 projects are involved in the guidance of HQP, for example by serving on students committees.

HQP and PIs from this project submitted abstracts for presentation in Special Session "Integrating Oceanography and Animal Tracking: The Ocean Tracking Network" at the international Ocean Sciences Meeting in Salt Lake City in February of 2012.

While the above list should be taken as an illustration rather than an exhaustive account of the many interactions within the Network.

Interaction/Outreach to Broader Community

We have connections to the tidal energy research community in the Bay of Fundy. Specifically, our experience and knowledge of using the new two-way nesting technique developed by Dr. Hasegawa and Dr. Sheng in the nested-grid modelling system for the OTN project will be useful for the tidal energy research community in the Bay of Fundy.
We also have strong interactions with the GOAPP community in examining the interannual variability of physical conditions over the northwest North Atlantic ocean based on model results produced by MD1 and strong connections with the scientific community in Canada in developing circulation model using NEMO.

8. Dissemination of information and results

List refereed journal articles (accepted/published, submitted) and conference presentations (invited, contributed). All other dissemination is included in section #9 (Other contributions and deliverables).

Note: Deliverables from collaborators are listed in their respective reports and not repeated here.

Refereed Journal Articles (1 total)- *Accepted/Published*

Shan, S., Sheng, J., Thompson, K.R., Greenberg, D. (2011). Simulating three-dimensional circulation and hydrography of Halifax Harbour using a multi-grid coastal circulation model. Ocean Dynamics, 61, doi:10.1007/s10236-011-0398-3, 951-976.

Refereed Journal Articles (2 total)- *Submitted*

Mattern, P., Fennel, K., Dowd, M., Estimating time-dependent parameters for a biological ocean model using an emulator approach, manuscript submitted to Journal of Marine Systems

Urrego Blanco, J., Sheng, J. (2011) Numerical investigation of interannual variability of circulation and hydrography over the eastern Canadian Shelf. Atmosphere-Ocean (resubmitted).

Invited Conference and Seminar Presentations (1 total)

Iverson, S. J., Lidgard, D. C., Bowen, W. D., Jonsen, I.D., Fennel, K. (submitted) Bioprobes and receivers in the Ocean Tracking Network (OTN): Grey seals as biological and oceanographic samplers, 2012 Ocean Sciences Meeting, February 20 – 24, Salt Lake City, UT.

Contributed Conference Presentations (7 total)

Bianucci, L., Fennel, K., Urrego-Blanco, J. (2011a) Modelling the continental shelf of Atlantic Canada, 45th CMOS congress, June 5 – 9, Victoria, poster presentation

Bianucci, L., Denman, K., Fennel, K. (2011b) Effect of sedimentary denitrification on near-bottom oxygen concentrations, 45th CMOS congress, June 5 – 9, Victoria, oral presentation

Bianucci, L., Fennel, K., Mattern, J.P. (submitted) An emulator approach for constraining net phytoplankton growth rates in the North Atlantic in winter, 2012 Ocean Sciences Meeting, February 20 – 24, Salt Lake City, UT

Lagman, K.B., Bianucci, L., Fennel, K. (2011a) Application of spectral nudging to NPZD-type models, 45th CMOS congress, June 5 – 9, Victoria, poster presentation

Sheng, J., Ohashi, K. (submitted) Numerical study of circulation and particle movements in the Gulf of St. Lawrence and Scotian Shelf, 2012 Ocean Sciences Meeting, February 20 – 24, Salt Lake City, UT

Shan, S., Sheng, J. (2011a) Application of a nested-grid ocean circulation model for investigating circulation, flushing time and dispersion in Halifax Harbour and adjacent water. 15th International Workshop on Physical Processes in Natural Waters: Fluids and Environments, Burlington, Ontario.

Shan, S., Sheng, J. (2011b) Application of a multi-nested ocean circulation model for investigating circulation, flushing time and dispersion in Halifax Harbour and adjacent waters. 45th Annual CMOS Congress, Victoria, Canada.

9. Other contributions and deliverables

Radio or television interview or contribution to a programme/documentary, etc.

- On June 8, 2011 Dr. Fennel was guest on CBC's Halifax Morning Show "Breakfast TV" and was interviewed about ongoing initiatives related to ocean science including the OTN Network.

Invited or contributed presentation/contribution at a workshop.

Fennel, K. (2011) OTN Atlantic Arena: Integrating oceanography and animal tracking, 1st OTN Symposium, June 1 – 3, Halifax, invited plenary presentation

Bianucci, L., Fennel, K., Urrego Blanco, J. (2011c) Modeling the continental shelf of Atlantic Canada, OTN-Canada Meeting, June 1 – 3, Halifax, poster presentation

Lagman, K.B., Bianucci, L., Fennel, K. (2011b) Testing the Application of spectral nudging to biological models, OTN-Canada Meeting, June 1 – 3, Halifax, poster presentation

Lagman, K.B., Bianucci, L., Fennel, K. (2011c) Application of spectral nudging to NPZD-type models, Conference of Dalhousie Oceanography Students, March 18, Halifax, oral presentation

Invited or contributed presentation/contribution at a seminar series.

- Dr. Fennel was nominated by the Canadian National SCOR Committee as one of two speakers in the 2010 Coast-to-Coast SCOR seminar series. Between November 29 and December 3, 2010 she gave six presentations at Universities and Government Institutions (in Edmonton, Victoria, Nanaimo, Vancouver and Winnipeg) reporting on ongoing work within the Network.

Invited or contributed presentation/contribution at a conference (not listed under section 8 above).

- Dr. Fennel has been invited to join the scientific organizing committee of the 46th Annual CMOS Congress in 2012 in Montreal and is organizing a session at the international 2012 Ocean Sciences conference in Salt Lake City, Utah, thus facilitating the showcasing of Network results to the broader national and international community.
- Dr. Jinyu Sheng was the primary co-convener for the special session of "coastal Oceanography and Inland Water" of the 45th annual CMOS Congress in 2011 in Victoria.

Data reports, technical reports, manuscript reports, advisory documents, briefing notes, handbook or guide, checklist, barcode, CTD casts, Glider runs, and/or data deposition to an agency/database (e.g., MEDS, GenBank, OBIS, etc.), as well as a contribution to a larger piece of work in any of the former.

- Model products from MD1 have been available to the OTN community and beyond (upon request).

Invited or contributed consultation with an agency; public or private

- Dr. Fennel is serving as member of the IMBER/LOICZ Continental Margins Task Team (CMTT), which is part the International Geosphere Biosphere Program (IGBP). She is co-organizing the 2012 CMTT meeting in June in Halifax, which will allow for interaction of international CMTT members with Network researchers in the Halifax area, as well as showcasing Network science to these international guests. Dr. Fennel was recently invited as a member of the Working Group for Model Development within the international Climate Variability and Predictability (CLIVAR) project, which

was established by World Climate Research Program (WCRP). She was invited with the expressed objective of involving ecosystem modeler in a group traditionally dominated by atmospheric and physical oceanography scientists.

- Dr. Jinyu Sheng was chosen as a member for the Selection Committee for A.G. Huntsman Award for Excellence in Marine Science.

Leveraging your research/funds in order to make a new contribution to another initiative

- The ongoing OTN Network research was an important lever in the application for a Network of Centers of Excellence entitled "Marine Environmental Observation, Prediction and Response" (MEOPAR) that submitted in August 2011 and is led by Dalhousie scientists. Both, Dr. Fennel and Dr. Sheng, contributed significantly to the preparation of the proposal. The MEOPAR research plan relies on results currently produced by the OTN Network and, vice versa, will benefit OTN Network activities if funded.
- Our research team research also made an important contribution to the research program funded by the Lloyds Register Education Trust (LRET) in estimating extreme currents over the Northwest Atlantic Ocean from results produced by MD1. The LRET research program is an international network focused on modeling and prediction of marine extreme events.

A new technology, method, protocol, measure, analytical technique, algorithm, operational or numerical model, or predictive tool. Include the validation of any of the former and their practical application.

- A new method for two-way nesting was developed which is very useful for the development of nested grid circulation models.

Contribution as expert witness or expert panelist (COSEWIC, EIA).

In 2011 Dr. Fennel served twice as expert panelist for international agencies. In January 2011 she was member on a NASA ROSES panel in Washington, DC, evaluating proposals for the 2011 competition. In September she was member of an evaluation panel by the German Research Foundation evaluating the possible renewal of Sonderforschungsbereich 754 at the Institute for Marine Science/GEOMAR in Kiel, Germany.

10. Collaborations with Industrial and Government Partners

a) Please describe which partners are actively involved in management, research, and knowledge transfer within the network and the specifics of their involvement.

DFO scientists Dr. Peter Smith, Dr. Blair Greenan and Dr. David Hebert are actively involved in this project making available observations form the Halifax Line and other DFO monitoring programs (e.g.

AZMP) and a PhD student (Mathieu Dever) is jointly supervised. In turn our research products will be available to scientist and managers at DFO with interactions facilitated by our DFO collaborators.

b) Cash and in-kind contributions from partners for year 2

Name of supporting organization:	**Year 2** 2011
Cash contributions to direct costs of research	
In-kind contributions to direct costs of research	
1) Salaries for scientific and technical staff	
2) Donation of equipment, software	
3) Donation of material	
4) Field work logistics	
5) Provision of services	
6) Other (specify): _____	
In-kind contributions to indirect costs of research	
1) Use of organization's facilities	
2) Salaries of managerial and administrative staff	
3) Other (specify): _____	
Total of all in-kind contributions	

No in-kind support for Atlantic I.1.2

11. Expenditures and Support

Expenditures and support for Atlantic I.1-3 are reported and explained in a singular financial budget at the end of this Oceanography report (please see page 72).

References

Behrenfeld, M., Ecology 91, 977–989 (2010).
Higginson, S., et al., J. Geophys. Res. 116, doi:10.1029/2010JC006877 (2011).
Large, W., Yeager, S., Tech. Report TN-460+STR, NCAR, (2004).
Madec, G.,Institute Pierre Simon Laplace, France, No 27 ISSN: 1288-1619 (2008).
Mattern, J.P., et al., submitted to J. Mar. Sys.
Pickart, R., Smethie, W., Deep-Sea Res. 45, 1053-1083 (1998).
Shadwick, E., et al. Biogeosciences. 7, 3851-3867 (2010).
Smith R.D., et al. J. Phys. Oceanogr. 30, 1532-1561 (2011).
Sverdrup, H.U., ICES J. Mar. Sci. 18, 287–295 (1953).
Townsend, D., et al., Nature 360, 59–62 (1992).

Atlantic Arena I.1.3

1. Project Number: I.1.3

2. Project Title: Integrated Interdisciplinary Observing and Modeling Platform – Data Assimilation

3. Project Leader(s): K. Thompson (Dal U)

Collaborator(s): J. Sheng (Dal U), K. Fennel (Dal U) and J. Cullen (Dal U)

4. Training of Highly Qualified Personnel:

a) List of the HQP and level of their salary support by SNG.

Personnel	*Title*	*%Time involved in project*	*% Supported from SNG*	*Dates*
Anna Katavouta	PhD	100	100	September 2010 to September 2014 (planned)
Vasily Korabel	RA	100	100	February, 2011 to September 2014 (planned)

b) Explain the role, activities and opportunities for training of technical staff in your project.

Although no technical staff are employed directly by this project, we have interacted over the reporting year with technicians supported by project I.1.1 (Advanced Observing Component). Most of the interactions have focused on providing short-term forecasts of ocean currents on the Scotian Shelf and adjacent shelf waters that will be used to guide the deployment and control of the ocean gliders. Through this interaction the technicians (specifically J. Pye and R. Davis) are gaining experience in dealing with output from complex, data assimilative forecasts ocean models and using such information in glider mission planning.

5. Progress towards Objectives/Milestones (1 Oct 2010 – 30 Sep 2011)

a) Please provide brief description of the overall objectives of this project (max ½ page).

The main objective is to develop effective and efficient methods for assimilating physical, biological

and chemical data, collected by fixed and mobile observing platforms, into realistic models of the shelf and deep ocean. The time scales of interest are hours to decades, and space scales of interest are 1 to 10^3 km. The physical data to be assimilated include remotely sensed surface temperature, coastal sea level and *in situ* measurements of bottom pressure, current, temperature and salinity from the Halifax Line. We also plan to assimilate physical data from gliders and bioprobes as they become available.

This project has the following deliverables:

(1) Development of modular FORTRAN codes for assimilating a wide range of physical, biological and chemical data into shelf and deep ocean models;

(2) Assessment of the performance of the assimilation schemes;

(3) Generation of realistic historical reconstructions (and climatologies) of currents, temperature, salinity, nitrate, ammonium, phytoplankton biomass, chlorophyll and oxygen fields from an assimilative hindcast from 2002 to date through assimilation of various observations.

The milestones for years 1 and 2 are to "*develop and validate methods for assimilating satellite measurements of surface temperature and in situ physical data from fixed platforms into models MD2 and MD3. … We will focus initially on the coarser resolution model (MD2)*." Note the MD2 model covers the Scotian Shelf, Gulf of Maine, and Gulf of St Lawrence; the MD3 model domain is embedded within MD2 and centered on the Halifax Line.

The milestones for years 2 and 3 are to *"develop and validate methods for assimilating satellite measurements of surface color and in situ biological and chemical data from fixed platforms … . We will also develop and evaluate schemes for assimilating physical, biological and chemical data from moving platforms (gliders and bioprobes) into the higher resolution models centered on the Halifax Line … "*

b) Describe progress towards meeting the project's objectives and specific milestones for the project.

Coastal Forecast System for the Scotian Shelf: Refinements have been made to the DalCoast ocean forecast system (MD2 domain) in order to assimilate remotely-sensed sea surface temperature (SST) images into a fully nonlinear, baroclinic (temperature and salinity evolve with time) shelf model. The model is based on the POM code and includes tides, and open boundary forcing that comes from a large-scale storm surge forecast model of the Northwest Atlantic. The assimilation system is based on the ensemble optimal interpolation (EnOI) scheme outlined by Oke et al. (2008).
The forecast skill of the coastal forecast system is demonstrated in Figure 1 which compares the SST observed from a wave buoy at the mouth of Halifax Harbour with 24 hour forecasts of SST for the same

location for days 245 to 277 of 2011. The agreement during this period is quite reasonable; the differences are typically less than 2C.

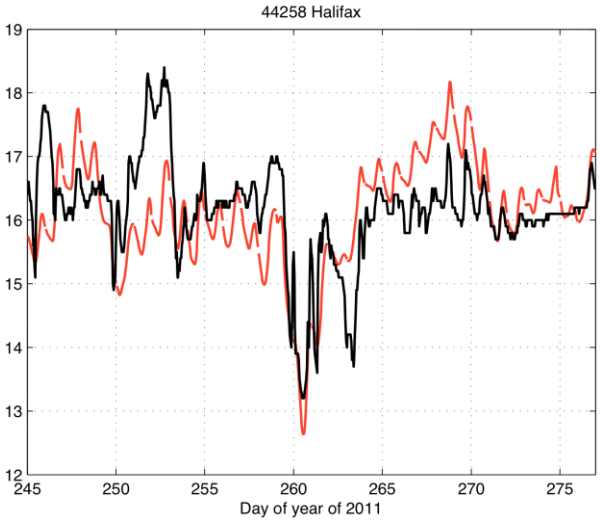


Figure 1: Comparison of observed (black line) and forecast (red line) SST at the entrance to Halifax Harbour from day 245 to 277 of 2011.

A snapshot of the forecast SST for the complete MD2 domain for day 277 of 2011 is shown in Figure 2. Note that the forecast has no gaps unlike the observed satellite images that are generally patchy due to the presence of clouds**.**

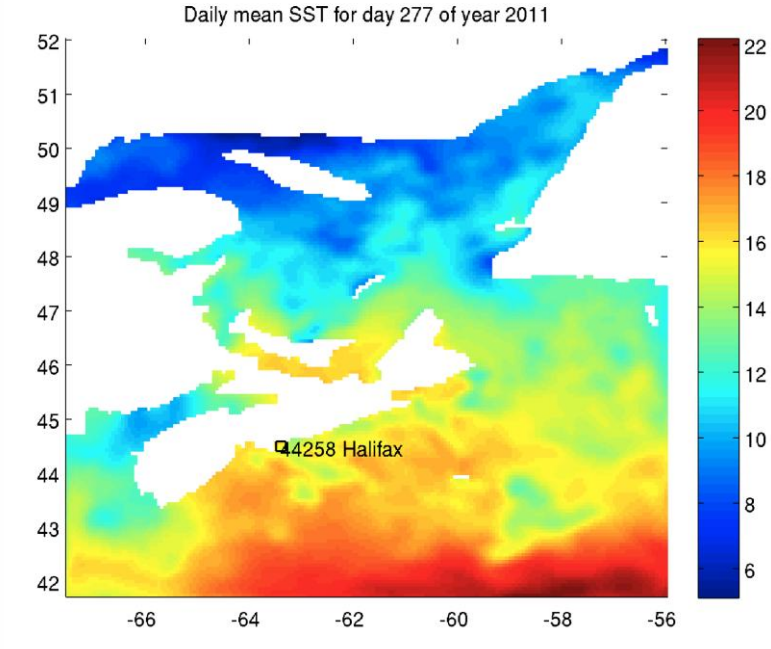


Figure 2: One day forecast of SST for day 277 of 2011 from DalCoast.

The output from the DalCoast model (including ocean currents) is in the process of being made available to technicians John Pye and Richard Davis from project I.1.1 (Advanced Observing Component) for glider mission planning.

Development of a Data Assimilative Model of the North Atlantic: In order to include the influence of the adjacent North Atlantic on the circulation and hydrographic state of the adjacent shelf seas, and also model the impact of ocean conditions on the basin scale migrations of animals such as the American eel, Research Associate Vasily Korabel is developing a data assimilative, eddy permitting model of the North Atlantic. The model covers the whole of the North Atlantic with a horizontal resolution of ¼ degree and has a high resolution, nested sub-model (resolution of 1/12 degree) covering the Northwest Atlantic. (The resolution of the coarse grid is eddy permitting and the resolution of the high-resolution nest is eddy resolving, which is important for accurate modeling of the currents in coastal regions.) The model is based on the NEMO code (developed in France). The assimilation scheme is multivariate based on EnOI.

The main goals of this activity are (1) assimilate a variety of data streams (e.g., sea surface height, vertical profiles of temperature and salinity measured by Argo floats, SST from satellites) into the two way nested North Atlantic model; (2) assess the impact of the assimilation of observations into the coarse model on the predictive skill of the nested fine model, and vice versa.

During the reporting year, a long 15-year hindcast run has been performed using the two-way nested grid model of the North Atlantic. The results of the hindcast run are being used to estimate the background error statistics from an ensemble composed of 190 model anomalies. The background error covariances vary seasonally in both magnitude and spatial structure. Figure 3 shows a correlation map between the SST at a point on the Scotian shelf (marked with cross) with SST from all other model grid points. Note the strong dependence of the correlation on the orientation of the coastline and bathymetric contours, highlighting the need to use non Gaussian correlation structures when assimilating ocean data.

A parallel version of the multivariate EnOI assimilation code has been developed during the reporting year and it is presently being tested. New, high quality observations of SST from the GHRSST project have been assimilated into the North Atlantic model (1/4 degree version). This data stream combines observations from multiple satellites and, in comparison with earlier (Pathfinder) SST images, has very good spatial coverage.

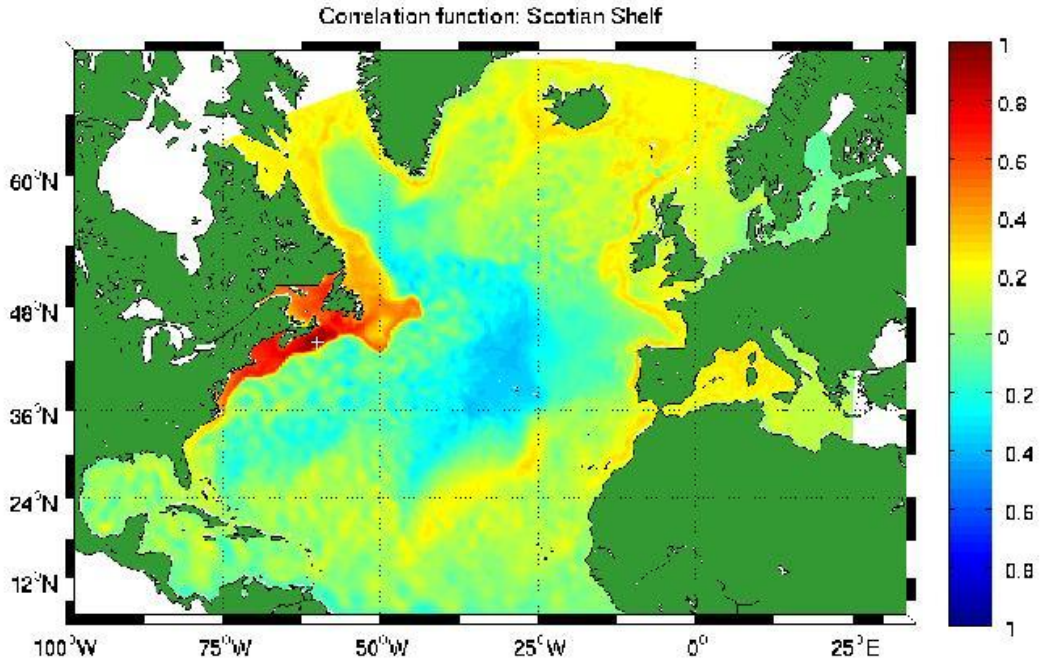


Figure 3: Correlation map of SST on the Scotian Shelf (location shown by white cross) with SST from all other model grid points. Based on the 15 year predicted SST fields.

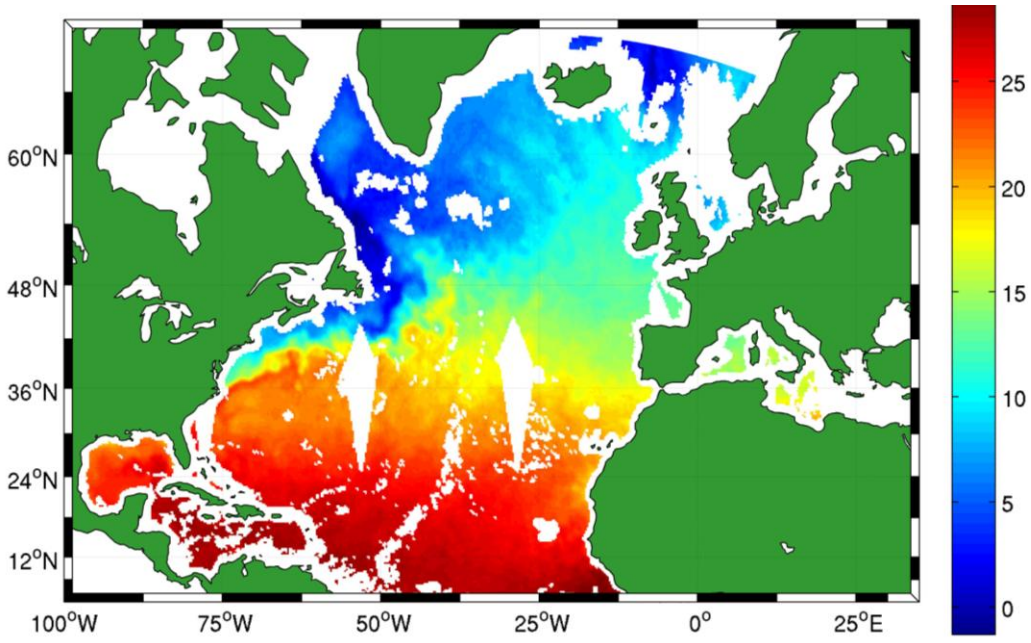


Figure 4: Observed SST for 1-5 January, 2004 from the GHRSST project.

An initial study has been performed to assess the data assimilation scheme performance using two different sets of SST observations (Pathfinder and GHRSST). The use of new data has significantly improved the predictions. (See Figures 4 and 5 for the observed SST and the model analysis, after the observations have been assimilated.)

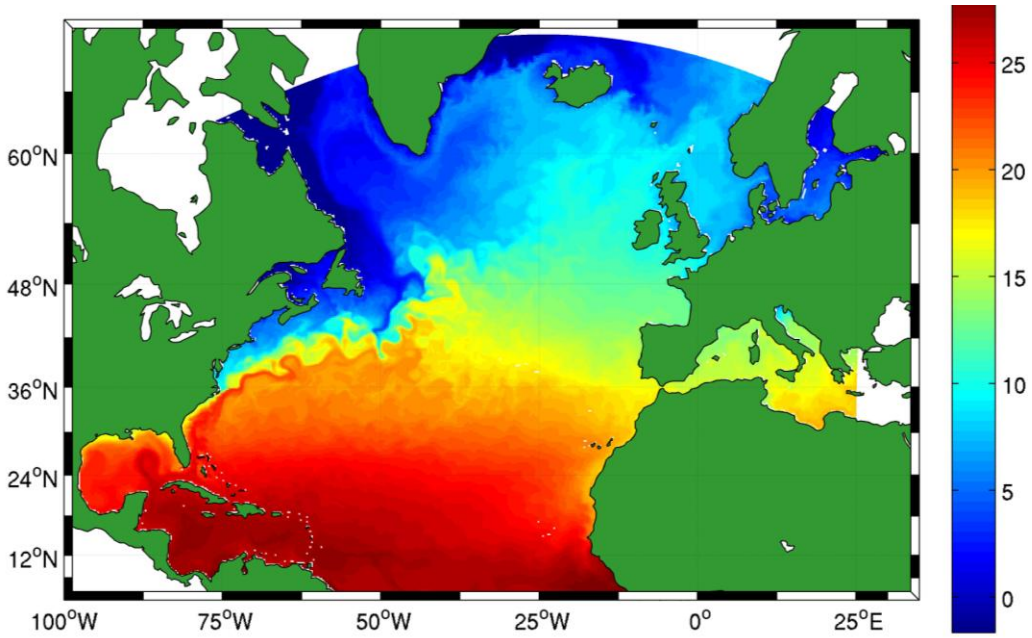


Figure 5: Predicted SST for 1-5 January, 2004 resulting from the assimilation of GHRSST data.

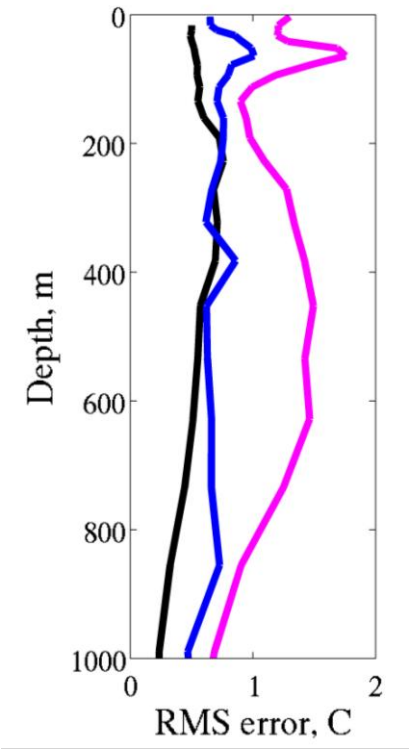


Figure 6: Standard deviation of water temperature as a function of depth in the vicinity of the Gulf Stream. The purple line shows the standard deviation of observed temperature (from the Argo floats) about the seasonal climatology. The black line shows the standard deviation of the prediction errors of the model that assimilates GHRSST SST data. The blue line is similar to the black except that it is based on assimilation of the lower quality Pathfinder SST images (leading to generally larger prediction errors at depth).

The quality of the assimilation scheme has been assessed by comparing the model's predictions with observations that were not assimilated. Figure 6 shows how well the assimilative model can reconstruct subsurface temperature. The prediction error has a standard deviation of about 0.5C and is significantly less that the standard deviation of the observed profiles about the climatology.

Given that Research Asociate V. Korabel only started in Februray of 2011, progress on the development of a data assimilative model of the North Atlantic, with a high resolution nested sub-model focused on the Northwest Atlantic and adjacent shelf seas, has been excellent.

Downscaling of Information from Large Scale Models to Higher Resolution Local Models: In order to project information from the coarser grid, North Atlantic models to the finer model grids (spacing of several km) needed to interpret the observations collected by OTN, it is necessary to develop innovative ways of "downscaling" in such a way that one extracts the maximum amount of information from all observations and the dynamics represented on both model grids (coarse and fine). This is a difficult problem and is more difficult that just imposing open boundary conditions on a fine scale "inner" model based on predictions from a coarser "outer" model.
Graduate student Anna Katavouta is developing ways of downscaling information from larger scale models, and also effective and efficient schemes for assimilation a range of ocean observations including those made by gliders. She is tackling a number of technical challenges including the high non linearity of the dynamics represented by the fine scale model, and the relatively small ensemble sizes available for the EnOI assimilation.

Anna Katavouta has been with OTN since September 2010 as a PhD student. Over the last academic year she has had to focus on coursework and has now completed 7 graduate courses. (She has just been co-awarded the Kathy Ellis Memorial Prize for obtaining the best course marks in the Department of Oceanography with another OTN graduate student, Fran Broell).

Anna has also started research based on a simplified (quasi-geostropic, QG) ocean model since the completion of coursework in April 2011. The first part of her research has been to explore the impact of localization of the ensemble on the effectiveness of EnOI. She conducted an experiment in which pseudo sea level observations generated by the QG model were assimilated into the same model with the wrong initial condition. As shown in Figures 7 and 8, the EnOI assimilation method provides sea levels that are in good agreement with the "true sea level" when a large number of ensemble members is used.

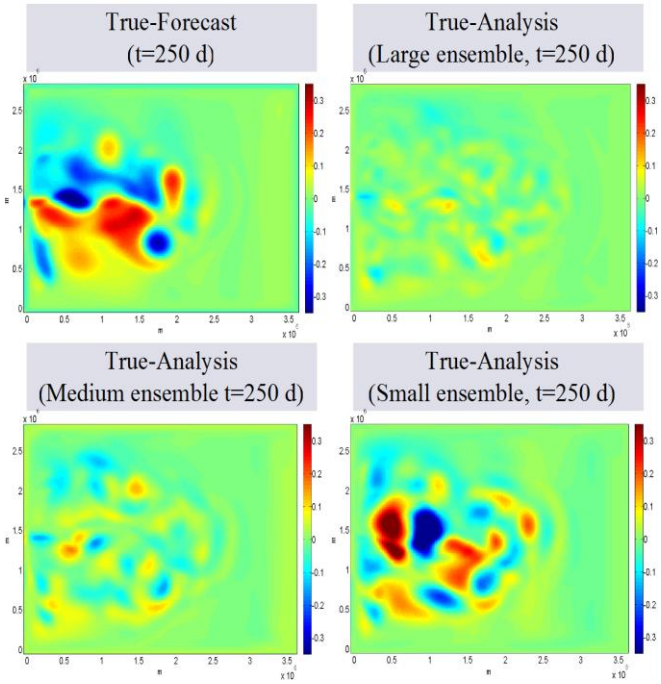


Figure 7: Snapshot of the sea level difference between the truth and the prediction from the model with no assimilation (top left), using 88 ensemble members (top right), 27 ensemble members (bottom left) and 14 ensemble members (bottom right). Note reducing the ensemble size increases the error.

However, as the ensemble size decreases, the discrepancies between the analysis sea level and the true sea level increase (Figure 8). In fact, if the ensemble size is too small, the assimilation does not produce better results than the simple forecast.

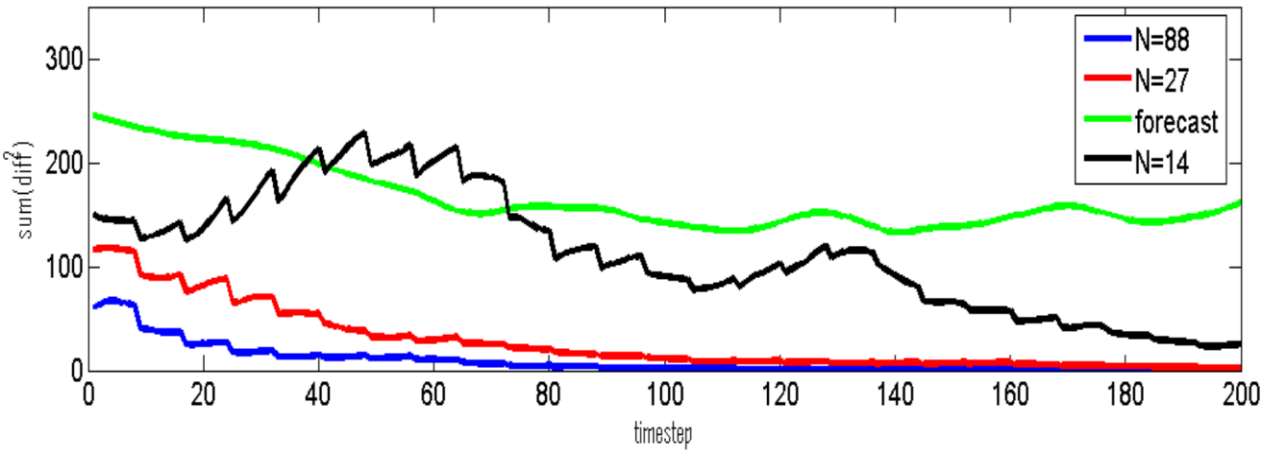


Figure 8: The total squared error (i.e., the squared difference between the truth and the prediction, squared and summed over all grid points) for different ensemble sizes as a function of time. Note the assimilation drives the model more quickly to the true state as time advances. N is the ensemble size.

To compensate for the small size ensemble, localization of the ensemble members was used. Using localization, adequate sea level fields were obtained with minimum computational cost (Figure 9). The above results indicate that EnOI with localization can be used in more complicated models and data types (e.g., information from gliders), which is our next target.

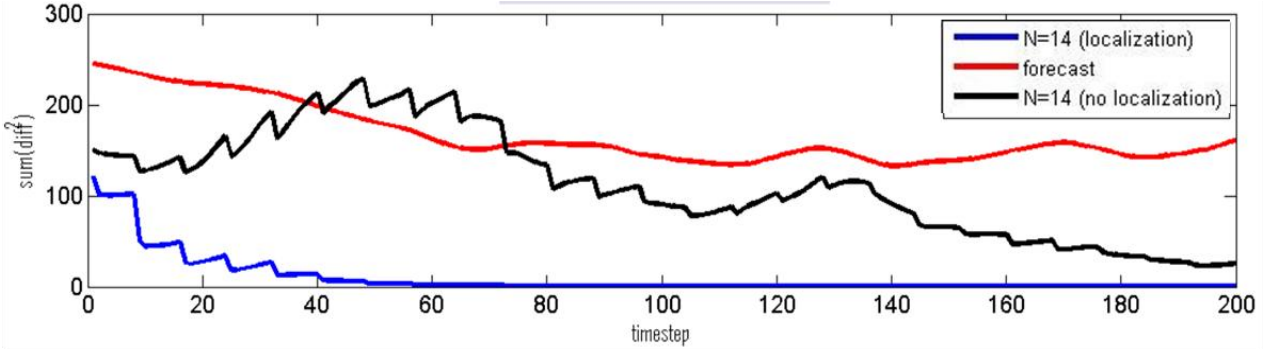


Figure 9: Same format as Figure 8 but for an ensemble size of 14, with and without localization. Note that an ensemble size of 14 can be effective (error drops quickly to zero) if localization is used.

The second part of Anna's research has focused on the more challenging task of developing a data assimilation technique that takes advantage of the non-linear coupling between different scale ocean variability due to nonlinear dynamics. Using again results from the QG model, she was able to reconstruct the small-scale variability by using information extracted from the large-scale. In more detail, only a few first Fourier modes (corresponding to large scale motion) and a simple linear regression model was shown capable of reproducing a large fraction of the small scale eddies (Figure 10). This suggests that we can develop a method where the large scale motion (from large scale circulation models) can be assimilated into the local models which will then correctly reproduce the small scale variability resulting from the more accurately represented nonlinear dynamics on the finer grid.

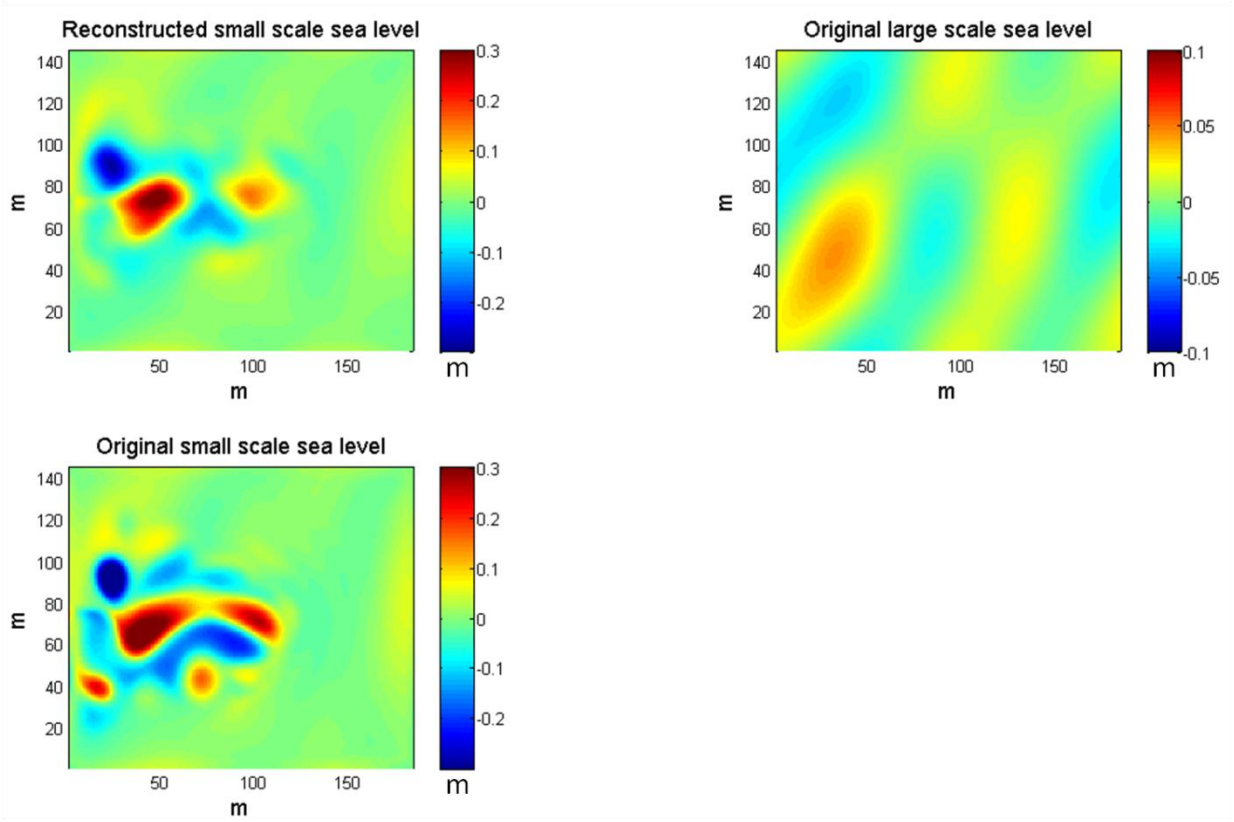


Figure 10: Snapshot of the reconstructed small scale sea level field (top left) reconstructed from knowledge of the large scale features of the sea level field at the same time (top right). The original small-scale sea level field is shown in the bottom left panel. Note the agreement between the two left panels indicating that much of the small-scale variability in the QG model can be predicted from information of the large-scale features alone. (The time mean has been removed for better visualization).

A new assimilation scheme is presently being constructed that blends EnOI with the downscaling ideas described above.

c) Describe and justify any significant deviations from the original objectives or plans, including any revised goals, new projects, or deleted projects.

All of the objectives listed in the proposal have been met, and original plans are being followed.

New activities (e.g., parallel version of the assimilation codes for the North Atlantic to reduce computation time, using large scale information to drive small scale variability in nested, higher resolution sub-models) have been undertaken as described above.

d) *Describe how the work of the project's co-investigators and collaborators was coordinated and integrated.*

Principal investigator Keith Thompson is in daily contact with Research Associate Vasily Korabel, graduate student Anna Katavouta, and project collaborator JInyu Sheng. Coordination and integration with collaborator Katja Fennel is achieved through approximately bi-monthly, face-to-face meetings and also involvement on the supervisory committees of each other's graduate students.

Coordination and integration with project I.1.1 has taken place primarily through technicians as explained above.

Recently an OTN modeling validation group has been created by the members of projects I.1.2 (modeling) and I.1.3 (assimilation). The goal is to bring together observational data sets, and metrics, that can be used to assess the quality of the various models and assimilation schemes being developed by these two projects. The group plans to develop a "toolbox" that will include Matlab scripts that will facilitate the comparison of the observations and model outputs.

e) Describe the benefits of conducting this research as part of a network rather than as a separate project (e.g., scope of the research, cross disciplinary collaborations, new synergies and research opportunities, access to ship time, planning and coordination of research activities, exchange of information and data, benefits to students and technical staff).

From a physical modeling respective, the benefits to date of being part of this Network include access to a wide range of modeling and assimilation expertise, models of different types and resolution, the development of OTN toolboxes to facilitate model inter-comparison (see above), and access to unique observations from, for example, ocean gliders and the finely sampled Halifax Line.

From a broader perspective, the Network is providing opportunities for the physical oceanographers in this project to interact with researchers from other disciplines, particularly biological oceanographers.

f) Describe the scientific and/or engineering significance of the results to date.

The main achievements over this reporting year are as follows:

- A 15 year hindcast of physical conditions (sea level, currents, temperature and salinity) of the North Atlantic using realistic surface forcing. Results are available for general use by all OTN researchers.
- Ensemble based scheme for assimilating SST images into the North Atlantic model (and its high resolution nested sub-model).

- Demonstration of the importance of localization, and specification of large-scale conditions, to the development of data assimilative models of ocean variability on small scales (e.g., several km).
- New methodology for calculating the probability density functions of animal position both forwards and backwards in time, with and without animal behavior.

6. Difficulties encountered

a) Identify the main difficulties encountered in carrying out the research during the reporting period from the list below:

- ❑ Scientific problems/difficulties
- ❑ Equipment and technology issues (e.g., delivery and malfunctioning of equipment, etc)
- ❑ Personnel problems
- ❑ Involvement of partners
- ❑ Other (specify): _____
- ❑ No problems occurred during this instalment of the grant

b) For each checked box, describe the difficulties identified above and the steps taken to resolve them.

No problems were encountered.

7. Networking and outreach

Discuss the extent of networking and outreach by the project, both within the OTN Canada Network and with the broader community, by co-PIs, collaborators and HQP. Describe how the project's research has been impacted by, and contributed to, the research carried out by other projects from across the Network.

Intra-Network Collaboration and Partner Meetings

Our project is about to provide routine forecasts of ocean conditions on the Scotian Shelf to assist in glider mission planning as described above.

Research has recently been carried out by principal investigator K. Thompson and Dalhousie graduate student S. Shan on the use of flow fields from the large-scale North Atlantic model in order to examine the effect of animal behavior (e.g., preference for a specific temperature range or latitude) on their spatial distribution as a function of time. This work is motivated primarily by project I.2.2 (Estuarine and oceanic migrations of the juvenile and reproductive stages of the American Eel). Figure 11 shows

the distribution of passive particles 100 days after their release on the shelf slope of the Scotian Shelf (shown by the cross hairs). Some of the particles are advected eastward by the Gulf Stream, while others are carried westward by shelf and shelf break currents.

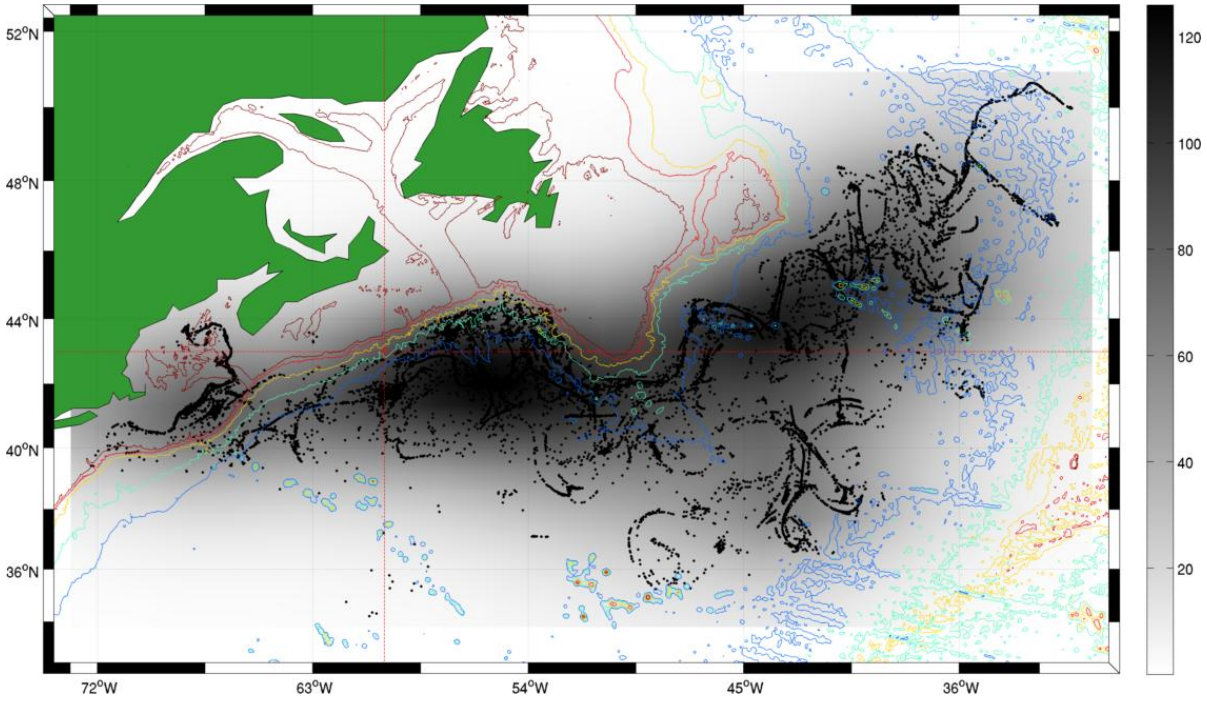


Figure 11: Distribution of passive particles 100 days after their release on the shelf slope of the Scotian Shelf (shown by the cross hairs). The distribution is based on combining positions from a range of release dates.

The impact of a weak preference for more southerly latitudes (i.e., the addition of a southward velocity of 2cm/s to each particle) is indicated in Figure 12. These very preliminary results show that the final distribution of particles is strongly influenced by the weak response of the particles to their physical environment.

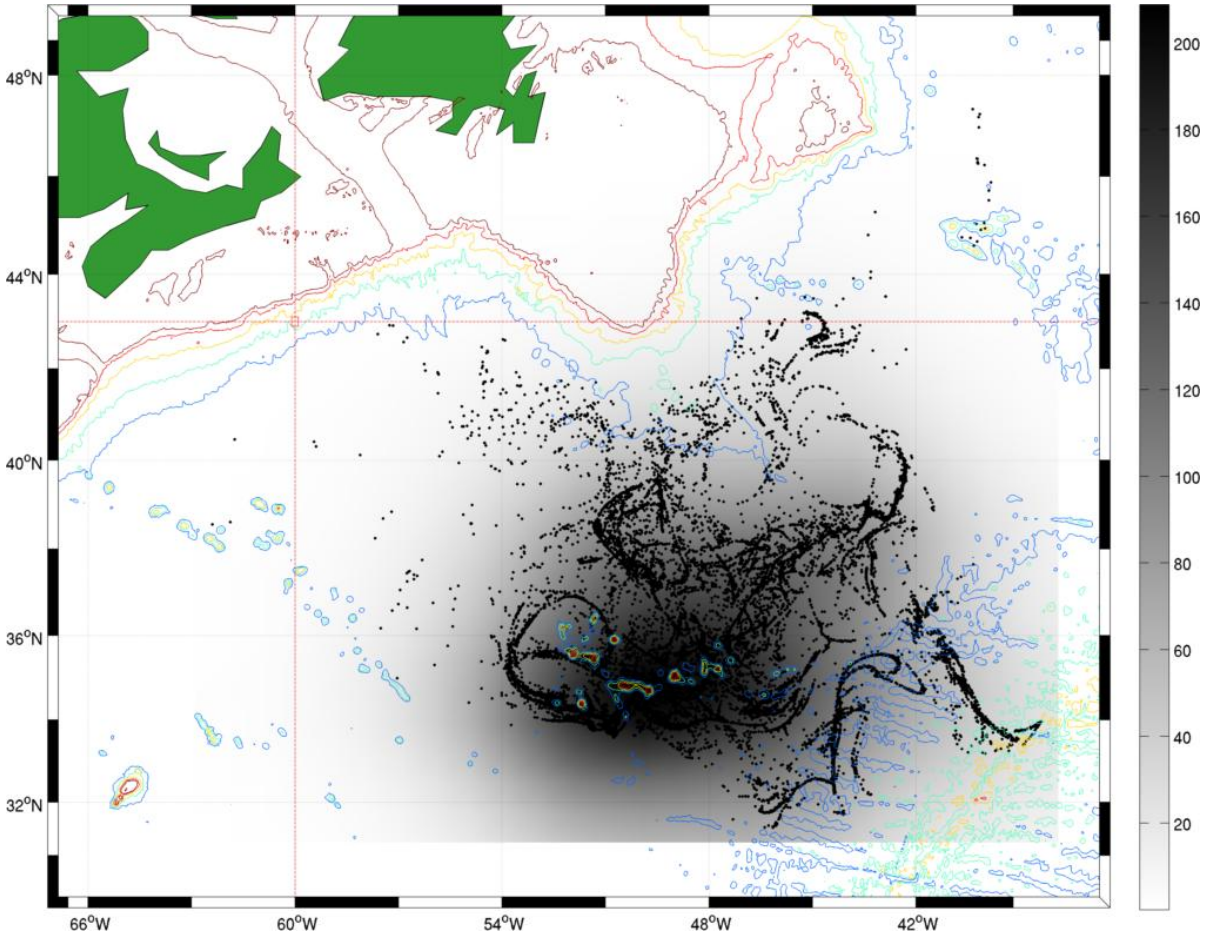


Figure 12: Same format as Figure 11 except that each particle has a small (2 cm/s) velocity toward the south.

Discussions on the above type of analysis have taken place with the principal investigators of I.2.2. (Julian Dodson and Martin Castonguay). Graduate student Mélanie Beguer plans to visit Dalhousie in November 2011 to learn how to use the newly developed codes. (The codes calculate the probability density functions of animal position forwards and backwards in time, with and without animal behavior. Specific goals are to estimate spawning sites and also animal behavior from the model flow fields and knowledge of the spatial distributions of the marine animals.) A presentation on ways of modeling the migration of the American eel from the St. Lawrence River to the Sargasso Sea will be given at the Ocean Sciences meeting in 2012 by Mélanie Beguer.

Another example of interdisciplinary collaboration make possible by the Network is our interaction with C. Taggart, principal investigator of subproject I.1.C (*Accelerometery is the key to monitoring temperature-dependent fish growth and activity in the wild*). Discussions have taken place on how best to use information on time-varying, 3D ocean environment (estimated from our assimilative models) on the trajectories of fish carrying tags that record temperature, acceleration and other variables. In essence by combining these two sources of information we hope to "fill in the gaps" in the position of

the fish between the times of their release, passing within range of OTN receivers, and their recapture. Details on the approach are given in this year's annual report of C. Taggart. This research topic is presently being pursued by graduate student F. Broell under the supervision of C. Taggart.

Interaction/Outreach to Broader Community

We have worked closely with the Global Ocean and Atmosphere Prediction and Predictability (GOAPP) Network over the present reporting year. (The Network was funded by the Canadian Foundation for Climate and Atmospheric Sciences from 2006 to September 2011).

We have worked closely with a Dalhousie-led research project entitled Platform for Ocean Knowledge Management (POKM) that is developing web-based tools for analyzing and visualizing ocean data (including animal trajectories).

Collaboration has been established with Dr Gary Brassington from the Centre for Australian Weather and Climate Research, Melbourne, Australia. We are working on issues related to ocean modeling and assimilation.

8. Dissemination of information and results

List refereed journal articles (accepted/published, submitted) and conference presentations (invited, contributed). All other dissemination is included in section #9 (Other contributions and deliverables).

Please note that the first year of funding for the Research Associate for this project was cut in response to the external reviews. Research Associate Vasily Korabel joined the project in February of 2011. Graduate student Anna Katavouta spent the first year of her PhD program completing courses (finishing in April 2011). It is anticipated that the publication rate will accelerate greatly over the next reporting year.

Contributed Conference Presentations (2 total)

Vasily Korabel, Keith Thompson, Shiliang Shan, Frederic Dupont and Youyu Lu, Assessing an Ensemble Optimal Interpolation data assimilation scheme applied to the North Atlantic Ocean. Contributed presentation at 45th CMOS CONGRESS, Victoria, June 2011.

Beguer, M. Benchetrit, J., Castonguay, M., Hatin, D., Verreault, G., Bourque, J.F., Jonsen, I., Thompson, K., Sheng, J., Dodson, J.J., Multiple approaches to elucidate the migration of the American eel (ANGUILLA ROSTRATA) from the St.-Lawrence River to the Sargasso Sea. 2012 Ocean Sciences Meeting, February 20 – 24, Salt Lake City, UT.

9. Other contribution and deliverables

Invited or contributed presentation/contribution at a workshop.

Contributed presentation on 2 June, 2011 in Halifax at the OTN Annual Congress: Data Visualization and Analysis Workshop. Keith Thompson demonstrated new software for tracking animals forwards and backwards in time, with and without behavior.

10. Collaborations with Industrial and Government Partners

a) Please describe which partners are actively involved in management, research, and knowledge transfer within the network and the specifics of their involvement.

We are working closely with colleagues at the Bedford Institute of Oceanography (notably Dr Youyu Lu) and Environment Canada (Dr H. Ritchie) on ocean modeling and assimilation.

b) Cash and in-kind contributions from partners for year 2.

Name of supporting organization:	**Year 2** 2011
Cash contributions to direct costs of research	
In-kind contributions to direct costs of research	
7) Salaries for scientific and technical staff	
8) Donation of equipment, software	
9) Donation of material	
10) Field work logistics	
11) Provision of services	
12) Other (specify): _____	
In-kind contributions to indirect costs of research	
4) Use of organization's facilities	
5) Salaries of managerial and administrative staff	
6) Other (specify): _____	
Total of all in-kind contributions	

No cash or in-kind support for Atlantic I.1.3

11. Expenditures and Support

NOTE that this section 11. Includes financial budget reporting for the entirety of the Atlantic Oceanography project: Project Numbers I.1.1, I.1.2 and I.1.3

Year 2 (2011)

a) Indicate approved year 2 budget, actual expenditures from 1 January to 30 Sep 2011 and projected expenditures for the remainder of this installment (through to 31 December 2011).

Year 2 (2011)	Proposed	Actual Expenses 1 Jan-30 Sep 2011*	Total Balance 30 Sep 2011*	Projected Balance 31 Dec 2011**
1) Salaries and Benefits				
a) Students	126,000	119,489	**6,511**	**0**
b) Postdoctoral Fellows	121,679	94,326	**27,353**	**0**
c) Technical/ Professional Assistants	42,800	39,509	**3,291**	**0**
d) Other (specify)	0	**0**	**0**	**0**
2) Equipment or Facility				
a) Purchase or rental	14,000	14,024	**-24**	**-24**
b) Operation and Maintenance Costs	12,000	9,230	**2,770**	**1,331**
c) User Fees	9,000	463	**8,537**	**1,587**
3) Material and Supplies	6,000	5,882	**118**	**118**
4) Travel				
a) Conferences	8,000	9,209	**-1,209**	**-1,209**
b) Field Work	0	0	**0**	**0**
c) Collaboration/ Consultation	0	0	**0**	**0**
5) Dissemination Costs				
a) Publication Costs	0	0	**0**	**0**
b) Other Activities	2,000	0	**2,000**	**2,000**
6) Other (specify)				
a)	0	**0**	**0**	**0**
b)	0	**0**	**0**	**0**
Totals	**341,479**	**292,132**	**49,347**	**3,803**

The total balance as of September 30, 2011 was filled based on the Dalhousie Financial Services ledger sheets. A Form 300 was not available to us, hence it is possible that there are slight deviations because spent amounts are not yet included or entered in a different category.

Remaining expenditures for the rest of the year were calculated by projecting student stipends and salaries forward in time up to the point where a balance of zero is reached (from that point forward another source of funding was presumed).

b) Below, explain any significant deviations from the proposed expenditures. (Note: Changes of >20% from budget categories require advance approval from the Reprofiling Committee and NSERC, and must come first to S. Iverson).

There are no significant deviations in the categories “Salaries and Benefits”, “Equipment or Facility” and “Travel.” The only deviation >20% is in the category “Dissemination Costs” where $2,000 that were budgeted for a glider workshop remain unspent. The workshop was to be held in conjunction with the OTN Annual meeting, but due to technical problems described in more detail in the report from project I.1.1 was postponed to the next OTN workshop.

Year 3 (2012)

a) Using the same excel form provided, indicate your approved year 3 budget and any revisions to that original budget that you are proposing for year 3, noting that it must sum to ≤ the original total.

Year 3 (2012)	Original	Revised	Carry Over Requested
1) Salaries and Benefits			
a) Students	105,000	105,000	0
b) Postdoctoral Fellows	135,000	135,000	0
c) Technical/Professional Assistants	40,800	40,800	0
d) Other (specify)	0	0	0
2) Equipment or Facility			
a) Purchase or Rental	14,000	14,000	0
b) Operation and Maintenance Costs	11,000	11,000	0
c) User fees	8,000	8,000	0
3) Material and Supplies	12,000	12,000	0
4) Travel			
a) Conferences	6,000	6,000	0
b) Field Work	0	0	0
c) Collaboration/Consultation	0	0	0
5) Dissemination Costs			
a) Publication Costs	0	0	0
b) Other Activities	4500	4500	0
6) Other (specify)			
a)	0	0	0
b)	0	0	0
Totals	**336,300**	**336,300**	**0**

No revisions to the original year 3 budget.

b) Provide a detailed justification for your year 3 budget. You may use your original justification (just as submitted in the proposal) and state that it remains on track if that is the case. For budget items that you are proposing to change, you must give a clear explanation/justification of why; these proposed changes must be approved by the SAC.

1) Salaries and benefits

Five graduate students will be supported @ $21,000/yr:

- one PhD student (Mathieu Dever) will work primarily on the analysis of physical data collected along the Halifax Line (from benthic pods, ADCPs and gliders) and will collaborate in model-data comparisons and assimilation of these data;
- one MSc student (Matt Beck) will work on glider deployment, operation and calibration as well as on analysis and interpretation of interdisciplinary glider data and the development of data products for assimilation into the models;
- one PhD student (Shiliang Shan) will focus primarily on physical model development and collaborate in assimilation of physical data;
- one PhD (Karl Lagman) student will focus on coupled physical-biological modeling and collaborate in the assimilation of interdisciplinary data;
- one PhD student (Anna Katavouta) will focus on development and implementation of data assimilation methods.

Three Post-Doctoral fellows will be supported @ $45,000/yr:

- One Post-Doctoral fellow (Kyoko Ohashi) will work on physical model development and analysis.
- One Post-Doctoral fellow (Laura Bianucci) will work on biological model development and analysis.
- One Post-Doctoral fellow (Vasily Korabel) will work on data assimilation.

One technician (Adam Comeau) will be supported @ $33,800/yr to assist in glider deployment, operation, recovery, and the analysis of glider data and development of data products

Part-time technical support will be required (@ $7,000; 17.5% FTE) for research in development, calibration and interpretation of accelerometry for fish growth/activity in the laboratory and accelerometer tag development.

2) Equipment or Facility

a) This budget line covers the boat rental fee for the *in situ* sampling that is necessary for ground truthing of glider observations. We have budgeted for 14 ship days (one ship day of 8 hour duration at $1000).
b) This budget line includes costs of minor computer hardware and software upgrades ($3000/yr) and instrument calibrations ($8000/yr). The instrument calibration budget will cover the calibration of the profiler, the AC9, the fluorometer, the CTD and the oxygen sensors. These sensors are all part of the optical/chemical/physical profiling package owned by the Department of Oceanography and will be used for in situ sampling (ground truthing of glider observations).

c) Sample analysis costs are budgeted at $1000 per trip for 5 trips per year and cover the analysis of CDOM, particulate absorption, chlorophyll, nutrients, POC, PON, and oxygen for 2 stations at 4 depths. These analyses will be conducted by the Department of Oceanography's marine analytical services group on a cost recovery basis. Also budgeted are $3,000/yr for Aquatron holding tanks, flume-tank and video recoding user fees for acceleration-at-size calibration and equipment maintenance costs

3) Material and Supplies

$12,000 for accelerometer tag development (acoustic) and deployment for in situ application. Anticipate collaboration with VEMCO/AMIRIX in all phases.

4) Travel

This will cover conference participation for students, Post-Doctoral fellows and PIs (4-5 trips total per year).

Atlantic Arena I.2.1

1. Project Number: I.2.1

2. Project Title: Atlantic salmon (*Salmo salar*): migration, distribution, and oceanographic features.

3. Project Leader(s): Sara Iverson* (Dalhousie), Ian Fleming (Memorial), Bruce Hatcher (Cape Breton)

**Note: S. Iverson helps to lead this project through co-supervision of PhD student Edmund Halfyard and managing his graduate program and research at Dalhousie*

Collaborator(s): Fred Whoriskey (Dalhousie U.), Mike Stokesbury (Acadia U.), Jamie Gibson (DFO), Daniel Ruzzante (Dalhousie U.), Dave Reddin (DFO retired), Peter Downton (DFO), Martha Robertson (DFO), John Hart (MSA), Shelley Deny (UINR), Shelley Porter (CSI), Atlantic Salmon Federation Club Hill Camp Nova Scotia Salmon Association

4. Training of Highly Qualified Personnel:

a)List of the HQP and level of their salary support by SNG

Edmund Halfyard	PhD Candidate	100	100	Jan – 30 Sep 2011
Connie Conway	Technician	50	50	1 Oct 2010 – 30 Sep 2011
David Woodland	B.Sc. student	100	100	1 Apr 2011 – 30 Sep 2011
Stacey Pettipas	B.Sc. student	100	100	1 Apr 2011 – 30 Sep 2011
Chris McQuaid	B.Sc. student	100	100	1 Apr 2011 – 30 Sep 2011
Martin Estoban Leguizamon-Velez	Research associate	15	15	1 Apr 2011 – 30 Sep 2011

b) Explain the role, activities and opportunities for training of technical staff in your project.

This project is instrumental in the training of PhD candidate E. Halfyard (subcomponent 1, Dalhousie University), who is using the support received to conduct his PhD research. A multidisciplinary group of highly qualified scientists from the University sector, and from Government, are sharing their experience with the candidate.

The subcomponent based out of Memorial continues to provide training for technical staff, including Corinne Conway of MUN, DFO technical staff (e.g. Peter Downton) and technical staff from the local community operating the Campellton River counting fence. A postdoctoral fellow will be hired shortly, who will add to training environment. Collaborative interactions between university and government

researchers and technical staff provide the cross-fertilization of ideas, techniques and knowledge, creating a positive training environment within the subcomponent.

The Subcomponent at Cape Breton University incorporates undergraduate students as summer employees and B.Sc. Honours students. One 4th year student (David Woodland), is continuing on an advanced research project during the academic year. These students worked on both the technical work of establishing receiver arrays with a marine acoustics engineer (M. Leguizamon –Velez), and on the operation of a Salmon smolt wheel in the Middle River with First Nations collaborators at the UINR and CSI. Two of the students received training as Scientific Divers under the Standard of the Canadian Association for Underwater Science. This exposure to the full range of research elements, both practical and theoretical, encouraged two of the students to remain engaged with the project next year (D. Woodland, and C. MQuaid, 3rd year B.Sc. student). The project also benefited greatly from the arrival of an acoustic engineer from the Columbian Navy (Martin Estoban Leguizamon-Velez), who has joined the team as a part-time researcher. Besides helping us with the siting, deployment, calibration and range testing of tags and receivers, Martin is developing new skills in marine ecology. He is considering undertaking graduate studies in association with this project.

5. Progress towards Objectives/Milestones (1 Oct 2010 – 30 Sep 2011)

a) Please provide brief description of the overall objectives of this project (max ½ page).

This project has four subcomponents:

(1) *Documentation of migration pathways of Atlantic salmon from different regional groupings.* The objective is to implement tagging programs for Atlantic salmon populations from differing regions to see if these fish use different migration pathways and parts of the ocean, or whether they ultimately link up with the previously described Gulf of St. Lawrence fish in a single mixed Atlantic salmon ocean feeding group.

(2) Use of novel technologies to document how Atlantic salmon make use of the oceans. The objective is to field test the new archival tags, which we will deploy on kelts leaving the Campbellton River. The tags will be recovered from returning adults and the data compared to the results from previous work with large archival tags to evaluate the reliability of the new tags. In a second experiment, smolts will be fitted with the miniaturized version of the tags, and recovered data will be used to document the conditions they experience in the ocean, and geolocation data analyzed in an attempt to determine if it provides sensible information about the movements of the fish in the ocean.

(3) *Are ocean distributions of Atlantic salmon associated with particular and predictable oceanographic conditions?* The objective is to combine the modeling capacity of the oceanographers (see ***I.1***) with associated fieldwork on salmon. Models will be developed to provide descriptions of the places in the ocean that have favourable conditions for Atlantic salmon, which will be compared to the actual areas occupied by the salmon. Discrepancies between predicted and actual distributions will become the focus of future research.

(4) *Do Atlantic salmon close their life cycle in the Bras d'Or ecosystem of Cape Breton?* Objective is to test a nested set of hypotheses having progressively greater generality and lower certainty: Salmon exiting the mouths of four known spawning rivers in the Bras d'Or watershed 1) do not

subsequently leave the sub-basin into which the river drains, 2) do not subsequently exit the estuary to the NW Atlantic ocean, 3) do not make their way back into the Bras d'Or estuary or its rivers, and 4) do not survive to return to those rivers to spawn in subsequent years. Ingress to the Bras d'Or estuary of salmon tagged elsewhere in the North West Atlantic Ocean will also be tracked.

b) Describe progress towards meeting the project's objectives and specific milestones for the project.

Subcomponent 1

There were two primary objectives in this subcomponent. The first was to develop the capacity of using autonomous vehicles to carry mobile receivers to document salmon movements at sea. The second was to support the PhD research of E. Halfyard. This work specifically addressed:

- Identifying spatio-temporal dynamics of estuarine survival of Atlantic salmon smolts in Nova Scotia's Southern Upland
- Assessing the potential impact of estuarine predators on the survival of Atlantic salmon smolts
- Assessing the in-river migratory behaviour of adult Atlantic salmon using acoustic telemetry
- Examining the efficacy of an alternative enhancement strategy for Atlantic salmon

An autonomous vehicle mission using a Slocum electronic glider was planned and launched in the Gulf of St. Lawrence in spring 2011. Satellite contact with the vessel was lost several days after the launch, and automatic emergency procedures for the vessel either failed to activate, or were insufficient, to bring the vessel to the surface. Thus, after a promising start, the mission failed when the vehicle sank, with the loss of all data and the vehicle.

With regards to the PhD program of E. Halfyard, 185 acoustic tags deployed for the salmon smolt projects and 75 acoustic tags deployed for the adult salmon / enhancement projects. Furthermore, 5 networks of acoustic receivers were deployed to monitor tagged fish, consisting of 183 individual receiver deployments.

Subcomponent 2

The focus of the research based at Memorial University this past year was on completion of the testing of tag shape and tagging methodologies for fitting smolts with the miniaturized versions of Data Storage Tags (DST's), and ultimately, on the tagging and release of smolts at the Campellton River. This study was initiated by PI I. Fleming and collaborators in May 2010 and continued through February 2011. On 14 May 2010, 102 smolts from the Rocky River, Newfoundland, and captured at a smolt trap, were transported to the Ocean Sciences Centre (Memorial University) for testing tag attachment methodologies. An outbreak of a flavobacterium at the end of May lead to 24 mortalities and the need to treat the fish with tetracycline. The remaining fish recovered and were tagged on 6 July: 20 with an internal version of the dummy DST, with a light stalk protruding from the body cavity; 40 with an external version of the dummy DST, 20 attached with a bridle design in the dorsal musculature and 20 with a tether through the dorsal musculature; and 14 fish served as controls, with PIT tags for individual identification. These fish were monitored through November 2010. Our findings indicated that the tether attachment was the most effective methodology; many of the internal tags were

expelled over the course of 1.5 mo and bridles caused excessive wear. Further testing, including swim chamber tests, with refined tag shapes and tagging methodologies was commenced November 2010 and ran through to February 2011. A flat, rectangular design of the LAT2900 tag with tether attachment was decided upon. In May 2011, 215 smolts (fork length 21.2 ± 2.1 cm; total weight 99.1 ± 28.5 g) were collected, tagged and released at the Campbellton River. Survivors should return in summer 2012. We also tagged nine kelts with Lotek geo-magnetic internal tags during June 2011. These were extra tags that Lotek had available and provided to the project as the kelt run was coming to its end (later migrating kelts tended to be in poorer condition). To date, we have not recovered any of these tags.

Subcomponent 3

The loss of the Ocean Tracking Network's CFI-funded Slocum glider will impact work upon this subcomponent. While modeling efforts underway in the oceanographic components of this award will proceed as planned and provide predictions of the oceanographic conditions across the putative migration routes of Atlantic salmon, empirical tests of the models, and of the presence of salmon in those region, are dependent upon launching the autonomous vehicles into the area equipped with both oceanographic sensors, and mobile acoustic receivers. In addition to the glider that was lost, the OTN also operated two other gliders of the same model. Both of these have failed as well, suggesting a systematic weakness in the construction run of these units of the gliders. The lost vessel was insured, and OTN is presently negotiating with the insurance company over the payment that will be received. We are also experimenting with alternate autonomous vehicle models (the Liquid Robotics Wave Glider, in association with Vemco), and the hope is that an alternate vision of the autonomous vehicle use will be developed, and new missions addressing this subcomponent will be launched in the future.

Subcomponent 4

Work at Cape Breton University in this first year of the project focused almost entirely on designing the VR-2W receiver array for a large, complex estuary. The work began with a series of reconnaissance dive surveys in the nine passages between the NW Atlantic Ocean and the Bras d'Or estuary, and between the various basins and river catchments of the estuary. Seabed and channel topography was measured, video taped and mapped, and the hydrological and hydrodynamic regime was characterized using CTD and ADCP profiles, as well as samples of water for analysis of sound scattering properties. We had hoped to deploy a turbulence profiler to measure fine scale structure of the water column, but the instrument to be borrowed did not become available. Subsequent to this work, we identified optimal deployment sites within the various channels, designed, tested and constructed moorings for the most challenging deployment sites, and undertook trial deployments of VR-2W receivers in three of the simplest locations (depth less than 20m, smooth channel contours, currents typically <2.0 m.s-1). The probability of tag detection and the frequency of failed detections was then measured using a variety of transit methods, including towed fish bodies and attachment to SCUBA divers challenged to "sneak" past the receiver. In two of these trial sites experiencing current velocities of greater than 1.3m.s-1 we found very low probabilities of detection (less than 18% over 800 trials), This has caused us to halt the further deployment of receivers in the Bras d'Or array and to re-examine the assumptions made in the original design. Collaboration has been explored with the instrument manufacturer and other commercial users of the gear in hydrographically and hydrodynamically complex environments using the NSERC Engage grant program. We will not proceed to the tagging stage until we have resolved

these problems, because the experimental design is highly susceptible to Type-II errors. In parallel to this work, we took the opportunity to participate fully in OTN network activities with our partners, including two workshops and the initiative by the ASF, CSI and UINR to acquire and test a Salmon Smolt Wheel in the Middle River of the Bras d'Or watershed. This pilot exercise, while not resulting in the acoustic tagging of any smolts, provided valuable experience to faculty, collaborators and students alike in the techniques of mark and recapture.

c) Describe and justify any significant deviations from the original objectives or plans, including any revised goals, new projects, or deleted projects.

Subcomponent 1

There are no major deviations to report.

Subcomponent 2

There were no major deviations to report. The tagging of nine kelts with geo-magnetic tags was an addition to the project. We also sought and received approval to hire a postdoctoral fellow (2 years) in place of a PhD student (4 years) at no additional cost to the project. The reason for requesting the change is because the nature of the project requires a high level of expertise for data interpretation (geolocation based on light, temperature and depth data) and we also had to change in response to the CFI funding available for the data storage tags (DST) ($100k; i.e. less than we had hoped). The limited number of DSTs that could be purchased meant that we have had to focus on only a single release of salmon smolts and a single release of salmon kelts (repeat breeding adults). Thus, it is felt that this alone would not be sufficient for a PhD thesis and would be more appropriate for a postdoctoral fellow. By the time the postdoc comes on the project, initial work with geolocation data should be possible and oversight of the recovery of returning fish needed. The salmon kelt experiment would also need to be undertaken. Thus, shifting from a PhD student to a postdoctoral fellow would be a more effective use of the available funding for HQP given the nature of the project.

Subcomponent 3

The loss of the glider, as previously described, has forced us to rethink our strategy for this component. Future developments will depend upon the availability of insurance payments to assist with replacement of the lost equipment, and development of alternative autonomous vehicle strategies.

Subcomponent 4

The unacceptably poor performance of the VR-2W receivers in the narrow, shallow, stratified and fast channels of the Bras d'Or estuary has delayed the establishment of the Bras d'Or acoustic array by at least 12 months. We are now reallocating effort and resources to establish a rigorous measurement, testing and calibration program aimed at designing receiver arrays that produce at least 95% probability of detection. This represents a significant shift of research focus towards the methodological and technical aspects. In this endeavor, the acoustic engineer will play a significant role, and we will establish a formal partnership with the industry players to ensure that the lessons learned contribute to better research outcomes for other clients who are faced with similar challenges to effective establishment of acoustic tracking receiver arrays. This change to the project is currently viewed as a deferrable of the planned salmon tagging and tracking activities, rather than a departure

from them. Given the initial outcomes of the partners' experiment with the smolt wheel, the deferral of array deployment does not yet pose an impediment to the research. The shift in focus away from tagging of animals during the first year also interfered with the preparation of application to the University's Animal Care Committee, which blocked access to some funds during the first year.

d) *Describe how the work of the project's co-investigators and collaborators was coordinated and integrated*.

Subcomponent 1

Regular meetings occurred between the candidate and the advisory committee. Additionally, integration has occurred via reviews of analytical techniques and collaboration on manuscript preparation.

Subcomponent 2

Biological and engineering expertise of Memorial, DFO (NF) and private industry (Lotek Wireless) was brought together in the development of data storage tags and appropriate tagging methodologies. This was done through laboratory experiments at the Ocean Sciences Centre examining the effects of tags and tagging methodologies on smolts and their growth. There were several joint meetings to design, execute and review findings from the experiments. This all led to the joint tagging effort between Memorial and DFO of 215 smolts and nine kelts in Spring 2011.

Subcomponent 3

Planning meetings to design the glider mission that was launched in the Gulf of St. Lawrence included oceanographers, biologists, and technical staff from different components of the OTN NSERC project, as well as individuals from OTN Global.

Subcomponent 4

The Bras d'Or project has a large group of collaborators because the fish tagging work throughout the estuarine watershed, as well as in the surrounding NW Atlantic ocean is primarily to be conducted by partners. A full-day "kick-off" workshop was held near the start of the project cycle, at which all aspects of the objectives, methods and outcomes of the project were discussed with 22 representatives of partner agencies. Agreements were reached on the shared responsibilities of the various partners, and the commitment to capacity building within the academic, government, NGO and private sector nexus was made. A continuing series of subsequent meetings and workshops (totaling 8 over the 12 month period) were used to refine and adapt the partnership and task sharing to the needs of partners and the significant challenges faced by the research (see section c above). These included the OTN Canada workshop in Halifax, as well as meetings with Fisheries & Oceans Canada staff, the Collaborative Salmon Initiative for Cape Breton, the Unama'ki Institute of Natural Resources, the Eskasoni Fish and Wildlife Commission, the Atlantic Salmon Federation, the Margaree Salmon Association, the Cape Breton Anglers Association and NSERC Atlantic.

e) Describe the benefits of conducting this research as part of a network rather than as a separate project (e.g., scope of the research, cross disciplinary collaborations, new synergies and research opportunities, access to ship time, planning and coordination of research activities, exchange of information and data, benefits to students and technical staff).

Subcomponent 1

The integration of this project with the greater network has provided additional data collection platforms and provided insight on animal behavior not otherwise possible. For example, both salmon smolts and adult salmon tagged as part of these studies were detected on the Halifax array of receivers operated by OTN and by the bioprobe project of this award. Additionally, being part of the network has provided opportunity to gain insight on techniques and methodology to improve our projects – much of which is cutting-edge and newly developed.

Subcomponent 2

The network has played an instrumental role in the undertaking of this subcomponent, allowing us to tap into knowledge from several areas, including animal behaviour and ecology, oceanography (which is critical to the analysis of the geolocation data) and engineering (tag development). We have benefitted from our discussions with others in the salmon components of the Ocean Tracking Network (both in the East and West Coast Arenas) with regards to tagging techniques and experimental design (data collection). It is anticipated that these discussions will continue and lead to an integrated understanding of salmon behaviour at sea. Moreover, they are fostering novel ideas and experiments to better understand salmon behaviour at sea.

Subcomponent 3

Oceanographers and biologists were involved in the planning and execution of the eventually unsuccessful glider mission. This permitted designing a mission that met individual needs of the participating scientists, as well as testing hypotheses that integrated the work of the separate teams.

Subcomponent 4

Simply stated: the Bras d'Or project would not have happened had it not been for the OTN. The PI at CBU knows little about salmon ecology, and has no experience of acoustic tagging or tracking. Were it not for the knowledge, experience and encouragement shared by OTN collaborators, the proposal would not have been competitive in the NSERC application process. Fellow members of the Salmon component team (Whoriskey, Flemming & Halfyard), as well as partners in the DFO, Dalhousie, UNB and Memorial) have been essential to the design and implementation of the project to date. They, and others in industry and NGO's will continue to guide the research for maximum, shared benefit. The common denominator is a network-wide recognition of the unique attributes of Canada's Inland Sea for the tracking of marine species (not just salmon, but also eels, seals and cod). The job of the CBU team members is to design, install and maintain an extremely effective acoustic array in an incredibly complex estuarine ecosystem. It is those OTN members and partners who tag marine organisms who will benefit first from the acoustic "recaptures". The benefits to the local science, conservation and management communities of Cape Breton will come from the integrated interpretation of the animal movement trajectories and source-sink relationships elucidated by the OTN effort. The opportunities

to build local capacity for cutting edge, globally-networked research (i.e. “Big Science”) in a small undergraduate university, First Nation’s research and management institutions, and local community conservation groups can not be over-estimated. Without the OTN, there is no value or usefulness of the Bras d’Or acoustic array…

f) Describe the scientific and/or engineering significance of the results to date.

Subcomponent 1

- Identification of the timing and extent of Atlantic salmon smolt mortality in estuaries permits further examination of the impact of this mortality on the population regulation in salmon
- Identification of mortality vectors for Atlantic salmon smolts in estuaries provides managers options for conservation efforts

Subcomponent 2

- Miniaturization of a data storage tag for use in tagging smolts. This, to the best of our knowledge, is the first attempt to design a tag and tagging methodology for use of a geo-location data storage tag on smolts
- Development of an effective tagging methodology
- Development of a tag shape suitable for external attachment to smolts

Subcomponent 3

If this component had worked, it would have provided empirical tests of the predictions of 1) oceanographic conditions in the putative salmon migration pathways, and 2) whether salmon were migration along predicted pathways. It would also have fused existing oceanographic and animal tracking technologies in innovative ways. The loss of the glider is now causing us to forge links with new technology sectors, which is expected to generate new approaches and technologies to address the questions that we wish to address.

Subcomponent 4

- Design and successful testing of a durable and affordable acoustic receiver mooring for use in extremely high velocity channels carrying large volumes of bed-load transport macrophytes.
- Development of safe and reliable scientific diving protocols for servicing acoustic receivers and conducting range testing in dangerous flow environments.
- Collection and analyses of site-specific hydrographic and hydrodynamic data relevant to calculations of acoustic tag signal propagation in constrained, stratified, high velocity flows containing high concentrations of particulate material.
- Results of extensive range testing in critical channels of ingress and egress to the Bras d’Or estuary that demonstrate very low probability of detection.
- All of these results have the potential to provide significant improvement in the efficiency of operation of acoustic receiver arrays in the Bras d’Or and other complex estuarine environments.

6. Difficulties encountered

a) Identify the main difficulties encountered in carrying out the research during the reporting period from the list below:

- ❑ Scientific problems/difficulties
- **X** Equipment and technology issues (e.g., delivery and malfunctioning of equipment, etc)
- ❑ Personnel problems
- ❑ Involvement of partners
- **X** Other (specify): ____ _
- ❑ No problems occurred during this instalment of the grant

b) For each checked box, describe the difficulties identified above and the steps taken to resolve them.

Subcomponent 1

No major problems.

Subcomponent 2

No major difficulties encountered to this point.

Subcomponent 3

Loss of the glider as previously described.

Subcomponent 4

- Steep learning curve for local PI
- Receivers, moorings and tags were greatly delayed ion delivery.
- Undergraduate students take longer to become proficient at research, and spend less time on the project (requiring annual retraining of new students).
- Finding funding for an acoustic engineer not included in the original budget has been difficult.
- No problems with involvement of partners: they have been excellent.
- Difficulty in determining whether approval from the University's Animal Care Committee was required, and what degree of responsibility that oversight carried to external partners that did the actual capture, handling and tagging of fish.

7. Networking and outreach

Discuss the extent of networking and outreach by the project, both within the OTN Canada Network and with the broader community, by co-PIs, collaborators and HQP. Describe how the project's research has been impacted by, and contributed to, the research carried out by other projects from across the Network.

Subcomponent 1

- Networking with ENGO's, other academic institutions and both Federal / provincial governments has made each research project possible through support, funding and in-field collaboration. Collaborators include: Nova Scotia Salmon Association, Atlantic Salmon Federation, Natural Science and Engineering Research Council, Donner Foundation Canada, Fisheries and Ocean Canada, Pacific Ocean Shelf Tracking project, Bluenose Coastal Action Foundation, Canadian National Sportsman Show, Nova Scotia Department of Fisheries and Aquaculture, Lahave River Salmon Association, St. Mary's River Association, Eastern Shore Wildlife Association, Atlantic Society of Fish and Wildlife Biologists and the Gold River Marina

- For each ENGO, at least one presentation has been delivered discussing the results of the projects or providing project updates.

Subcomponent 2

- Given the nature of this subcomponent there has been extensive networking among academia (Memorial), government (DFO) and industry (Lotek Wirelss). This networking has resulted in the development of a first-generation, geolocation data storage tag and tagging methodology applicable for Atlantic salmon smolts. It has fostered the production of an industry (Lotek) pamphlet entitled "Attaching Lotek geolocation archival (LAT2900) to salmon smolts," as well as two articles in industry related publications (*Oceans Advance* and *International Ocean Systems*).
- Networking has also occurred with the other salmon subcomponents, including those in the West Coast Arena. There is interest in the potential for this tag, which may be particularly complementary to the work using the acoustic bingers. Future networking will occur with oceanographers as we analyze geolocation data recovered from returning fish.

Subcomponent 3

- Networking occurred primarily with environmental NGO's interested in the conservation of Atlantic salmon. They were kept informed on development of the project through reports to the Atlantic Salmon Federation.

Subcomponent 4

- Networking within the Salmon project team and the local community of partners is summarized in section e above: it has been substantive, positive and is continuing apace.
- The significant networking in the broader context of the OTN occurred at the OTN Atlantic meeting in June. There, the opportunities to hear from the corporate partners, the data managers and the other projects within the OTN were extensive and exciting. One particularly important result is an emerging plan to partner with the PI of the American eel tracking project on tagging this species in the Bras d'Or, where the eel population appears to be large, but where a new parasite has been taking an as yet unknown toll on animal growth, survival and reproduction rates. Another result of networking at this workshop was the commitment from some highly experienced salmon taggers to come to the Bras d'Or and provide training to local partners.

- The large challenge posed by the low probabilities of tag detection by receivers in estuarine channels has encouraged us to form partnerships with the manufacturers and experienced commercial users of this equipment. We have applied the NSERC for industry partnership grants to build this collaboration by including the contributions of our marine acoustic engineer.

8. Dissemination of information and results

List refereed journal articles (accepted/published, submitted) and conference presentations (invited, contributed). All other dissemination is included in section #9 (Other contributions and deliverables).

Refereed Journal Articles (1 total)- *Accepted/Published*

Reddin, D.G., Dowton, P., Fleming, I.A., Hansen, L.P. and Mahon, A. 2011. Behavioural ecology at sea of Atlantic salmon (*Salmo salar*) kelts from a Newfoundland (Canada) river. Fisheries Oceanography 20: 174-191.

Refereed Journal Articles (1 total)- *Submitted*

Migratory Behaviour and Survival of Atlantic Salmon Smolts from Nova Scotia's Southern Upland (Journal of Fish Biology)

9. Other contributions and deliverables

It is particularly important for the Network to document items that have been "delivered" to the following sectors, organizations and agencies

- The public (e.g., scientific outreach and education).
- Civic (e.g. water commission), provincial (e.g. parks), territorial, national and First Nations (e.g. hunter-trapper associations) monitoring/regulatory agencies (e.g. Environment Canada, Fisheries and Oceans, Transport Canada, Parks Canada, etc.) and their scientific, statistical and management branches.
- International agencies (e.g. UNESCO, SCORE, ICES, PICES etc.) and their scientific, statistical and management arms. .
- Private (e.g. technology firms), corporate (e.g. offshore oil & gas) and NGO (e.g. CPAWS, WWF, etc.) organizations. Describe how the project has helped advance the interests, capabilities, and/or insights of these organizations, including *the betterment of the Canadian economy".*

Production of a video, blog, webinar, podcast, webpage, etc.

- The project was covered by a Kings College student and featured on the webpage produced to cover the issues facing Atlantic salmon (http://salmon.kingsjournalism.com/solutions/marine-tracking/).
- Oceans Advance webpage - Lotek achieves breakthrough with miniature "message in a bottle." by Andrew Safer

Radio or television interview or contribution to a programme/documentary, etc.

- CTV news – July 2011 (E. Halfyard)
- Radio Canada TV news– Sept 2011 (F. Whoriskey)

- National Geographic TV background interview February 2011 (Whoriskey with David Elisco)
- CBC Radio (Saint John's, NF), September 2011 (Whoriskey).

Print-media contribution: international, national, local, university, etc.

- Chester times 1(12). October 1 2010."Gold River salmon study shows early positive results". (Halfyard)
- NB Telegraph Journal interview, 1 Oct 2011 (Whoriskey with Derwin Gowan)
- Lotek Wireless leaflet 2011 – "Attaching Lotek geolocation archival (LAT2900) to salmon smolts"
- A milestone in miniaturization. *International Ocean Systems*, in press. by Andrew Safer

Invited or contributed open-to-public presentation/contribution.

- Use of acoustic arrays to assess impacts of marine tidal power generators. Marine Energy in Cape Breton Conf. 25 Aug, 2011. UINR, Eskasoni (Hatcher).
- Recreational Fisheries Advisory Council Meetings – April 2010 and November 2010 - public meetings run by the Nova Scotia Department of Fisheries and Aquaculture. (Halfyard)
- Presentations were made in four-consecutive years at the annual general meeting of the Nova Scotia Salmon Association, at the 2011 AGM of the Bluenose Coastal Action Foundation, at the 2010 and 2011 AGM of the St. Mary's River Association, and at the 2011 AGM of the Lahave River Salmon Association. (Halfyard)
- Where do they go and how do they get there? Spying on Atlantic salmon with new technologies. Gulf of Maine Research Institute Sea State Public Lecture Series, Sept 2011 (Whoriskey)
- Presentations were made to the Collaborative Environmental Planning Initiative for the Bras d'Or Lakes Steering Committee Meeting and Management Meeting. Jan. & March 2011 (Hatcher)
- Presentation was made to the Atlantic Coastal Action Program Cape Breton Meeting. May, 2011. (Hatcher)
- Ocean Tracking Network Canada: Bars d'Or Salmon Tracking Project kick-off meeting. June 2010. Bras d'Or Inst., Cape Breton University (Hatcher)

Invited or contributed presentation/contribution at a workshop.

- The Ocean Tracking Network. Bedford Institute of Oceanography Ecosystem Lunch and Learn seminar series, April 2011 (Whoriskey)
- Ocean Tracking Network Canada meeting – June 2011, Halifax, NS (Halfyard)

Invited or contributed presentation/contribution at a seminar series.

- November 2010 – Dalhousie University Friday Biology Seminar Series (Halfyard)

Invited or contributed presentation/contribution at a conference.

- Plugging the Holes: Evaluations and Designs for Acoustic Array Integrity in a Complex Coastal Ecosystem. Ocean Sciences Meeting, Salt Lake City. Feb. 2012 (Hatcher and Leguizamón Vélez)
- Improving client outcomes from applied research. Atlantic Canada Coastal & Estuarine Science Society (ACCESS) Annual Meeting. 13 May, 2011. Coady Inst. St. Francis Xavier University (Hatcher)
- American Fisheries Society AGM, Seattle, Wa. September 2011 (Halfyard).

- Ocean tracking network - data policy, methods and first year collection results. First International Symposium on Fish Telemetry, Sapporo, Japan, June 2011 (Whoriskey et al.).
- Sonic tracking of Atlantic salmon smolts to sea: correlates of survival and lessons on the migration pathway. International Symposium on fish telemetry, Sapporo, Japan, June 2011 (Whoriskey)
- Sonic tracking of North American Atlantic salmon: migration pathways, mortality points, and social dynamics. Gulf of Maine Research Institute. September 2011 (Whoriskey)
- Sonic tracking of Atlantic salmon smolts to sea: correlates of survival and lessons on the migration pathway. International Atlantic Salmon Summit, LaRochelle, France, Oct. 2011 (Whoriskey)
- Ian A. Fleming, Dave G. Reddin, Peter Downton, Martha Robertson, Lars Petter Hansen, and Andrew Mahon. Use of data storage tags to study the behavioural ecology at sea of Newfoundland Atlantic salmon kelts and smolts.. Poster. International Conference - Salmon at Sea: Scientific advances and their implications for management. LaRochelle, France, Oct. 2011

Data reports, technical reports, manuscript reports, advisory documents, briefing notes, handbook or guide, checklist, barcode, CTD casts, Glider runs, and/or data deposition to an agency/database (e.g., MEDS, GenBank, OBIS, etc.), as well as a contribution to a larger piece of work in any of the former.

- Contributed to the Fisheries and Oceans Recovery Potential Assessment Document for Atlantic Salmon in Nova Scotia's Southern Upland. This document was incorporated into the Species at Risk Act review of salmon in the designable unit. Results of our studies provided important information (Halfyard)

Invited or contributed consultation with an agency; public or private

- MetOcean (private corporation specialized in the development of oceanographic equipment), regarding underwater autonomous vehicle developments and use in science (Whoriskey, July-August 2011)
- Anything else that isn't a primary publication that has you communicating (specify) with others (specify)

Leveraging your research/funds in order to make a new contribution to another initiative.

- Application to NSERC for InterAction Grant to enter discussions with AMIRIX Systems Inc., McGregor GeioScience Ltd. & Kintama Research Services Ltd. on producing a manual for the establishment, testing and calibration of acoustic tracking arrays in complex estuaries.
- Application to the Ocean Energy & Environment Research Council for funding to use the Bras d'Or OTN array to assess the impacts of marine tidal power generators on fish life in the Bras d'Or estuary.

A spin-off from the research that provided a new opportunity or new initiative.

- The OTN project ion the Bras d'Or attracted the attention of a marine acoustic engineer working with the Colombian Navy on the tracking of marine animals. He has emigrated to Canada and is participating in the design and testing of the Bras d'Or acoustic tracking array. His participation is a huge asset to the project.

A patent application, or pending, or issued.

A new technology, method, protocol, measure, analytical technique, algorithm, operational or numerical model, or predictive tool. Include the validation of any of the former and their practical application.

- Development of miniaturize geolocation data storage tag and tagging methodology suitable for Atlantic salmon smolts.

Baseline measures (e.g. reference for change), empirical relations (e.g. rates and states), or mapping products (e.g. range expansion or contraction) especially if of use to other scientists and the organizations listed above.

- CTD and ADCP current profiles of the water column in the Little Bras d'Or Channel, Great Bras d'Or Channel, Barra Strait, Little Narrows, Boom Channel, and St. Anne's Bay Channel as baseline measures of the environment in which acoustic receivers are deployed.

Contribution as expert witness or expert panelist (COSEWIC, EIA).

- Expert Witness for the Cohen Commission on Sockeye Salmon. Vancouver, Aug. 2011 (Fleming).

10. Collaborations with Industrial and Government Partners

a) Please describe which partners are actively involved in management, research, and knowledge transfer within the network and the specifics of their involvement.

- Fisheries and Oceans Canada, Diadromous Fish Division, Bedford Institute of Oceanography – Provided funding (spring 2010), field support and supervision (advisory panel) for each of the salmon tracking projects.
- Nova Scotia Department of Fisheries and Aquaculture (spring 2010) – provided funding and field support for each of the salmon tracking projects.
- Atlantic Salmon Federation – Collaboration in establishing a joint OTN-ASF receiver line in the Strait of Belle Isle, and tagging of salmon ($100k for acoustic tags)for detection by the autonomous vehicle mission.
- Club Hill Camp. Provided materials and logistical support to tag salmon from the Quebec North shore for detection by the autonomous vehicle mission.
- Fisheries and Oceans Canada, Salmonid Section, Newfoundland and Labrador Region – provided tagging expertise, collaborated in project design, execution and analyses, and provided field support at the Campellton River salmon counting fence.
- Lotek Wireless, St. John's Office – provided the engineering expertise for tag development and worked closely with the researchers on tag shape and tagging methodologies.

b) Cash and in-kind contributions from partners for year 2

- *Note: Funding for EAH projects was largely in 2008-2010 (outside the window of this report). Below is only for year 2 of the OTNC report.*

Name of supporting organization:	**Club Hill Camp**	**Fisheries & Oceans Canada**	**St. Mary's River Assoc.**	**N.S. Dept. Fisheries & Aquaculture**	**N.S. Salmon Assoc.**	**Dalhousie Univ.**	**Atlantic Salmon Federation**	**Cape Breton Univ.**	**U.I.N.R. *****
Cash contributions to direct costs of research					500				
In-kind contributions to direct costs of research									
13) Salaries for scientific and technical staff		1,000 750			500.		500	2,400	3,050
14) Donation of equipment, software		300 800							
15) Donation of material	9,000								
16) Field work logistics			3,500	$400	1,000		2,000	4,800	3,540
17) Provision of services									
18) Other (specify): __Tags for Atlantic salmon for autonomous vehicle mission._____							100,000		
In-kind contributions to indirect costs of research									
7) Use of organization's facilities						1,200 (12 months of office)		1,200 (12 mon. of office)	
8) Salaries of managerial and administrative staff	7,000								400
9) Other (specify): _____									
Total of all in-kind contributions		2,850	3,500	400	1,900	1,200	102,500	8,200.	$,990

*** the Unama'ki Institute of Natural Resources paid for, installed and co-operated the smolt wheel on the Middle River for 7 weeks.

Name of supporting organization: **Memorial University of Newfoundland**	**Year 2** (1 Oct – 30 Sep 2011)
Cash contributions to direct costs of research	
In-kind contributions to direct costs of research	
19) Salaries for scientific and technical staff	8,000*
20) Donation of equipment, software	1,200**
21) Donation of material	800***
22) Field work logistics	
23) Provision of services	
24) Other (specify): _____	
In-kind contributions to indirect costs of research	
10) Use of organization's facilities	1,500[#]
11) Salaries of managerial and administrative staff	
12) Other (specify): _____	
Total of all in-kind contributions	11,500

*Estimated salaries of DFO personnel (50%) Dave Reddin, Peter Downton and Martha Robertson, as well as Lotek personnel (50%) Paul Russell, Paul Bassler and Padraic O'Flaherty.

** PIT tag reader, handling nest and transport truck (MUN)

*** Dummy tags (Lotek – 80%), PIT tags and other tagging materials (MUN – 20%)

[#] Use of trapping facilities on Rocky River, Newfoundland (DF0)

11. Expenditures and Support

Year 2 (2011)

a) Indicate your approved year 2 budget (already entered for you), your actual expenditures from 1 January to 30 Sep 2011 and your projected expenditures for the remainder of this installment (through to 31 December 2011).

NOTE: Please note that this budget for Atlantic Salmon project is incomplete and that the numbers presented here will not necessarily match up with the text provided below. The members of the Atlantic Salmon project will present and discuss their Year 2 expenditures and Year 3 proposed/revised budget at the Scientific Advisory Committee meeting to be held on 22-23 November 2011.

Year 2 (2011)	Proposed	Actual Expenses 1 Jan-30 Sep 2011*	Total Balance 30 Sep 2011*	Projected Balance 31 Dec 2011**
1) Salaries and benefits				
a) Students	49,200	46,106	**3,094**	**3,094**
b) Postdoctoral fellows	0	0	**0**	**0**
c) Technical/professional assistants	20,000	19,445	**555**	**555**
d) Salmon anglers	6,400	0	**-5,000**	**-5,000**
2) Equipment or Facility				
a) Purchase or rental	1,000	1,343	**-343**	**-343**
b) Operation and maintenance costs	30,600	23,431	**7,169**	**2,669**
c) User fees	0	0	**0**	**0**
3) Material and supplies	14,845	4,311	**10,534**	**4,784**
4) Travel				
a) Conferences	0	0	**0**	**-1,690**
b) Field work	13,700	6,345	**7,355**	**1,258**
c) Collaboration/consultation	3,000	1,996	**1,004**	**-1,329**
5) Dissemination costs				
a) Publication costs	1,000	0	**1,000**	**1,000**
b) Other activities	0	1,875	**-1,875**	**-1,875**
6) Other (specify)				
a) Reward to fishermen (tag returns)	0	75	**-75**	**-75**
b)	0	2,065	**-2,065**	**-2,065**
Total	**139,745**	**106,992**	**21,353**	**983**

There are three components to the Atlantic salmon project, quartered in different universities (Cape Breton University, Memorial University, and Dalhousie University) and working on complementary but different projects. Here we report on our expenses by project. Form 300's were not available from all of these Universities, so our reporting of expenditures to September 30 is based on University Leger sheets. It is possible that there will be slight deviations in our reporting from any finalized form 300's that are produced because spent amounts are not yet included or entered in a different category.

Remaining expenditures for the rest of the year were calculated by projecting student stipends and salaries forward in time to project a final balance.

b) Below, explain any significant deviations from the proposed expenditures. (Note: Changes of >20% from budget categories require advance approval from the Reprofiling Committee and NSERC, and must come first to S. Iverson).

Dalhousie University (Iverson). $46,353 was allocated to this project, of which $21K was for a PhD salary, and the rest for Operations and Maintenance costs for the project. There are no significant deviations in the categories "Salaries and Benefits". Budgeted money provided Mr. Halfyard's stipend, and he is making excellent progress in his PhD program. Within the operations and maintenance category, $25,000 had been budgeted of which $16K was allocated for replacement of lost telemetry equipment. Ten replacement acoustic receivers are needed, for a total cost of $17 K. $9K had been budgeted for surgical supplies, maintenance of field equipment, and field travel. For this year only, alternate sources were found to absorb these costs. From this surplus, $2k was used to permit graduate student E. Halfyard to present his work at the American Fisheries Society annual meeting. This has left a small budget surplus (approximately $6K) in this project (13% of project budget).

Memorial University (Fleming). $55,151 was budgeted for year 2 of this project. There was a significant deviation from the proposed expenditures, which was requested and approved by the Reprofiling Committee and NSERC. This involved reallocating the funds designated for four years of support for a PhD stipend to support for a Postdoctoral Fellow for two years (same total funding). The reasoning behind this request is provided earlier the report. Surplus funds in the travel component were used to support I. Fleming's attendance and presentation of our data storage tag results from this project at the Salmon Summit - 'Salmon at Sea: Scientific Advances and their Implications for Management' in LaRochelle. A small amount of funds had to be allocated to provide rewards for the return of tags from fish captured by fishermen.

Cape Breton University (Hatcher). $44,647 was allocated to the Bras d'Or project, of which $14,400 was for student stipends and $11,400 was for salmon anglers in partner organizations who would capture and tag fish. Because of the problems encountered in establishing an effective acoustic receiver array in the narrow channels of the estuary, no tagging of salmon was undertaken during the 2011 year. Therefore the $11,400 for anglers was not spent. In compensation, additional students were hired during the summer to assist with the operation of the smolt wheel in the Middle River, and to work on the extensive range testing of receivers. The extra funds spent on student stipends ($10,353) nearly offsets the money not spent on anglers. All other spending categories fall within the

20% margin of variation, such that there is a small surplus of $1,412 projected for the end of the fiscal year. Confusion concerning the necessity of approvals by the Cape Breton University Animal Care Committee, under the revised research plan meant that research expenses were not debited to the NSERC project account. This discrepancy is being resolved in light of the change in activities from those involving the use of animals to those involving the calibration of receivers. The actual expenditure amounts will be restored to the budget as per the attached spreadsheet when the Animal Care conditions are met.

11. Year 3 (Jan-Dec 2012) Budget – proposed and justified

a) Using the same excel form provided, indicate your approved year 3 budget and any revisions to that original budget that you are proposing for year 3, noting that it must sum to ≤ the original total.

Year 3 (2012)	Original	Revised	Carry Over Requested
1) Salaries and Benefits			
a) Students	49,200	49,200	0
b) Postdoctoral Fellows	0	0	0
c) Technical/Professional Assistants	20,000	20,000	0
d) Other (specify)	6,400	6,400	0
2) Equipment or Facility			
a) Purchase or Rental	1,000	1,000	0
b) Operation and Maintenance Costs	29,600	29,600	0
c) User fees	0	0	0
3) Material and Supplies	16,000	16,000	0
4) Travel			
a) Conferences	0	0	0
b) Field Work	15,900	15,900	0
c) Collaboration/Consultation	6,200	6,200	0
5) Dissemination Costs			
a) Publication Costs	2,400	2,400	0
b) Other Activities	0	0	0
6) Other (specify)			
a)	0	0	0
b)	0	0	0
Totals	**146,700**	**146,700**	**0**

Dalhousie University (Iverson): No revisions.

Cape Breton University (Hatcher): No revisions.

Memorial University (Fleming): As mentioned earlier, funds previously assigned to PhD stipend support will be reassigned to support for a postdoctoral fellow.

b) Provide a detailed justification for your year 3 budget. You may use your original justification (just as submitted in the proposal) and state that it remains on track if that is the case. For budget items that you are proposing to change, you must give a clear explanation/justification of why; these proposed changes must be approved by the SAC.

1) Salaries and benefits

a) Dalhousie University (Iverson): A stipend ($23K) is requested for PhD candidate E Halfyard to continue with his program.
b) Memorial University (Fleming): A stipend of ($42 K) is requested for a postdoctoral fellow through the reallocation of funds previously designated for a PhD student

2) Equipment or Facility

a) Iverson (Dalhousie). Funding is requested for Operations and Maintenance costs to 1) replace lost telemetry equipment ($17K) from this year's field work, and 2) for surgical equipment and to operate and maintain the field components of the project ($7K).

3) Travel

a) Dalhousie (Iverson): $2K is requested to permit graduate student E. Halfyard to attend a major scientific conference.
b) Cape Breton (Hatcher): $2k is requested to permit marine acoustic engineer (M. Leguizamon-Velez) to attend the special OTN session at the Ocean Science Meeting in February 2012.

Atlantic Arena I.2.2

1. Project Number: I.2.2

2. Project Title: Estuarine and Oceanic migration of the juvenile and reproductive stages of the American eel (*Anguilla rostrata*).

3. Project Leader(s): J. Dodson (Laval U), M. Castonguay (DFO)

Collaborator(s): D. Hatin (Ministry of Natural Resources and Wildlife–MNRF)
M. Dionne (MNRF), P. Dumont (MNRF), M. Legault (MNRF), G. Verreault (MNRF), Y. Mailhot (MNRF), J. Dussureault (MNRF), J-F. Bourque (AECOM), V. Tremblay (AECOM), K. Thompson (Dal U), J. Sheng (Dal U), S. S. R. Abidi (Dal U), I. Jonsen (Dal U), R. Apostle (Dal U)

4. Training of Highly Qualified Personnel:

a) List of the HQP and level of their salary support by SNG.

Personnel	*Title*	*%Time involved in project*	*%supported from SNG*	*Dates*
Mélanie Béguer	PDF	100	100	01 October 2010- 30 Dec. 2014
José Benchetrit	MSc	100	83	01 October 2010- 30 April 2013
Simon Bernatchez	RA	100	20	01 May 2011 – 31 August 2011

b) Explain the role, activities and opportunities for training of technical staff in your project.

The role of Mélanie Béguer (PDF) is to facilitate and maintain communication among all project collaborators, to lead in the data analysis as well as contribute to the supervision of the M.Sc. student. She is also involved in the field work by participating in eel tagging, deployment, checking and retrieving acoustic receivers, and X-tag experiments.

José Benchetrit is a M.Sc. student. The aim of his project is to retrace the environmental history and movement patterns of yellow eels at the scale of the St. Lawrence River, using both telemetry data and otolith microchemistry analyses. As a result, he is involved in both eel tagging and in the management of acoustic receiver arrays. Moreover, he is being trained to use techniques involved in the analysis of trace element concentrations in otoliths using Laser Ablation Inductively-Coupled Plasma Mass

Spectrometry (LA ICP-MS). This work is supervised by Professor Pascal Sirois, professor at the University of Quebec at Chicoutimi.

Simon Bernatchez was employed over the course of 4 months in the summer of 2011 to assist with operations in the field, i.e. eel tagging and acoustic receiver management. Simon's role also involved assisting Jose with the dissection and processing of yellow eels in the laboratory as well as contributing to the development of our X-tag attachment method.

5. Progress towards Objectives/Milestones (1 Oct 2010 – 30 Sep 2011)

a) Please provide brief description of the overall objectives of this project (max ½ page).

The aim of the project is to establish the migration routes of the American eel, *Anguilla rostrata*, in the St. Lawrence system and beyond to the Cabot Strait and the Atlantic Ocean and to identify the abiotic and biotic conditions that prevail along these pathways. Two stages of the species lifecycle are being investigated: yellow-stage eels (juveniles) and silver-stage eels (reproductive adults). To study both life-history stages, we conduct a system-wide effort to capture and acoustically tag a total of 300 eels from the Saint Lawrence River with V9 and V13 pingers (depending on fish size). We first hypothesize that yellow eels exhibit periodic migrations to feed in the estuary. This hypothesis will be tested by exploiting fixed arrays of acoustic receivers deployed along the St. Lawrence River and Estuary to track movements of tagged fish. To complement these telemetry efforts, environmental history and potential alternative patterns of habitat-use of yellow eels will be studied through the analysis of otolith microchemistry. Otoliths will be used to determine the age of individuals and the use of microchemistry techniques will enable us to establish chronologies of habitats used by the eel during its continental growth stage.

Migration routes of the silver eel stage en route towards the presumed spawning site in the Sargasso Sea will also be determined using V13 pingers. As nothing is known of the migration of silver eels, no hypotheses may be formulated. Furthermore, 18 silver eels will be fitted with archival tags (X-tags, Microwave Telemetry) to track, for the first time, their diel horizontal and vertical migrations to the spawning site in the Sargasso Sea. Data on the eel's oceanic migration obtained from those archival tags and results from a reconstruction of the physical state of the Northwest Atlantic Ocean developed by OTN colleagues will be used to interpret the silver-eel movements from the St-Lawrence to the spawning site. Physical data and models will also provide projections of the possible impact of climate change on eel migration

b) Describe progress towards meeting the project's objectives and specific milestones for the project.

39 acoustic receivers were deployed during August 2010 and subsequently retrieved in November 2010. Two receivers were lost (La Malbaie array). Nevertheless, given that a very large amount of data was retrieved from the remaining receivers, the project's pilot year proved successful. The data were analyzed during winter 2010-2011 and presented to all collaborators during a March 2011 meeting.

The project's second year objectives and methodologies were adjusted based on the first year's results. 7 hydrophone arrays were added in order to spatially refine the survey of yellow eels. During April and May 2011, a total of 104 acoustics receivers (VR2W) were deployed along 10 arrays from "Iles-de-la-Paix" (slightly upstream from the Island of Montréal) to Ouelle River, as illustrated in Figure 1. All acoustic receivers are still in place and are scheduled to be recovered at the beginning of November 2011.

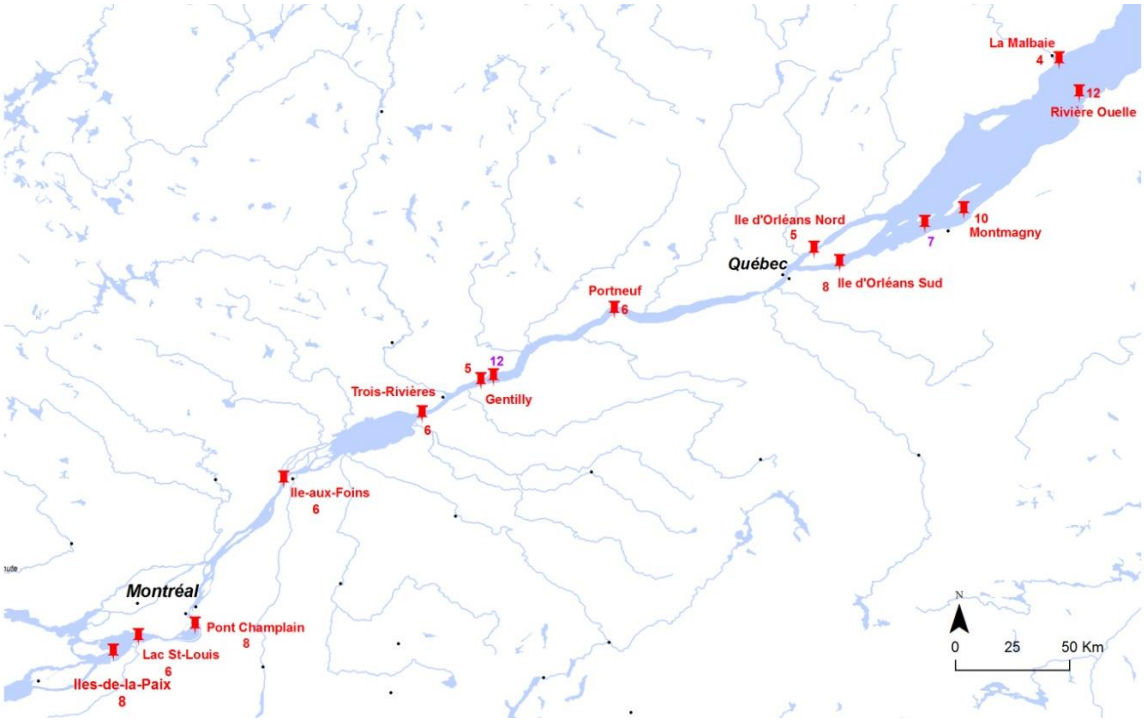


Figure 1. Location of arrays deployed for studying eel movements between spring and autumn 2011 in the St-Lawrence system. The number of acoustic receivers is indicated for each array. A total of 121 eels were tagged with either V9 or V13 pingers between June 6 and October 30, 2011. Receivers have been downloaded 3 or 4 times since their deployment and to date, at least 74 eels have been detected during summer 2011. A total of 73982 detections were recorded by the Saint Lawrence arrays.

Experiments involving archival-tags began in June 2011 at the Maurice-Lamontagne Institute. After testing several different systems to externally fix these tags without success, we tested a method

developed by a Japanese scientist, Ryotaro Manabe, who published a paper on the oceanic migration of Japanese eel with the use of pop-off archival transmitting tags. Five eels were equipped with dummy-tags in August and kept for monitoring in a large saltwater basin. Eels easily accepted the attachments with no apparent adverse effects and we have tagged 8 eels with X-tags (Microwave Technology) that were released in the St. Lawrence estuary at Mont-Joli between October 3 and 10, 2011. Tags are programmed to be automatically released for pop-up on 15 March 2012.

Furthermore, collaborations to model eel movements as a function of oceanographic features have been initiated during this summer and will start this autumn/winter with the research team of Theme I.1 (Jinyu Sheng, Keith Thompson and Ian Jonsen). Briefly, Keith Thompson's team will provide us their Matlab code and supporting oceanographic fields so that we can start to understand how the models work and explore what we can do with respect to our questions about eel migration. Secondly, Ian Jonsen will work to translate the Matlab code into R so that it can be embedded in POKM and become a tool that our team and other OTN researchers can easily access and use. We will test the models in POKM and share our experience using this aspect of POKM with others in the OTN community.

Otolith analysis: The final 10 – 20 remaining eels (out-migrating silver eels) to be sampled will be captured during the month of October, 2011. These will be added to the 54 eels collected during 2010 and 76 collected in 2011, bringing the total number to approximately 140 – 150 individuals. These otoliths are scheduled to be sectioned in November 2011 and subsequently analyzed at the University of Quebec at Chicoutimi in February 2012.

c) Describe and justify any significant deviations from the original objectives or plans, including any revised goals, new projects, or deleted projects.

As previously mentioned in the 2010 report, the idea of having a double line for each acoustic array, as initially intended, was abandoned due to the significant technical demand. In addition, the one line (Lanoraie) that was doubled in 2010 failed to provide any additional data – the lines were placed too close together to detect movements between them. For the second year of deployment, we chose, instead, to use all acoustic receivers available to extend the total distance and surface area covered by the arrays.

In 2011, we introduced a new goal into our project. For several years now, silver eels, significantly smaller in size than usual, were observed to be migrating downstream within the St. Lawrence system. These eels were identified by the Quebec Minister of Natural Resources as individuals originating from a stocking program involving glass eels caught in Nova Scotia and released in the Richelieu River. This provided the first evidence that stocking produce small silver eels capable of migrating seaward as far as the estuary in synchrony with naturally recruited female silvers eels en route to their spawning

grounds in the Sargasso Sea. We thus decided to tag 15 of these small silver eels using V9 tags in order to compare their migration with the larger, naturally-recruited conspecifics.

We decided to deploy the total number of eels fitted with Archival-tags (X-tag from Microwave Telemetry) over two years. 8 eels were tagged with X-tags in October 2011 and 10 eels will be tagged during autumn 2012.

d) *Describe how the work of the project's co-investigators and collaborators was coordinated and integrated*.

On December 12th 2010, a meeting was held at Laval University bringing together all co-investigators and collaborators involved in the project's first year. The pilot year's results were presented and discussed. Goals for 2011 were then discussed and a second meeting was planned and held on February 2nd 2011. During that meeting, the specific details surrounding the organization and planning of the 2011 field efforts were thoroughly discussed. As was the case during the first year, the subsequent planning and coordinating of field trips were, from thereon, largely conducted via email and over-the-phone communication. In the latter case, this allowed for all collaborators to be kept informed of progress. Following the first meeting at the end of 2010a non-official report of the first year was sent to all collaborators in January 2011.

To foster greater collaboration with Ian Jonsen's and Keith Thompson's teams within OTN, Dr. Mélanie Beguer will be visiting Dalhousie in Late November to review her working knowledge of the POKM platform and further the modeling exercise.

We are also collaborating with social scientists and lawyers within OTN who are working on the science and governance dimensions of the eel fishery. David Vanderzwaag, from Dalhousie's Law School, is providing the overall lead for the lawyers and social scientists involved. Dr. Richard Apostle visited Université Laval in July, 2012 to begin discussions with Julian Dodson on how best to proceed with the collaboration. Specifically, we initiated a search for information to build a socio-economic impact assessment of eel restoration measures and actions taken by countries having habitats for eel.

e) Describe the benefits of conducting this research as part of a network rather than as a separate project (e.g., scope of the research, cross disciplinary collaborations, new synergies and research opportunities, access to ship time, planning and coordination of research activities, exchange of information and data, benefits to students and technical staff).

Firstly, the technical challenges of a project with such a vast geographical scale/scope can only be ensured through a network of partners and collaborators. Indeed, our arrays extend from the Lac St-

Louis (slightly upstream from the Island of Montreal) to Cabot Strait and the continental shelf off Halifax. The acoustic arrays in the fluvial and estuarine part of the Saint Lawrence system (covering a total distance of approximately 384 km) are managed by many of our collaborators from Montreal to Mont-Joli: the Quebec Ministry of Natural Resources, AECOM (a private consulting company) and Fisheries and Ocean Canada. This, in itself, represents a significant work load as each array must be deployed, periodically verified, downloaded and, ultimately, retrieved. This implies a great amount of logistical planning and a significant investment in man hours, material (particularly boats) and budget. The acoustic receivers composing the Cabot Strait, Canso Strait and Halifax lines, deployed by OTN Canada, are essential for our project as the marine leg of the eel migration remains completely unknown. It would have been technically and financially impossible for a separate project to deploy acoustic receivers in those oceanic areas given the logistic requirements. Furthermore, these arrays are being exploited by several other projects within OTN.

Secondly, our estuarine arrays have the potential to detect any tagged species being studied through other OTN projects, such as the Atlantic sturgeon and striped bass. Conversely, our tagged eels can also be detected by marine coastal arrays deployed by other projects of within the network. As a result of the network, we are aware of the species that can be detected by our arrays and we are, similarly, informed as to whether or not our tagged eels were detected. Even if no eels are detected along the coastal marine areas, this still represents fundamental information for our project.

Our partners from the Quebec Ministry of Natural Resources and Wildlife also provided us with assistance with the capture of the eels for tagging as well as teaching us tagging procedures.

Another important objective of our project is to attempt to link physical and oceanographic factors with eel migration routes. This will require the use of the physical environment models developed within Theme I.1. Once we have data on the eel's oceanic migration obtained from the X-tags (eels will have been fitted with these and released during October 2011 and October 2012), results from a reconstruction of the physical state of the Northwest Atlantic Ocean will be used to interpret the silver-eels movements from the St-Lawrence to the spawning site. Physical data and models will also be used to project the potential impacts of the climate change on the eel migration. Furthermore, a modified version of DalCoast (Theme I.1) that provides realistic circulation and hydrographic distributions over the Gulf of St. Lawrence will also be useful to understand eel migration in the Gulf of St. Lawrence.

We are also collaborating with social scientists and lawyers within OTN who are working on the governance dimensions of the eel fishery. Such multi-disciplinary collaborations bringing together natural and social scientists is only possible within the structure of a large multidisciplinary research network.

Finally, the network represents an extremely stimulating and unique opportunity for both students and post-doctoral fellows involved. For example, Mélanie (PDF) is going to work this winter with people from Theme I.1 and José (M.Sc. student) is given the opportunity to work with a variety of academic and governmental partners from the Quebec MRNF and Fisheries and Oceans Canada.

f) Describe the scientific and/or engineering significance of the results to date.

At the present time, we only have results from the project's pilot year (2010) as all acoustic receivers deployed this year (2011) remain moored along their respective lines (these are scheduled to be recovered at the beginning of November 2011). These receivers have been collecting data since April/May 2011. 39 hydrophones were distributed along 4 arrays in the St-Lawrence system from August 2010 to the beginning of November 2010. 30 yellow eels and 62 silver eels were tagged with V9 or V13 (depending on their size) and released between August 19th and September 16th 2010. Most eels were caught and tagged near Trois-Rivières and released in St-Pierre Lake and the remainder were caught and released near St-Louis Lake. We consider the project's pilot year to have been a success. In total, 63% of tagged eels were acoustically detected by at least one array.

More specifically, 33% of tagged yellow eels were detected and most of these were detected at a single array suggesting, at least at this scale, a more sedentary lifestyle for this part of the lifecycle than we had initially hypothesized. To this same end, 7 lines (see Fig 1) were added to the system in 2011, allowing us to reduce the spatial scale of our observation with respect to yellow eel stage movement patterns.

In 2010, 77% (48/62) of tagged silver eels were detected by the Saint Lawrence arrays and 43% of these were recorded by 3 successive arrays. This allowed us to obtain fundamental information about silver eel migration which had previously never been studied at this scale. All eels exhibited unidirectional and downstream movements except for two individuals that were detected at both sides of Orléans Island within the span of a few days. This may have been the case for other eels as well since at least one line had breaches (Orleans Island South). This result was surprising and showed that the fluvial part of the silver eel migration is not necessarily completed as one continuous directed movement.

The individual rate of displacement calculated between each array increased significantly with the date of passage for each section. An individual's morphometric characteristics measured such as total length or body condition was not correlated with the rate of displacement.

Most eels were detected during the night as was previously reported in the literature. It also appeared that most eels were detected during ebb tide, suggesting for the first time that migrating silver eels are using active tidal stream transport to assist downstream displacement.

None of the tagged eels were detected at either the Canso Strait or the Cabot Strait. Canso Strait is an extremely narrow passage when compared to Cabot Strait and we were thus not surprised to see that eels did not exit the Gulf of Saint Lawrence through that passage. Eels out-migrating from the Saint Lawrence system are then likely to be exiting through the Cabot Strait. Only a small section of the strait was covered by acoustic receivers last year. Since no eels were detected by these receivers, we suspect that they exit the Gulf via the main channel that was not covered by any receivers in 2010. This hypothesis will be verified this year as additional receivers are being deployed to completely cover the Cabot Strait. We are very eager to obtain detections at Cabot Strait of fish tagged in 2011 as this will represent a significant step forward in the understanding of the course and speed of the Gulf of St. Lawrence phase of the eel migration.

This project's pilot year provided significant results with certain observations and patterns never before demonstrated at this spatial scale for this species. The work conducted in the first year was also insightful and allowed us to improve and refine our approach for 2011. In this respect we corrected acoustic 'breaches' observed in certain arrays in the St-Lawrence estuary, increased the number of lines to allow for better tracking of yellow-eel movements and extended the monitoring period from spring through autumn.

6. Difficulties encountered

a) Identify the main difficulties encountered in carrying out the research during the reporting period from the list below:

- ❑ Scientific problems/difficulties
- ❑ Equipment and technology issues (e.g., delivery and malfunctioning of equipment, etc)
- ❑ Personnel problems
- ❑ Involvement of partners
- ❑ Other (specify): _____
- **X** No problems occurred during this instalment of the grant

b) For each checked box, describe the difficulties identified above and the steps taken to resolve them.

No problem encountered.

7. Networking and outreach

Discuss the extent of networking and outreach by the project, both within the OTN Canada Network and with the broader community, by co-PIs, collaborators and HQP. Describe how the project's research has been impacted by, and contributed to, the research carried out by other projects from across the Network.

Intra-Network Collaboration and Partner Meetings

We are particularly excited about another important part of the networking focus within OTN Canada that will be carried out this winter, as specified in last year's report. Contacts were established during spring 2011 and more particularly during the annual OTN meeting held in Halifax in early June 2011. Collaboration will start on modeling the movement of silver eels from the Gulf of St. Lawrence to the spawning site in the Sargasso Sea. Given the fact that nothing is known about the migration routes eels take to reach the spawning site, an initial model will be run to try and understand the different potential routes that allow eels may exploit to reach the Sargasso Sea within a given time frame. The platform developed by investigators of theme I.1 (POKM) will be used to this end. Indeed, this platform, that can run models for animal movements, contains oceanographic data that is essential for understanding oceanic eel migration. In the context of this collaboration, we will be working particularly closely with Ian Jonsen, Keith Thompson and Jinyu Sheng. The use of these tools for modeling will greatly benefit the entire network as the eel migration project is one of the pilot projects for the development of coupled biological-physical modeling.

We are also collaborating with social scientists and lawyers within OTN who are working on the governance dimensions of the eel fishery. Following a summer meeting between Dodson and Apostle, we initiated a search for information to build a socio-economic impact assessment of eel restoration measures and actions taken by countries having habitats for eel.

Interaction/Outreach to Broader Community

We collaborate with MRNF of Quebec which is actually working on the acoustic tracking of striped bass and the yellow walleye. Our arrays are providing information on the spawning migration and dispersal of the striped bass following their reintroduction in the Saint Lawrence system. Secondly, our arrays are helping MRNF to track the dispersal of yellow walleye in the vicinity of Lac St. Pierre.

Our participation in the upcoming working group on eel biology that will be held in November 2011 at Montreal will allow us to contribute to the development of a national plan for eel management. This will be a critical meeting as the USA has announced its intention to list the American eel as an

endangered species, thus requiring considerable scientific input from Canadian scientists. Finally, we are in discussion with OTN, Bermuda, who intends to deploy VR2Ws to detect eels.

8. Dissemination of information and results

List refereed journal articles (accepted/published, submitted) and conference presentations (invited, contributed). All other dissemination is included in section #9 (Other contributions and deliverables).

Invited Conference and Seminar Presentations (1 total)

Béguer, M., Benchetrit, J. D., Dodson, JJ, Castonguay, M. Estuarine and oceanic migrations of the juvenile and reproductive stages of the American eel (*Anguilla rostrata).* Poster presentation at the annual meeting of Quebec-Ocean, November 2010, Lac Beauport, QC, Canada.

Contributed Conference Presentations (2 total)

Béguer, M., Benchetrit, J. D., Dodson, J., Castonguay, Hatin, D., Dumont, P., Legault, M., Verreault, G., Mailhot, Y., Bourque, J.F. Estuarine and oceanic migrations of the juvenile and reproductive stages of the American eel (*Anguilla rostrata).* Oral presentation given by Y Mailhot at the 37th Annual Meeting of the Atlantic International Chapter of the American Fisheries Society, September 25-27, 2011, Québec, Canada

Beguer, M. Benchetrit, J., Castonguay, M., Hatin, D., Verreault, G., Bourque, J.F., Jonsen, I., Thompson, K., Sheng, J., Dodson, J.J., Multiple approaches to elucidate the migration of the American eel (ANGUILLA ROSTRATA) from the St.-Lawrence River to the Sargasso Sea, 2012 Ocean Sciences Meeting, February 20 – 24, Salt Lake City, UT.

9. Other contributions and deliverables

Invited or contributed presentation/contribution at a workshop, seminar series or conference.

Béguer, M., Benchetrit, J. D., Dodson, JJ, Castonguay, Hatin, D., Dumont, P., Legault, M., Verreault, G., Mailhot, Y., Bourque, J.F. Estuarine and oceanic migrations of the juvenile and reproductive stages of the American eel (*Anguilla rostrata),* 1st OTN Canada Symposium, Halifax 2, 3 June 2011 (Oral presentation)

Béguer, M., Benchetrit, J. D., Castonguay, Hatin, D., Dumont, P., Legault, M., Verreault, G., Mailhot, Y., Bourque, J.F and Dodson, J., Tracking the movements of the American eel in the St-Lawrence River: Project description and first results, 9th Annual meeting of the Canadian Eel Science Working group that will be held at Montreal, 29th-30th November 2011

Invited or contributed consultation with an agency; public or private

- On September 29, 2011, the U.S. Fish and Wildlife Service published a notice in the *Federal Register* announcing a petition to list the American eel (*Anguilla rostrata*) as threatened under the

Endangered Species Act of 1973, as amended (Act). We will thus be called upon to provide scientific knowledge by way of the Canadian Eel Science Working Group to contribute to this process.

10. Collaborations with Industrial and Government Partners

a) Please describe which partners are actively involved in management, research, and knowledge transfer within the network and the specifics of their involvement.

The particular roles of each partner have been determined and assigned based on their location and their skills. Our partners from AECOM, a private consulting company, are in charge, with our assistance, of 1 VR2W array. They also provided technical expertise (boat captain) to verify 3 other arrays. Our partners from the Quebec Ministry of Natural Resources –MNRF- are in charge of an additional 5 arrays (3 upstream arrays and 2 arrays in the middle estuary). Our partners from Fisheries and Ocean Canada are in charge of the last downstream array at Ouelle River/Montmagny. All those partners provided material, technical and logistical support to our core team to manage the acoustic arrays. Furthermore, partners from the MNRF also deployed additional acoustics receivers, in the regions of Gentilly and Montmagny, for their specific projects about the movement of striped bass and walleye. Those receivers are thus providing additional information on eel movements. In the same time, our arrays serve in their studies.

As in year one, tagging efforts were led by the MNRF at Longueuil as was the teaching of these tagging procedures to the HQP. Partners from the MRNF also contributed to the capture of eels. Those from Longueuil organized and supported the electric fishing in June 2011 which was conducted to capture yellow eels in the St. Louis Lake. MRNF partners from Rivière-du-Loup provided some yellow and silver eels thanks to fishing gear they operate at Cap Santé. All contributors were also invited to two meetings in order to discuss last year's results and to plan the second year.

b) Cash and in-kind contributions from partners for year 2.

Name of supporting organization: **MRNF**	**Year 2** (1 Jan – 30 Sep 2011)
Cash contributions to direct costs of research	5,750
In-kind contributions to direct costs of research	
1) Salaries for scientific and technical staff	36,325
2) Donation of equipment, software	-
3) Donation of material	500
4) Field work logistics	2,500

5) Provision of services	23,000
6) Other (specify): _____	-
In-kind contributions to indirect costs of research	-
1) Use of organization's facilities	2,950
2) Salaries of managerial and administrative staff	100
3) Other (specify): _____	-
Total of all in-kind contributions	**69,925**

Name of supporting organization: **POC**	**Year 2**
	(1 Jan – 30 Sep 2011)
Cash contributions to direct costs of research	
In-kind contributions to direct costs of research	
1) Salaries for scientific and technical staff	20,000
2) Donation of equipment, software	
3) Donation of material	
4) Field work logistics	3,000
5) Provision of services	
6) Other (specify): _____	
In-kind contributions to indirect costs of research	
1) Use of organization's facilities	10,000
2) Salaries of managerial and administrative staff	
3) Other (specify): _____	
Total of all in-kind contributions	**33,000**

Name of supporting organization: **AECOM**	**Year 2**
	(1 Jan – 30 Sep 2011)
Cash contributions to direct costs of research	
In-kind contributions to direct costs of research	
1) Salaries for scientific and technical staff	1,500
2) Donation of equipment, software	
3) Donation of material (VR2Ws)	20,700
4) Field work logistics	750

5) Provision of services	
6) Other (specify): _____	
In-kind contributions to indirect costs of research	
1) Use of organization's facilities	
2) Salaries of managerial and administrative staff	
3) Other (specify): _____	
Total of all in-kind contributions	**22,200**

Name of supporting organization: **Québec-Océan**	**Year 2** (1 Jan – 30 Sep 2011)
Cash contributions to direct costs of research	
In-kind contributions to direct costs of research	
1) Salaries for scientific and technical staff	2,000
2) Donation of equipment, software	
3) Donation of material	
4) Field work logistics	
5) Provision of services	
6) Other (specify): *lend equipment (VR2)*	
In-kind contributions to indirect costs of research	
1) Use of organization's facilities	
2) Salaries of managerial and administrative staff	
3) Other (specify): _____	
Total of all in-kind contributions	**2,000**

11. Expenditures and Support

Year 2 (2011)

a) Indicate your approved year 2 budget, your actual expenditures from 1 January to 30 Sep 2011 and your projected expenditures for the remainder of this installment (through to 31 December 2011).

	Proposed	Actual Expenses 1 Jan-30 Sep 2011*	Total Balance 30 Sep 2011*	Projected Balance 31 Dec 2011**
1) Salaries and Benefits				
a) Students	41,300	12,109	**29,191**	**25,391**
b) Postdoctoral Fellows	45,000	33,045	**11,955**	**0**
c) Technical/Professional Assistants	1,000	9,431	**-8,431**	**-15,431**
d) Other (specify)	0	0	**0**	**0**
2) Equipment or Facility				
a) Purchase or Rental	3,000	2,269	**731**	**0**
b) Operation and Maintenance Costs	5,200	8,042	**-2,842**	**-6,342**
c) User Fees	0	0	**0**	**0**
3) Material and Supplies	0	0	**0**	**0**
4) Travel				
a) Conferences	4,000	2,939	**1,061**	**0**
b) Field Work	10,325	7,376	**2,949**	**0**
c) Collaboration/ Consultation	2,000	358	**1,642**	**0**
5) Dissemination Costs				
a) Publication Costs	0	0	**0**	**0**
b) Other Activities	0	0	**0**	**0**
6) Other (specify)				
a)	0	0	**0**	**0**
b)	0	0	**0**	**0**
Total	**111,825**	**75,569**	**36,256**	**3,618**

b) Below, explain any significant deviations from the proposed expenditures. (Note: Changes of >20% from budget categories require advance approval from the Reprofiling Committee and NSERC, and must come first to S. Iverson).

1) Salaries and Benefits

(a) *Students*. We had originally planned to engage two graduate students, one post-doctoral fellow and one summer student to participate in the project. As explained in last year's report, we decided to delay the start of one student position because of budget cuts in year 1. However, it became obvious during the operation of our first year of activity that we had badly underestimated certain budget items; particularly technical/professional assistance and operation and maintenance costs. We thus abandoned the second graduate student position to allow for these additional expenditures (see below).

(b) *Technical/professional assistants*. We had to greatly increase this line item to employ technical assistants for the deployment and management of acoustic receivers that was far more onerous than anticipated. One technician, an expert in the design and deployment of moorings, was employed for a month to design and prepare the moorings for VR2W hydrophones in high current environments (the St. Lawrence R. channel). Although we have access to the Boston-Whaler of Quebec-Ocean, we are required to hire a licensed boat captain for several weeks over the field season to take responsibility for VR2W deployment, downloading and eventual retrieval (November 2011) of 4 acoustic arrays.

2) Equipment or facilities

(a) *Operation and maintenance costs*. Field expenditures were much higher than planned. This was largely due to two budget items. Firstly, we failed to budget for the charges for access to Argos satellites associated with the use of satellite tags. This alone represents an additional 4 000$ in charges reserved on the 2011 budget. Secondly, we are obliged to purchase eels for tagging from commercial fishermen. Commercial prices for eels have doubled since 2010. Silver eels (weighing between 2.5 and 3 kilos) cost 75$ each! This amounted to approximately 4 000$ in additional charges that we failed to budget for.

Balance of year 2 budget: The estimated approximately 3 000$ balance at the end of fiscal year 2011 will help to defray the costs of the visit of Dr. Kim Aarestrup, Technical University of Denmark, who we invited to participate in the p-sat tagging of American eels and to give seminars at IML and Université Laval.

Year 3 (2012)

a) Using the same excel form provided, indicate your approved year 3 budget (already entered for you) and any revisions to that original budget that you are proposing for year 3, noting that it must sum to ≤ the original total.

Year 3 (2012)	Original	Revised	Carry Over Requested
1) Salaries and Benefits			
a) Students	42,300	23,500	0
b) Postdoctoral Fellows	45,000	45,000	0
c) Technical/Professional Assistants	0	10,000	0
d) Other (specify)	0	0	0
2) Equipment or Facility			
a) Purchase or Rental	3,000	3,000	0
b) Operation and Maintenance Costs	5,200	12,000	0
c) User Fees	0	0	0
3) Material and Supplies	0	0	0
4) Travel			
a) Conferences	4,000	4,000	0
b) Field Work	11,250	11,250	0
c) Collaboration/ Consultation	2,000	4,000	0
5) Dissemination Costs			
a) Publication Costs	0	0	0
b) Other Activities	0	0	0
6) Other (specify)			
a)	0	0	0
b)	0	0	0
Total	**112,750**	**112,750**	**0**

b) Provide a detailed justification for your year 3 budget. You may use your original justification (just as submitted in the proposal) and state that it remains on track if that is the case. For budget items that you are proposing to change, you must give a clear explanation/justification of why; these proposed changes must be approved by the SAC.

1) Salaries and benefits.

   (a) This amount represents the stipend of one M.Sc. student (José Benchetrit) and one undergraduate summer student (to be determined), as originally proposed. We have suspended the recruitment of a second student as these monies are needed elsewhere (see below).

   (b) This amount represents the stipend of Mélanie Béguer, post-doctoral fellow, as originally proposed.

   (c) This amount represents the costs of hiring a licensed captain for the deployment, downloading (2 occasions) and retrieval of 3 acoustic arrays. We had not originally budgeted for this expense.

2) Equipment and facilities

   (a) purchase or rental. $3,000. Ship time for deployment and servicing of VR2 hydrophone array in the middle estuary, as originally proposed.

   (b) Operation and maintenance costs. Batteries for VR2 receivers = $4,000, Argos satellite charges = $4,000, eel purchase = $4,000.

3) Travel

   (a) Conferences. Attendance at international conference for 2 = $4,000.

   (b) Field work. Expenses for field surgery. 25 days x $250 per day for living expenses for 2 people = $6,250. Mini-van rental. 25 days x $100 per day = $2,500. Fuel for field trips. 5 trips @ $500 = $2,500 per annum. Total = $11,250.

   (c) Collaboration-consultation. Team meetings and workshops = $2,000, travel to Halifax for consultation with oceanographers and social scientists = $2,000

Atlantic Arena I.2.3

1. Project Number: I.2.3

2. Project Title: Atlantic sturgeon on the east coast of Canada: migratory behavior and origin, and the potential for tidal Power impacts

3. Project Leader(s): M. Dadswell (Acadia), M. Stokesbury (Acadia), M. Litvak (Mount Allison)

Collaborator(s): P. Smith (BIO DFO), R. Bradford (BIO DFO), J. Gibson (BIO DFO), J. Sheng (DAL), R. Karsten (Acadia), S. Munroe (Acadia), A. Redden (ACER, Acadia), D. Fox (U Delaware), S. Laporte (NOAA, NMFS), I. Wirgin (NYU, NY), T. King (USGS), M. Fast (UPEI Veterinary Collage), S. Cooke (Carleton U), C. Taggart (Dal U)

4. Training of Highly Qualified Personnel:

a) List of the HQP and level of their salary support by SNG.

Personnel	*Title*	*%Time involved in project*	*%supported from SNG*	*Dates*
Sierra Wehrell (Acadia)	MSc	100	100	1 Jan – 1 Sep 2011
Montana McLean (Acadia)	MSc	100	100	1 Jan – 30 Sep 2011
William Roberts (Acadia)	BSc	100	100	1 May – 1 Sep 2011
Jeffrey Beardsall (Acadia)	MSc	100	0	1 May – 30 Sep 2011
Jeremy Broome (Acadia)	M Sc.	20	0	1 May – 30 Sep 2011
Colin Burhiliwalla (Acadia)	B Sc.	20	0	1 May – 30 Sep 2011
Bridgitte Donovan (UPEI)	M Sc.	20	0	1 June – 30 Aug 2011
Andrew Taylor (Mount Allison)	B.Sc.	25	0	1 January-30 April 2011
Andrew Taylor	M Sc.	100	100	1-May- present

(Mount Allison)				
Christine Adams (Mount Allison)	B.Sc.	100	100	1-June- 21 July 2011
Sima Usvyatsov (UNBSJ)	Ph.D.	10	0	1-Jan – present
Justin Barkhouse (Mount Allison)	B.Sc.	20	20	1 May- 31 August 2011
Alicia Cassidy (Mount Allison)	B.Sc.	10	10	1 May- present

b) Explain the role, activities and opportunities for training of technical staff in your project.

Our HQP's are completely integrated into every facet of this study. They prepare and deploy receivers. They operate on and acoustically tag sturgeon. They sample sturgeon for morphological characteristics (length, weight, etc), assist in blood collection for stress analysis, collect samples for DNA analysis, stable isotope analysis, larval sampling and observe and help collect parasites. They are involved in active and passive tracking of Atlantic sturgeon. They assist in record keeping and data analysis and independently write up and present results at international and local scientific meetings from portions of the study for which they are responsible. They hold the major role in preparing first drafts of manuscripts for publication in the projects they are responsible for.

5. Progress towards Objectives/Milestones (1 Oct 2010 – 30 Sep 2011)

a) Please provide brief description of the overall objectives of this project (max ½ page).

Overall objectives of this project are to:

1. Determine the migratory behavior and origin of Atlantic sturgeon on the east coast of Canada
2. Describe the annual, summer migration of Atlantic sturgeon through Minas Basin and the population characteristics of this aggregation.
3. Determine the role that Minas Basin plays in the coastal migration of Atlantic sturgeon stocks on the east coast of North America.
4. Determine the importance of Minas Basin to the growth and health of Atlantic sturgeon (feeding, parasites)
5. Determine the movement of Atlantic sturgeon through Minas Passage and the potential impact of tidal power on east coast stocks.
6. Increase our understanding of the biology of Atlantic sturgeon and how this knowledge may assist in determining the status of east coast Atlantic sturgeon stocks and provide managers with information that can assist in the sustainable exploitation of these stocks.

7. Improve scientific information on the existence and movements of Atlantic sturgeon stocks in eastern Canada
8. Improve communication and information transfer with researchers and managers in the United States concerning the migratory behavior and status of transboundary stocks of Atlantic sturgeon
9. Determine large and fine scale movement patterns, seasonal distribution and habitat use of Atlantic sturgeon from the Saint John River, NB, Canada.
10. Define critical river reaches of Atlantic sturgeon such as spawning sites and holding areas within the Saint John River. For example, the Mactaquac dam controls flow regimes and water levels which may have adverse effects on spawning, hatching and recruitment. Information on habitat utilization can be used to inform decision makers on management of water flow at the Maqtaquac dam that will minimize impact on Atlantic sturgeon.
11. Communicate our findings locally, nationally and internationally through meetings, presentations and publications.

b) Describe progress towards meeting the project's objectives and specific milestones for the project.

A total of 63 Atlantic sturgeon were tagged with acoustic tags in Minas Basin, 60 of which were temperature and pressure sensitive and three that were pop-up. A total of 57 VR2w acoustic receivers were deployed in Minas Basin and Channel. Total receivers include a dense array of 15 receivers, sync tags and telemetry tags in the Southern Bight off Kingsport used to record 3-D movement of sturgeon on critical feeding habitat. In addition 10 intertidal receivers (3 contributed by NMFS), 6 in an array around the Nova Scotia Power tidal turbine and), 12 across the Minas Channel (contributed by ACER) and 14 across Minas Channel (contributed through OTN) were deployed to study migratory corridors, seasonality, environmental preferences (including depth) and survival of sturgeon as they move between the Minas Basin and outer Bay of Fundy in an area targeted for instillation of tidal power turbines in 2012.

The intertidal array of receivers off Kingsport observed sturgeon exploiting the soft-sediments of the inter-tidal zone during high tide for feeding. A total of 10 sturgeon tagged in 2010 and 18 tagged during 2011 were acoustically recaptured between April and August 2011 within the array. Food recovered from captured individuals by gastric lavage indicated the sturgeon were feeding on soft-bodied invertebrates such as polychaetes and amphipods *(Corophium* sp) which are common members of the intertidal infauna of Minas Basin.

Our results indicate an aggregation of juvenile and sub adult Atlantic sturgeon occurs in Minas Basin of the inner Bay of Fundy during April to September. Tag-recapture data indicate the aggregation contains approximately 6,000 sturgeon. Mean size and range is 135cm FL and 56 - 219cm FL and ages range from 6-60 yr. External tag and acoustic tag recoveries during 2010 and 2011 indicate the

aggregation apparently feeds in the inner portions of Minas Basin over soft sediments mainly in the intertidal zone at high tide and moves slowly in a clockwise pattern around the Basin from the northern shore in spring to the southern shore by late summer. Sturgeon enter and exit Minas Basin through Minas Passage where deployment of tidal turbines is planned. Early results from pressure sensitive tags indicates sturgeon move through the passage at mid-depths and would encounter the turbines.

A total of 25 sturgeon were tagged in the Saint John River estuary with acoustic tags, 12 of which were coded pingers, six were pressure sensitive and seven that were pop-up. A total of 24 acoustic receivers were deployed in the Saint John River estuary. Twenty-one receivers were deployed throughout the river to gather information on large-scale movement patterns, while three receivers, a sync tag and a telemetry tag were deployed in an aggregation area in Long Reach to record fine-scale movement of sturgeon. Using a VR100 acoustic receiver with an omni-directional and directional hydrophone attached, active tracking methods were also used to triangulate fish position to determine fine-scale habitat use and movement. All tagged fish were acoustically recovered during 2011, and the majority has been observed exiting the Saint John River estuary by mid-September.

D-frame drift nets were used in the Saint John River to sample for larvae in suspected spawning areas. In July 2011, four sturgeon larvae were captured and will be sent for stable isotope analysis to verify the species. On first inspection it does appear that we have caught the first Atlantic sturgeon larvae from the Saint John River.

During tagging trips in the Saint John River and the Minas Basin, blood samples were taken to be used in stable isotope analysis. Stable isotopes will be used to determine diets and habitat utilization.

A total of 23 Atlantic sturgeon of 30 tagged in Minas Basin during 2010 were acoustically recovered in Minas Basin during 2011 for a known survival rate of 77% over one year at large. Two Atlantic sturgeon tagged in Minas Basin with only dart tags were recovered in the Saint John River estuary during 2010 and 2011 and one sturgeon dart tagged in the Saint John was recovered in the Minas Basin. Four Atlantic sturgeon acoustically tagged in the Saint John River have been passively tracked with VR2W's in the Minas Basin, one in September 2010 and three in June 2011. In addition, one of the tagged sturgeon from the Saint John River was picked up by a VR2 located near Musquash, NB, shortly after it was identified acoustically in the Minas Basin in June 2011.

During tagging trips in Minas Basin Atlantic sturgeon were examined for external and blood parasites by two researchers, Samantha Munroe (Acadia) and Mark Fast (UPEI Veterinary School). The study with S. Munroe has been published in the Journal of Parasitology

Also during tagging trips in Minas Basin a total of 181 Atlantic sturgeons were sampled for DNA analysis at the laboratories of Isaac Wirgin (NYU) and Tim King (USGS). Stock analysis using Microsatellites and Mitochondrial DNA indicated that 61% were Saint John River, New Brunswick stock, 34% were from the Kennebec River, Maine, 4% were from the Hudson River, NY and 1% was identified to the James River, Virginia. A manuscript on the DNA results is in review with the Transactions of the American Fisheries Society.

Presentations on our findings were given at two international and two regional scientific meetings by project leaders and HQP personal. The Lions Club sturgeon derby was used as a public outreach event during which fishers captured sturgeon to be tagged, measured and weighed. Overall the event promoted communication with the recreational fishing sector of the Maritimes.

Milestone	**Description of Activities**	**Anticipated starting date**	**Anticipated completion date**	**Progress as of 15 October 2011**
Animal care protocols	Submit animal care protocols to University animal ethics review board for tagging animals	Jan 2011	March 2011	Completed
Order Tags and Receivers	Tags and receivers must be ordered in advance as they are manufactured upon request	Jan 2011	April 2011	Completed
Order of Wildlife computer pop-up Archival tags.	Pop-up Archival tags must be ordered months in advance	Jan 2011	June 2011	Completed
Setup of CLS America account for transfer of satellite data from ARGOS	A carrier must relay satellite data from satellites to researchers.	June 2011	June 2011	Completed
Solidify collaboration with VEMCO for experimental design of VPS system	VPS setup and data analysis are done in collaboration with VEMCO	April 2011	May 2011	Completed
Undergraduate Research Assistant hired for field season at Acadia at Acadia begins programs	Assisting OTN MSc students Wehrell and McLean in deployment of acoustic receivers, receiver download, surgical implantation of acoustic tags, collection of DNA samples and parasites.	May 2011	Sept 2011	Completed
Receivers placed in the Saint John River	Receiver placement will be plotted and suitable depths and bottom structure will be determined. Receivers and moorings will then be deployed.	May 2011	May 2011	Completed
MSc student at MTA begins programs	Students must be in place prior to field activities: indentifying spawning grounds and determination of critical Habitat for sturgeon	May 2011	May 2013	Completed

Undergraduate research assistant hired for field season at Mount Allison	Assisting OTN MSc student Andrew Taylor in deployment and download of acoustic receivers, surgical implantation of acoustic tags, sampling of Atlantic sturgeon, active tracking and habitat characterization.	May 2011	August 2011	Completed
Receivers placed in the Minas Basin, and Minas Channel	Receiver placement will be plotted and suitable depths and bottom structure will be determined. Receivers and moorings will then be deployed.	June 2010	June 2010	Completed
Tagging in the Minas Basin begins	Coded acoustic transmitters will be surgically implanted in Atlantic sturgeon caught as by-catch in the Inner Bay of Fundy weir fishery.	May 2010	August 2010	Completed
Tagging in the Minas Basin southern bight	Coded acoustic transmitters and pop-up satellite tags deployed on Atlantic sturgeon caught in the Inner Bay of Fundy otter trawl fishery. Blood samples (indicators of stress), DNA samples, parasite samples, and stable isotope samples collected.	June 2010	September 2010	Completed
Tagging in the Saint John River begins	Coded acoustic transmitters were surgically implanted and pop-up satellite tags were externally attached to Atlantic sturgeon caught using gill nets in the Saint John River.	June 2011	August 2011	Completed
Active tracking in the Saint John River	Tracking tagged sturgeon using a VR100 receiver to determine fine scale movement and habitat use.	June 2011	Ongoing	Ongoing
Habitat characterization in the Saint John River	Depth, substrate, temperature, oxygen concentration and salinity were characterized in areas used by Atlantic sturgeon.	June 2011	September 2011	Completed
Larval sampling in the Saint John River	Larvae were sampled using d-frame drift nets in suspected spawning areas.	July 2011	August 2011	Completed
Meta-data submitted to OTN data managers	All deployment metadata and receiver download metadata needs to be submitted to OTNC at Dalhousie	June 2011	Ongoing	Ongoing
Receiver recovery Minas Basin	All recoverable receivers retrieved	Sept 2011	Nov 2011	Ongoing
Receiver recovery Saint John River	All recoverable receivers retrieved	Sept 2011	Nov 2011	Ongoing
Sturgeon Ecto-Parasite Manuscript	Paper published in the Journal of Parasitology	May 2010	July 2010	Ongoing
DNA manuscript	Tissues from collected sturgeon sampled for DNA stock analysis	March 2011	July 2011	In review

Good progress towards the project objectives has been made. Original milestones for the 2011 field season have all been met.

c) Describe and justify any significant deviations from the original objectives or plans, including any revised goals, new projects, or deleted projects.

There has been no significant deviation from the original objectives or plans. However, the project has become more complex and multifaceted. For example, we are now working on blood indicators of stress (cortisol, lactate, glucose) to determine the least stressful sampling and tagging methods for sturgeon. This is in collaboration with Steve Cooke, Carleton University and OTNC Pacific. Also, we have examined DNA for population structure in collaboration with Isaac Wirgin (New York University) and Tim King (USGS), external, gill and blood parasites with Samantha Munroe (Acadia) and Mark Fast (UPEI Veterinary College). Litvak's lab is also using blood samples to examine stable isotopes for diet and habitat use for Atlantic sturgeon caught in the Saint John River and the Minas Basin.

We have begun planning for acoustic tagging of sturgeon during 2012 in the Mira Estuary, Cape Breton, a little studied region of the Atlantic coastal environment, and other Maritime rivers (LaHave, Miramichi, etc). This work will broaden our study towards the realization of our primary objective to determine the migratory behavior and origin of eastern Canada sturgeon stocks. This expansion should exploit the existence of the two OTN receiver lines off Halifax and northern Cape Breton. These adjustments are normal expansions to a project of this nature and provide an economy of scales where we are more thoroughly able to meet our objective while also building research capacity and innovation at our (Acadia and Mount Allison) and other institutions. Litvak has been in communication with Eel Ground First nation and is examining the possibility of developing a collaborative research program on Atlantic sturgeon on the Miramichi River this coming summer.

d) *Describe how the work of the project's co-investigators and collaborators was coordinated and integrated*.

Co-ordination of field work during the 2011 field season was the responsibility of each research unit (Minas Basin and Saint John Estuary). Dadswell and Stokesbury worked together with their HQP personnel (Wehrell, McLean, Roberts – Funded by OTNC, Beardsall and Burhiliwalla – Funded by CRC funds to MJWS) to deploy receivers and tag sturgeon in Minas Basin. They also coordinated with and assisted Redden and Broome (ACER) in deployment of the additional receivers in Minas Basin. Litvak and his HQP personnel deployed receivers, tagged, sampled and tracked sturgeon in the Saint John estuary. Fast and his student (Donovan – Funded by UPEI) joined us and our HQP personnel during sturgeon tagging in weirs and onboard ship. DNA samples were shipped to Wirgin (NYU) and King (USCS) and they are using the information discovered to enter the debate in the United States on the status of US Atlantic sturgeon stocks (NMFS) and possible threats to the health of their population in light of possible mortalities from Tidal Power development in Canada.

e) Describe the benefits of conducting this research as part of a network rather than as a separate project (e.g., scope of the research, cross disciplinary collaborations, new synergies and research opportunities, access to ship time, planning and coordination of research activities, exchange of information and data, benefits to students and technical staff).

This work could not be completed without the Network approach. Research projects are discussed and moved forward by all PI's in the program. Student input in experimental design is incorporated. The research performed in this program is centred around building on capacity of OTNC and OTN Global. Technology is discussed with OTNG technicians, and data collection and storage with OTNG data management. Large scale arrays that add important added value to our research are provided by other OTN collaborators. Questions fundamental to diadromous life history are now being developed with assistance of other OTNC arenas including animal trackers, oceanographers, and social scientists. The network approach has not only significantly accelerated our learning curve with respect to the biology and migration of Atlantic sturgeon, it is facilitating scientific enquiry on a broader scale that would not be possible without the OTN Network.

New Synergies and research opportunities – Stokesbury's student (Beardsall M Sc) travelled to Quebec to perform field work and be trained in blood chemistry sampling and analysis with Dr. Steve Cooke's lab at Carleton university. Bearsall has returned that knowledge to Stokesbury's lab where he has trained other students in sampling techniques. Steve Cooke is on Beardsall's committee and more interaction between labs will be forthcoming. Stokesbury and Dadswell are working with Fast and his student (Donovan – Funded by UPEI) to examine parasite load and blood indicators of vitality for Atlantic sturgeon. In addition, DNA samples were shipped to Wirgin (NYU) and King (USCS) and they are using the information discovered to enter the debate in the United States on the status of US Atlantic sturgeon stocks (NMFS),

Litvak and his M.Sc. student, A. Taylor (Mount Allison University, OTN Atlantic) developed linkages with Broell (M.Sc. Dal, OTN Atlantic) and Taggart (Dal, OTN Atlantic). They jointly carried out a series of accelerometer swim trials on shortnose sturgeon at the Mactaquac Hatchery (DFO, New Brunswick; Litvak's lab has 200+ sturgeon there) in May/June 2011. This work could not have been accomplished without this collaborative effort. Broell was provided access to these fish and the facilities rented by the Litvak lab. Litvak's lab also provided a field assistant during the swim trials, while Broell provided the necessary accelerometer equipment, expertise of equipment usage and experimental protocol. The high-resolution accelerometer data on activity, swimming and burst acceleration collected will be used to determine optimal sampling frequencies for shortnose sturgeon for certain parameters of interest (size-at-age scaling parameter, parameters for activity patterns and energy budgets).

This linkage between two groups within OTN Canada is provides the opportunity to develop a larger collaborative effort. We propose to develop a longer-duration tag with the optimal frequency for the field to be used for tagging Atlantic sturgeon in the Saint John River. For this future collaboration between Litvak, Broell, Taggart, Taylor and Usvyatsov (PhD student and soon to be Postdoc in Litvak's lab) aim to use Pop-up Satellite Tags (Desert Star Systems, LLC) in combination with accelerometer tags to assess activity patterns and movement in this species. These PSAT tags (valued at $2900/piece plus $400/accelerometer) will be obtained by an NSERC RTI grant. If the RTI grant application is successful, these tags will be used for field trials on shortnose sturgeon or potentially Atlantic sturgeon juveniles, can also be used for similar experiments with black marlin in Australia in collaboration with ANU by Taggart's lab. If the RTI grant application fails, Taggart and Litvak will purchase at least one tag each from other funds to facilitate this collaboration. This collaboration benefits both labs. Broell's studies will be able to test the size-at-age and acceleration hypothesis as well as the relations between acceleration and activity/energy budgets. Taylor, Usvyatsov and Litvak's work will benefit from this novel application by adding information to sturgeon behavior that was previously limited to migration routes, and location detection. With the use of accelerometers more in-depth behavior (swimming, bursting activity, feeding, spawning etc.) can be developed to better understand habitat utilization and migration.

Since we became part of the OTN network other researchers discovered our work through web sites, meetings and publications and asked to collaborate in the study (DNA, Parasites). This has dramatically expanded the scope of our work with little extra effort and led to numerous cross disciplinary relationships. We have provided these researchers with samples and/or ship time for them to sample and this has expanded all our research and publication opportunities. Ours and their students have benefited in the planning and coordination of the combined research activities and have expanded the exchange of information and data: our students learned about parasites and DNA research; and their students saw how to sample and acoustically tag what seemed to them were humungous large fish, and handle them in a research atmosphere.

f) Describe the scientific and/or engineering significance of the results to date.

Scientific:

We have determined these previously unknown facts:

- That a summer aggregation of about 6000 Atlantic sturgeon occurs in Minas Basin each year consisting of mainly juveniles from 100- 200cm and 10-25 years of age.
- These sturgeon enter Minas Basin in spring and move through the Basin feeding over soft sediments. Movement is in a clockwise pattern from the northern portion of the Basin to the southern. Sturgeon exit the Basin in late summer.
- Passage into and out off the Basin occurs at mid-depths in Minas Passage.

- Sturgeon occurring in Minas Basin in summer consist of fish from stocks in at least four spawning rivers; the Saint John R, NB, the Kennebec in Maine, the Hudson in NY and the James River in Virginia.
- Sturgeon return to Minas Basin in successive years and survival of acoustically tagged individuals is excellent.
- Sturgeon parasite loads can be heavy but do not seem to harm their health. A complete list of external parasites for Atlantic sturgeon at any locality in eastern Canada has been compiled for the first time.
- In the Saint John River Atlantic sturgeon remain primarily in the lower reaches during the summer. We described daily activity schedules, fine scale movements of these tagged fish and habitat utilization.
- Timing of exit from the Saint John River is from early August to late September. The Atlantic sturgeon seem to time their exit based on tidal flow.
- Four Atlantic sturgeon larvae were caught in the Saint John River in late July. This provides us an indication of upstream spawning location.
- Fish tagged in the Saint John River have been found in the Minas Basin and Musquash estuary.

Engineering:

- In collaboration with Vemco we have demonstrated that the Vemco VPS 3-D acoustic tracking array design is effective for accurate 3-D tracking fish with minimal error (metres) on a scale of kilometers in a Macro Tidal Estuary.
- In the Stokesbury lab we have developed a method for leadering popup archival tags to Atlantic sturgeon that will reduce premature detachment of tags.
- Litvak and HQP Taylor have developed a procedure that allow accurate (scale of meters) positioning of an acoustically tagged organism through triangulation using active tracking techniques. This is unique in the literature and when completed will be of importance to tag engineering companies.
- Litvak, Taggart and HQP are working with to combine pop-up archival tag ability with the capacity to measure acceleration. If successful this will create an innovative solution to determining long term energy (and therefore somatic and reproductive potential) budgets for highly mobile animals. Creation of this tag would not only be of high significance to the scientific community but also of great interest to the Canadian and international animal tracking industry.
- Tagged sturgeon moving through the Minas Passage, an area scheduled for Tidal Power turbine infrastructure deployment in 2012, have provided information on seasonality, depth preferences and tidal transport. This information is central to the design, deployment and operation of hydro power turbines in the Minas passage. Information will also inform mitigation measures for the industry to reach conservation targets for species of concern.

- Definition of critical river reaches of Atlantic sturgeon within the Saint John River are required to manage flow rates at NB Power's hydroelectric facilities. Information on habitat utilization can be used to inform decision makers on management of water flow at the Maqtaquac dam that will minimize impact on Atlantic sturgeon.

6. Difficulties encountered

a) Identify the main difficulties encountered in carrying out the research during the reporting period from the list below:

X Scientific problems/difficulties
X Equipment and technology issues (e.g., delivery and malfunctioning of equipment, etc)
X Personnel problems
- ❑ Involvement of partners
- ❑ Other (specify): _____
- ❑ No problems occurred during this instalment of the grant

b) For each checked box, describe the difficulties identified above and the steps taken to resolve them.

Of the eight Pop-up archival tags to be deployed in the Minas Basin only three were deployed. Large sturgeon seem to leave the Basin early, likely as virgin spawners returning to their natal rivers, and the size range of remaining sturgeon is smaller. By the time that we acquired and developed an effective leadering system for the pop-up tags, large sturgeon had mostly left Minas Basin. We then were only able to capture 3 sturgeon of appropriate size (X> 175 cm TL) for tagging. Pat tags will be saved and used earlier in the 2012 field season.

A VR2 receiver malfunctioned and is being sent to Vemco in attempt to retrieve lost data and fix any lasting problems. Two VR2 receivers were lost after deployment and compensations with the Atlantic Salmon Federation must be reached to replace the lost receivers. One Wildlife Computers PSAT tag malfunctioned upon initialization, and was replaced prior to deployment free of charge.

In July 2011, one personnel problem was encountered as Christine Adams, a summer research assistant, left the program due to personal issues in mid-summer. Other members of Litvak's lab were sent to assist with the remainder of the summer research.

7. Networking and outreach

Discuss the extent of networking and outreach by the project, both within the OTN Canada Network and with the broader community, by co-PIs, collaborators and HQP. Describe how the project's

research has been impacted by, and contributed to, the research carried out by other projects from across the Network.

Intra-Network Collaboration and Partner Meetings

Our project provides proof of concept for the OTN Canada Network. As one of the smaller projects we have greatly expanded our scientific reach while we have not deviated from our priorities. The OTN was meant to provide a framework for collaborative research that would be expanded and provide an economy of scale of infrastructure to allow researchers to answer important questions. Our project continues to expand research collaborations and answer important question relevant to OTNs original goals.

As indicated previously, an active collaboration between the Taggart and Litvak labs was developed. Without OTN, we would not have been in the position to initiate this collaboration. The focus of this work is on the development of high-resolution accelerometer data on activity, swimming and burst acceleration. The collected data will be used to determine optimal sampling frequencies for shortnose and Atlantic sturgeons for certain parameters of interest (size-at-age scaling parameter, parameters for activity patterns and energy budgets).

Dadswell and Stokesbury had monthly meetings with Redden and Bradford to discuss acoustic receiver deployment, boat time and deployment of HQP. HQP personnel working with Dadswell and Stokesbury worked with HQP personnel of Redden and Bradford to tag fishes.

Dadswell, Stokesbury and Litvak had 4 extensive telephone conferences to discuss overall objectives and methods for handling the internal acoustic tagging of sturgeon.

Litvak's lab takes the weights and lengths for the Lion's Club Sturgeon Derby which occurs every fall on the Kennebecasis River. This provides us with an opportunity to talk to the public about our work tracking these fish.

Beardsall (MSc student at Acadia working on sturgeon blood indicators of stress, salary funded by CRC to MJWS, project funded by OTNC) spent 1 month with Steve Cooke's lab (OTN Pacific) at Carleton U learning techniques to sample and process blood in the field from sturgeon in lakes in Quebec.

Interaction/Outreach to Broader Community

Networking and outreach have been two of the main focus of our project. On an international scale the work of Stokesbury, Litvak, Dadswell and our HQP was presented at the NOAA sturgeon workshop in

Alexandria Virginia, USA in two presentations (Stokesbury et al. and Wirgin et al.). During these presentations and through conversations with researchers from New Brunswick to Florida we increased our collaborations (i.e., Gayle Zydlewski U. Maine, Dwayne Fox U. Delaware) and provided information central to the US decision as to whether they should list Atlantic sturgeon and endangered. Also at the Meeting Kim Robichaud of Fisheries and Oceans Canada was part of the Canadian group and she solicited input from our research group as a basis for a DFO stock status report for Atlantic sturgeon in the Maritime Provinces.

Nationally the OTNC sturgeon project has had impacts at the regulatory level (i.e. Tidal Power impacts, stock structure and abundance for DFO stock status report), and the industrial level (see above, i.e. McLean VPS tracking, Litvak and Taggart tag development). Also, knowledge and HQP transfer has occurred between the OTNC sturgeon project and OTN Pacific (see above, Beardall's tenure with Cooke's lab) and between OTN Atlantic oceanography projects.

OTN Canada sturgeon project has deployed infrastructure in the St. John River, the Minas Passage and the Minas Basin. This has provided information for researchers to reach objectives of the sturgeon project; it has also positively impacted other projects as we have gained tracking information on Spiny Dogfish (Campana, DFO), striped bass and American eels (Broome and Redden, Acadia) The Saint John array has also served other researchers tracking fish on the on the Saint John River. We were pleased to report tag information to Rod Bradford (DFO) and Allen Curry (UNB) for their tracking programs on striped bass. We have also formed collaborations with UPEI Veterinary school (Dr. Fast, parasites), New York University (Dr. Wirgin Microsatellites DNA) and the USGS (Dr. King mitochondrial DNA).

8. Dissemination of information and results

List refereed journal articles (accepted/published, submitted) and conference presentations (invited, contributed). All other dissemination is included in section #9 (Other contributions and deliverables).

Refereed Journal Articles (2 total)- *Accepted/Published*

Cooke SJ, Iverson SJ, Stokesbury MJW, Hinch SG, Fisk AT, Smith P, VanderZwaag D, Whoriskey F. Ocean tracking network Canada: A network approach to addressing critical issues in fisheries and resource management with implications for ocean governance. *Fisheries (in press)*

Munroe S, Avery TS, Shutler D, Dadswell MJ (2011) Spatial attachment site preferences of macroparasites on Atlantic sturgeon, *Acipenser oxyrinchus*, in Minas Basin, Bay of Fundy, Canada. J Parasitol 97: 377-383.

Refereed Journal Articles (1 total)- *Submitted*

Wirgin I, Meada L, Waldman JR, Wehrell S, Dadswell MJ, King T. Stock origin of migratory Atlantic sturgeon in the Minas Basin, inner Bay of Fundy, Canada determined by microsatellites and mitochondrial DNA analysis. Trans Amer Fish Soc (*submitted*, Aug 2011)

Contributed Conference Presentations (6 total)

McLean, M., Stokesbury, M.J.W. and M.J. Dadswell. 2011. Movement, behaviour and diet of Atlantic sturgeon tagged with acoustic and archival tags in the Minas Basin, Bay of Fundy. American Fisheries Society AGM, Seattle WA, USA, September 2011 (Student Poster)

McLean, M. F., Stokesbury, M. J. W., and M. J. Dadswell. 2011. Movement, Behaviour and Diet of Atlantic Sturgeon (Acipenser oxyrinchus) Tagged with Acoustic Transmitters in the Minas Basin, Bay of Fundy. Bay of Fundy Environmental Partnership, St. John, N.B. September, 2011.

Stokesbury, MJW, M Dadswell, J.Broome, A. Redden, S. Wehrell, R. Bradford and M. Litvak. 2011. Atlantic sturgeon studies in the Bay of Fundy. Sturgeon Workshop. NOAA, NMFS, Alexandria VA, 8-10 Feb., 2011.

Taylor, A. D., and Litvak, M.K. 2011. Movement patterns and habitat use of Atlantic sturgeon, *Acipenser oxyrinchus*, from the Saint John River, NB, Canada. APICS Aquaculture and Fisheries Conference. March, 2011. (Oral presentation: Recipient of the Skretting/NSERC award for 2nd best oral presentation)

Taylor, A. D., and Litvak, M.K. 2011. Movement patterns, seasonal distribution and habitat use of Atlantic sturgeon, *Acipenser oxyrinchus*, from the Saint John River, NB, Canada. Bay of Fundy Environmental Partnership, St. John, N.B. September, 2011. (Oral presentation: Recipient of Best Graduate Paper Award)

Wirgin, I., Meada, L., Waldman, J. R., Wehrell, S., Dadswell, M. J., and T. King. Stock origin of migratory Atlantic sturgeon in the Minas Basin, inner Bay of Fundy, Canada determined by microsatellites and mitochondrial DNA analysis. Sturgeon Workshop. NOAA, NMFS, Alexandria VA, 8-10 Feb., 2011.

9. Other contributions and deliverables

Production of a video, blog, webinar, podcast, webpage, etc.

Webpages:

- Stokesbury Lab (http://www.acadiau.ca/~mstokesb/)
- Litvak Lab webpage (http://sites.google.com/site/litvaklabsite/Home)

Radio or television interview or contribution to a programme/documentary, etc.

- Stokesbury is a featured scientist in a new National Film Board Documentary. It is currently being filmed and due to be released in 2013. The main focus of this documentary is bluefin tuna but OTNC sturgeon project has been discussed at length.
- Interviews by Stokesbury in which OTNC sturgeon research was noted:
  - 2011- Radio-Canada International "The Link": http://www.rcinet.ca/english/program/the-link/home/date/14-03-2011/

Print-media contribution: international, national, local, university, etc.

- Stokesbury's CRC Appointemnt and discussion of sturgeon and other research:
  - 2010: Canada Research Chair, Press Release: http://www2.acadiau.ca/acadia-news-reader/items/acadias-new-canada-research-chair-watching-the-waters.1012.html
  - 2010: Canada Research Chair, Press Release: Kentville Advertiser,

Invited or contributed open-to-public presentation/contribution.

- Litvak's lab participated in the Lions Club annual sturgeon derby on the Kennebecasis River, during which he had the opportunity to talk to the local fishers and sturgeon enthusiasts, and to promote this project and its results.

Invited or contributed presentation/contribution at a workshop, seminar series or conference.

Stokesbury M.J.W., Redden A., Broome J. and R. Bradford. 2010. 3-D acoustic tagging of fish, sediment laden ice and large woody debris in the Minas Passage of the Bay of Fundy: results, challenges, lessons learned. OEER Workshop on Tidal Power, NS, Canada October 2010.

Taylor, A. D., and Litvak, M.K. 2011. Movement patterns and habitat use of Atlantic sturgeon, *Acipenser oxyrinchus*, from the Saint John River, NB, Canada. OTN's First annual symposium. June 2011. (Oral presentation)

Invited or contributed consultation with an agency; public or private

- The Fundy Ocean Research Centre for the Environment (FORCE) board of directors includes CEO's of companies investing in tidal power, scientists, and government representatives. The results of OTNC sturgeon have been presented to this group many times.

Anything else that isn't a primary publication that has you communicating (specify) with others (specify).

- The OTNC sturgeon project provides information on animal behaviour to the Offshore Education and Environmental Research group. OEER is an arms length provincial government body that provincial that invests in environmental research for ocean energy. Stokesbury is a member of the

OEER Environmental Mitigation Advisory Committee, which has monthly meetings for reporting on progress of research.

- Rod Bradford of Fisheries and Oceans Canada is involved in our sturgeon work as he is responsible for Anadromous species of concern. Bradford meets with Stokesbury regularly and with Litvak when possible. Bradford and Fisheries and Oceans collaborated with Stokesbury on OTN C sturgeon presentation at the NOAA meeting in Virginia (detailed above) for providing advice to regulators in the US regarding the status of Atlantic sturgeon populations.
- The OTNC sturgeon project interacts with the public on several fronts. Commercial fishers in the Minas Basin belonging to the High Current Fishermen's Association are active participants in all tagging and receiver deployment planning. Commercial fishers for Atlantic sturgeon in the St. John River are active participants in the St. John River tagging. In both areas the commercial fishers that are involved in the project are active in their fishing and residential communities and help inform the public of the project goals and progress.
- The public are informed of our goal through several web applications. Stokesbury and Litvak have websites that are accessed by students and the public. Many potential students become interested in our projects through this outlet and we regularly receive emails enquiring about positions as students of technicians to work with our project. In addition the PI's and HQP have given multiple public presentations on our results and progress. Also, McLean, Roberts and Beardsall (Acadia) have gone from house to house in the entire community of Kingsport to inform residents of our project and to have the opportunity to answer any questions. When deploying large amounts of equipment off a public beach community involvement and input it central to the successful completion of the project.

Leveraging your research/funds in order to make a new contribution to another initiative

- Expansion to Mira and other Maritime Rivers
- Contribution to OEER tidal power impacts research

A new technology, method, protocol, measure, analytical technique, algorithm, operational or numerical model, or predictive tool. Include the validation of any of the former and their practical application.

- In the Stokesbury lab we have developed a method for leadering popup archival tags to Atlantic sturgeon that will reduce premature detachment of tags.
- Litvak and HQP Taylor have developed a procedure that allow accurate (scale of meters) positioning of an acoustically tagged organism through triangulation using active tracking techniques. This is unique in the literature and when completed will be of importance to tag engineering companies.
- Litvak, Taggart and HQP are working with to combine pop-up archival tag ability with the capacity to measure acceleration. If successful this will create an innovative solution to determining long

term energy (and therefore somatic and reproductive potential) budgets for highly mobile animals. Creation of this tag would not only be of high significance to the scientific community but also of great interest to the Canadian and international animal tracking industry.

- Tagged sturgeon moving through the Minas Passage, an area scheduled for Tidal Power turbine infrastructure deployment in 2012, have provided information on seasonality, depth preferences and tidal transport. This information is central to the design, deployment and operation of hydro power turbines in the Minas passage. Information will also inform mitigation measures for the industry to reach conservation targets for species of concern.

A proof of concept in relation to any of the above.

- McLean and Stokesbury in collaboration with Vemco we have demonstrated that the Vemco VPS 3-D acoustic tracking array design is effective for accurate 3-D tracking fish with minimal error (metres) on a scale of kilometers in a Macro Tidal Estuary.

Baseline measures (e.g. reference for change), empirical relations (e.g. rates and states), or mapping products (e.g. range expansion or contraction) especially if of use to other scientists and the organizations listed above.

- Analysis of DNA with Dr. Wirgin (NYU, as stated above). Quantification of parasite load and effect on sturgeon vitality with Dr. Fast (UPEI Veternary Collage, as above).

10. Collaborations with Industrial and Government Partners

a) Please describe which partners are actively involved in management, research, and knowledge transfer within the network and the specifics of their involvement.

- Dadswell, Stokesbury and Litvak are all actively involved in research on fish migrations, sturgeon biology and knowledge transfer. Dadswell has been actively involved in research of the effects of hydraulic turbines on fishes. All three partners are teaching undergraduates and supervising graduate students totaling 3 MSc.
- Dadswell, Stokesbury and Redden assist fisheries managers at DFO (Smith, Bradford and Gibson) on questions concerning stock composition of migratory fish species and migration routes.
- Partners include the Acadia Center for Estuarine Research (Anna Redden) which is involved with studying the movements of fishes within Minas Basin and along the NA Atlantic coast and the potential effects of tidal power.
- Dadswell has been involved with the Threatened Resources Section of the NMFS-NOAA in Gloucester, MA (Sarah Laporte and others) who are examining the coastal movements of Atlantic sturgeon and the status of the species in the United States and whether it should be listed as threatened or endangered.

- Wehrell and Dadswell are collaborating with Isaac Wirgin of NY University concerning the identification of the stock composition of Atlantic sturgeon in Minas Basin using mitochondrial DNA markers.
- Stokesbury is part of the Environmental Monitoring Advisory Committee (EMAC) for in-stream hydropower installations in the Minas Passage. Including Industry and government partners whom have provided funds for tagging of Atlantic sturgeon in the Minas Passage.
- Litvak is a PI on an NSERC strategic grant titled "Historical and current uses of sturgeon: an elemental analytic approach (https://sites.google.com/site/sturgeonecology/home)" using stable isotopes to examine First Nations diets from archeological finds and effect of climate change on sturgeon distributions over the last 4000 years in collaboration with Drs. Sue Blair (UNBF Archeology) and Mike Powers (Department of biology University of Waterloo). Currently, they are working on the following:
    - collaborating with Breviro and Target Marine sturgeon aquaculture facilities to distinguish between sturgeon products, such as caviar and smoked meat of shortnose, Atlantic and white sturgeon, from wild and aquaculture sturgeon stocks
    - collaborating with Metepengiag First Nation to acquire specimens of sturgeon remains from ancient settlements in Atlantic Canada in order to characterize First Peoples diet (4000 years before present) and climate change.
- Litvak is currently discussing the possibility of a joint project with the Eel Ground First Nation to examine Atlantic sturgeon past and current distribution in the Miramichi River.

b) Cash and in-kind contributions from partners for year 2.

Name of supporting organization: **CFI (OTNG)**	**Year 2** (1 Jan – 30 Sep 2011)
Cash contributions to direct costs of research	68,700
In-kind contributions to direct costs of research	
25) Salaries for scientific and technical staff	
26) Donation of equipment, software	
27) Donation of material	
28) Field work logistics	
29) Provision of services	
30) Other (specify):	
In-kind contributions to indirect costs of research	
13) Use of organization's facilities	
14) Salaries of managerial and administrative staff	
15) Other (specify): _____	
Total of all in-kind contributions	68,700

Name of supporting organization: **CFI (LOF - Stokesbury)**	**Year 2** (1 Jan – 30 Sep 2011)
Cash contributions to direct costs of research	97,000
In-kind contributions to direct costs of research	
31) Salaries for scientific and technical staff	
32) Donation of equipment, software	
33) Donation of material	
34) Field work logistics	
35) Provision of services	
36) Other (specify): _____	
In-kind contributions to indirect costs of research	
16) Use of organization's facilities	
17) Salaries of managerial and administrative staff	
18) Other (specify): _____	
Total of all in-kind contributions	97,000

Name of supporting organization: **Acadia University**	**Year 2** (1 Jan – 30 Sep 2011)
Cash contributions to direct costs of research	8,600
In-kind contributions to direct costs of research	
37) Salaries for scientific and technical staff	
38) Donation of equipment, software	
39) Donation of material	2,000
40) Field work logistics	4,000
41) Provision of services	1,000
42) Other (specify): _____	
In-kind contributions to indirect costs of research	
19) Use of organization's facilities	6,000
20) Salaries of managerial and administrative staff	2,500
21) Other (specify): _____	
Total of all in-kind contributions	24,100

Name of supporting organization: Mount Allison University	Year 2 (1 Jan – 30 Sep 2011)
Cash contributions to direct costs of research	
In-kind contributions to direct costs of research	
43) Salaries for scientific and technical staff	13,200
44) Donation of equipment, software	
45) Donation of material	2,000
46) Field work logistics	4,000
47) Provision of services	1,000
48) Other (specify): ASF loan of 21 VR2 receivers	42,000
In-kind contributions to indirect costs of research	
22) Use of organization's facilities	4,000

23) Salaries of managerial and administrative staff	2,500
24) Other (specify): _____	
Total of all in-kind contributions	68,700

11. Expenditures and Support

Year 2 (2011)

a) Indicate your approved year 2 budget, your actual expenditures from 1 January to 30 Sep 2011 and your projected expenditures for the remainder of this installment (through to 31 December 2011).

Year 2 (2011)	**Proposed**	**Actual Expenses** 1 Jan-30 Sep 2011*	**Total Balance** 30 Sep 2011*	**Projected Balance** 31 Dec 2011**
1) Salaries and benefits				
a) Students	51,526	38,646	**12,880**	**3,880**
b) Postdoctoral Fellows	0	0	**0**	**-2,400**
c) Technical/Professional Assistants	0	0		
d) Other (specify)	0	0		
2) Equipment or Facility				
a) Purchase or Rental	0	0	**0**	**0**
b) Operation and Maintenance Costs	2,500	1,250	**1,250**	**1,250**
c) User Fees	0	0	**0**	**0**
3) Material and Supplies	2,000	2,995	**-995**	**-995**
4) Travel				
a) Conferences	2,000	1,500	**500**	**500**
b) Field work	14,000	17,114	**-3,114**	**-14,814**
c) Collaboration/ Consultation	0	0	**0**	**0**
5) Dissemination Costs				
a) Publication Costs	0	0	**0**	**0**
b) Other Activities	0	0	**0**	**0**
6) Other (specify)				
a)	0	0	**0**	**0**
b)	0	0	**0**	**0**
Total expenditures	**72,026**	**61,505**	**10,521**	**-12,579**

b) Below, explain any significant deviations from the proposed expenditures. (Note: Changes of >20% from budget categories require advance approval from the Reprofiling Committee and NSERC, and must come first to S. Iverson).

Deviations that explain Year 2 over-expenditure of $12,579 (only a 17.5% deviation from originally proposed) include:

- **$2,400 of Student funding was shifted to Postdoctoral Fellow funding**
- **Increased costs for Field Work (by $28,814)** - The increase in projected costs of fieldwork reflects the expanded scope of this research and we still needed to find other funds to cover fieldwork as our costs have greatly exceeded the amount that we have requested from OTN.
- **Increased costs of Materials and Supplies (by $995)** – There were many materials and supplies that are needed, e.g., surgery supplies, ink, that were slightly more costly than anticipated.

Year 3 (2012)

a) Using the same excel form provided, indicate your approved year 3 budget (already entered for you) and any revisions to that original budget that you are proposing for year 3, noting that it must sum to ≤ the original total.

Year 3 (2012)	Original	Revised	Carry Over Requested
1) Salaries and benefits			
a) Students	38,300	35,460	0
b) Postdoctoral Fellows	0	2,840	4,700
c) Technical/Professional Assistants	0	0	0
d) Other (specify)	0	0	0
2) Equipment or Facility			
a) Purchase or Rental	1,521	1,521	699
b) Operation and Maintenance Costs	2,500	2,500	0
c) User Fees	0	0	0
3) Material and Supplies	2,000	2,000	0
4) Travel			
a) Conferences	0	0	0
b) Field work	10,000	10,000	5,000
c) Collaboration/ Consultation	0	0	0
5) Dissemination Costs			
a) Publication Costs	1,000	1,000	0
b) Other Activities	0	0	0
6) Other (specify)			
a)	0	0	0
b)	0	0	0
Total expenditures	**55,321**	**55,321**	**10,399**

b) Provide a detailed justification for your year 3 budget. You may use your original justification (just as submitted in the proposal) and state that it remains on track if that is the case. For budget items that you are proposing to change, you must give a clear explanation/justification of why; these proposed changes must be approved by the SAC.

Our budget has changed very little.

Justification of Proposed Expenditures for Direct Costs of Research

(It must be clear in the budget justification where and what funds are being allocated, particularly for funds associated with DFO. I have therefore provided this template to ensure clarity)

1) **Salaries and benefits** - *when listing part-time staff, please include the % equivalent of full-time work. Also, please list all students by degree, i.e. Masters, PhD and post-docs with start and end dates.*
   - Two MSc students are funded at Acadia University (McLean 13,600/year and Beardsall $6,200/year); One M.Sc. student at Mount Allison University (Taylor 15,660/year); Total for MSC students required is **$35,460**.
   - One Postdoc (Sima Usvyatsov 20% at **$7540/year**). We request that in Year 3, $2,840 be shifted from Students, which combined with $4,700 from Carry Over Requested total for Postdoc funding of $7540.

2) **Equipment or Facility** – Purchase of tools for tracking and blood sampling and storage and other lab gear **($2,220)**

3) **Operations and Maintenance**
   - Batteries for the receivers ($200/year), fuel (variable between $500 and $1,100) and winterization ($1,000/year) for the boat **(Total $2,500)**

4) **Material and Supplies**
   - Office supplies, including printer cartridges, field books etc. Filed operation supplies including antiseptics, operating supplies for tagging etc. **(Total = $2,000).**

5) **Travel**
   - Field work – Field work has been the major cost of the project. This included boat charter for tagging both in the Minas Basin and Saint John River. Also, rental vehicle and food and accommodation (Total = $15,000)

6) Dissemination costs
   - Page charges are included for 2 primary publications in year 3 of the project. (**Total = $1,000**)

Ocean Tracking Network Canada OTNC **NSERC**
Progress Report Year 2 Review: 1 October 2010 – 30 September 2011

Atlantic Arena I.2.4-5

1. Project Number: I.2.4 *and* I.2.5*

**Note: Projects I.2.4 andI.2.5 are fully collaborative and integrated projects with shared personnel and hence shared a single budget in the original NSERC SNG proposal and continue to do so. Because last year's report, which reported on the two components separately while maintaining a single budget report, resulted in confusion for the SAC, these two components are now being reported together, along with the combined/shared budget.*

2. Project Title: Grey seals (*Halichorus grypus*) as Bioprobes: Predicting Impacts on their Ecosystems, *and,* Design Principles for OTN and Climate Change Impacts on Leatherback Turtle (*Dermochelys coriacea*) Foraging and Distribution.

3. Project Leader(s): Sara Iverson (Dalhousie), Don Bowen (BIO-DFO Dalhousie), Joanna Mills Flemming (Dalhousie)

Collaborator(s): Luke Comeau (DFO NB), Katja Fennel (Dahousie), Mike Hammil (DFO Gulf region), Mike James (BIO-DFO), Jinyu Sheng (Dalhousie), Doug Swain (DFO Gulf region), Keith Thompson (Dalhousie)

4. Training of Highly Qualified Personnel (name, position, dates of participation):

a) List of the HQP and level of their salary support by SNG.

Personnel	*Title*	*%Time involved in project*	*%supported from SNG*	*Dates*
Stuart Carson	MSc	50	0*	1 Oct 2010 – 30 Sep 2011
Joey Hartling	Undergraduate	100	100	1 May 2011 – 30 Sep 2011
Susan Heaslip	PhD	15	0*	1 Oct 2010 – 30 Sep 2011
Ian Jonsen	RA	100	100	1 Oct 2010 – 30 Sep 2011
Shelley Lang	PDF/RA	20	20	1 Oct 2010 – 30 Sep 2011
Damian Lidgard	PDF/RA	80	80	1 Oct 2010 – 30 Sep 2011
Sarah AL Shaghay	Technical assistant	33	33	1 Oct 2010 – 30 Sep 2011

**Note: For those whose % time does not match % support: S. Carson received external support from the Dalhousie Mathematics & Statistics Department for full student stipend; S. Heaslip held a NSERC PSG2 Fellowship providing full external stipend.*

b) Explain the role, activities and opportunities for training of technical staff in your project.

Technical staff was responsible for analysis of grey seal and prey samples for diet analyses, organization and upkeep of the prey database, and support of field work.

5. Progress towards Objectives/Milestones (1 Oct 2010 – 30 Sep 2011)

a) Please provide brief description of the overall objectives of this project (max ½ page).

The objectives stated in the original SNG proposal over a 7-year period were as follows, with some aimed to be achieved in Phase I of this SNG and others to be achieved in Phase II:

1) To examine the hypothesis that grey seals are responsible for the high levels of natural mortality among adults in two declining and depleted Atlantic cod stocks, southern Gulf of St. Lawrence and Eastern Scotian Shelf;
2) To determine the extent to which grey seals contribute to ocean mortality of Atlantic salmon smolts;
3) To provide data on grey seal foraging locations to help validate behavioural state space switching models;
4) To collect fine (<500m) and meso-scale information on the distribution and movements of prey species that have been tagged with coded acoustic tags;
5) To test the hypothesis that grey seal movements and search/foraging behaviour are conditioned by oceanographic current field;
6) To determine what oceanographic features are associated with habitats heavily used by grey seals;
7) To determine how much of the seasonal changes in sex- specific habitat use by seals is explained by seasonal changes in oceanography; and
8) To develop predictive models of habitat use that incorporate physical/biological oceanographic features such as temperature, bathymetry, currents, prey biomass and diversity;
9) To predict the probabilities of encounter between grey seal bioprobes and acoustic-tagged species (e.g. Atlantic cod, Atlantic salmon) using a spatially-explicit simulation model;
10) To estimate encounter rates and spatial density of acoustic-tagged species;
11) To develop statistical (e.g. mark-recapture) methods for estimating movement rates and survival of acoustic-tagged species;
12) To estimate functional relationships between leatherback turtle movement behaviours and the bio-physical environment.

b) Describe progress towards meeting the project's objectives and specific milestones for the project.

During the period covered by this report, progress was made toward the objectives i – iii, ix and xi. Through plans developed in various meetings and workshops with PIs from projects I.1.1-I.1.3, we have begun to tackle objectives v-viii.

Through the work primarily of HQPs Damian Lidgard, Shelley Lang and Susan Heaslip, together with S. Iverson and D. Bowen and collaborators, seal movements and seal-seal acoustic encounters from the 2009 deployments were analysed using a Hidden Markov model with two behavioural states, slow (implying foraging) and fast (implying travel). The analysis revealed that grey seals showed strong preference to offshore banks (namely Middle, French, Sable and Canso Banks), that seals

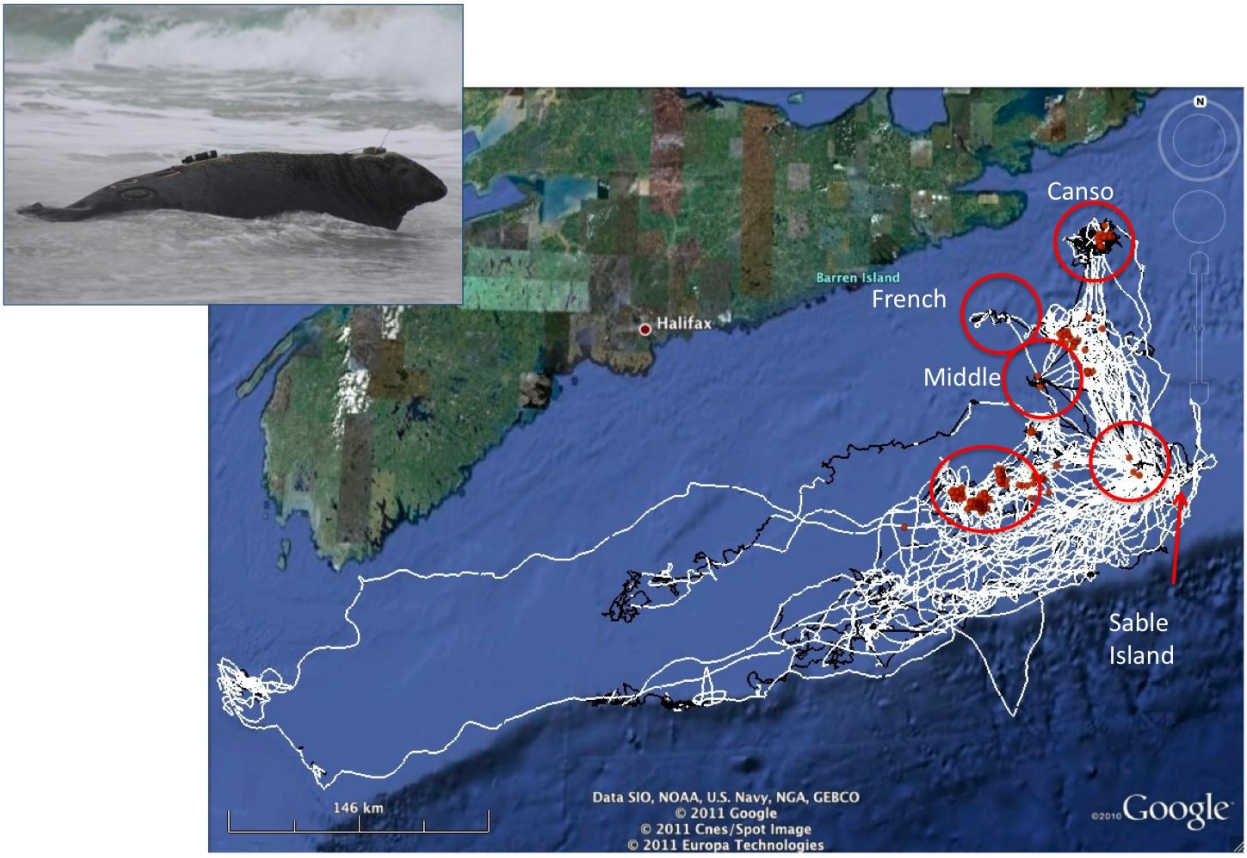


Figure 1. GPS and VMT data showing movement paths (white lines) of individual grey seals and acoustic encounters (red circles) between grey seals on the Scotian Shelf.

engaged in slow behaviour while on these Banks and encounters between seals were clustered around these Banks (Fig. 1). The spatial data clearly suggest that seals are visiting these areas to forage. The seal-seal acoustic encounter data provide the opportunity, for the first time, to begin to understand

the extent to which social interactions may influence the impact of grey seals on foraging areas. A manuscript is in preparation based on these initial findings.

Between December 2010 and January 2011, 20 adult grey seals (14 females, 6 males), initially tagged in September 2010 with VEMCO Mobile Transceivers (VMT) and Wildlife Computer Satellite-GPS transmitters, were re-captured on Sable Island, instruments removed and data retrieved. S. Heaslip spent several weeks on Sable Island in both January and June 2011 learning techniques for handling a large marine mammal, recovering and deploying scientific devices. D. Lidgard and S. Lang participated in and helped run both field camp seasons. Data from the VMT tags did not show detections of acoustically tagged cod, however four detections over four minutes were recorded with a blue fin tuna (tagged by B. Block, Stanford University) and 4 detections over 6 minutes and 9 detections over 10 minutes with two salmon smolts (tagged by E. Halfyard, Dalhousie University, OTN Canada project I.2.1; Fig. 2). These three encounters show that the concept of using acoustic tags to understand

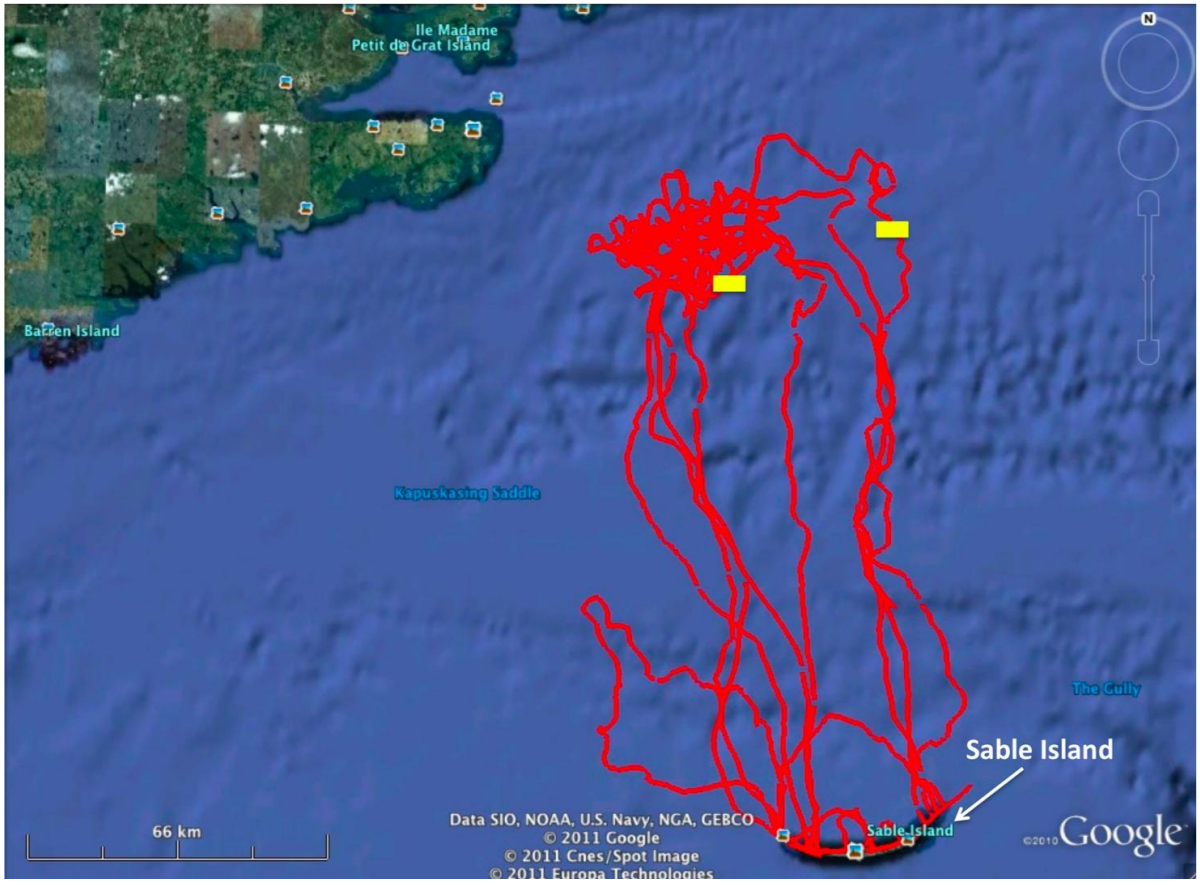


Figure 2. Females grey seal E223 “chats” (yellow boxes) with two salmon smolts in September 2010.

predator associations and predator-prey dynamics can work. Despite the small sample size, the two encounters with salmon smolt opens the door to better understanding predator-prey dynamics between seals and salmon, as well as providing new insight into the unexpected summer distribution

of salmon smolts. Similar to the previous year, detections (approximately 1100) were recorded between individual seals. These data not only provide further proof of concept of using bioprobes as mobile receivers (rather than fixed OTN arrays) to detect movements and distributions of other tagged animals, but also contribute toward understanding the dynamics of seal foraging behaviour and the spatial-temporal impact on or interactions with their prey resources.

In June 2011, another 20 adult female grey seals on Sable Island were deployed with the same configuration of tags and these will be re-captured in December 2011 - January 2012 for downloading and analysis. Unlike in previous years, no males were deployed since based on this and previous studies males tend to forage further offshore and are thus less likely to encounter acoustically tagged cod. From examination of ARGOS data, five of these females have spent considerable time in the southern Gulf of St. Lawrence and near Cape Breton and thus have the potential of encountering the 300 cod tagged in 2009-2011 for this study:

Atlantic cod have now been tagged in both the Southern Gulf of St. Lawrence and on the Scotian Shelf. The location for tagging cod has been influenced to a great extent by the costs of ship time, likelihood of capturing cod (from previous surveys or local knowledge) and the likelihood of tagged seals encountering the cod. In May 2009 and 2010, 200 cod were tagged with V13 tags in the southern Gulf of St. Lawrence by collaborators Doug Swain (DFO Gulf region) and Luke Comeau (DFO NB), partly because we were able to secure ship time but also because testing the hypothesis that seals were responsible for the high mortality on Gulf cod was a principle objective of this project and of great current political and socio-economic interest. In November 2010, an additional 100 cod were tagged near Canso on the Eastern Scotian Shelf. This area was chosen due to the abundance of cod in the area and the proximity to offshore banks where grey seals are known to forage. However, the seals tagged in September 2010 on Sable Island did not move close to the Canso area nor did they spend time in the southern Gulf. Thus, in May 2011 we attempted to tag 100 cod on Middle Bank, a highly favourable foraging area for grey seals. However, very few adult cod were found and only 6 were tagged. The lack of cod at that time in that area was unusual, but these observations were corroborated with data from the annual summer DFO survey and observations from fishermen. Consequently, in June the remaining tags were deployed along the Eastern Scotian Shelf where cod were found in abundance.

While full evaluation of the encounter rates between acoustically tagged grey seals and cod will rely on the recovery of the VMT tags from seals in Jan 2012, evidence from this study to date and the documented seal movements in relation to known cod aggregations, suggest that grey seals may in fact not be targeting cod. These findings would be consistent with, and would corroborate, previous and concurrent diet studies showing that cod are in general a minor component of grey seal diets, despite common public assumptions. These diet studies have currently been ignored by the groups lobbying for a large cull of grey seals. Our results from the 2012 recoveries and future planned

deployments of both seals and cod, as well as other potential prey, will provide important insight into these debates.

To better understand the performance of the VMTs with respect to detecting acoustic tags, eight V13 VEMCO acoustic transmitters were anchored at a known location on Middle Bank. Encounter data between these fixed V13s and acoustically tagged seals will be available starting in January 2012. While a VMT was hung over the side of the boat during the final June deployment in an effort to learn more about both VMT and V13 performance, as well as the post-tagging behaviour of cod, the data obtained were insufficient to evaluate.

ix. *To predict the probabilities of encounter between grey seal bioprobes and acoustic-tagged species (eg. Atlantic cod, Atlantic salmon) using a spatially-explicit simulation model*

Led by I. Jonsen, a simulation model of grey seal and cod movements was developed to explore the encounter rates between grey seal bioprobes and acoustically-tagged cod in the Eastern Scotian Shelf (ESS) region. Initial results imply a very low encounter probability with the numbers of VMT-tagged seals and acoustic-tagged cod that have currently been deployed. These simulations, however, suffer from relatively little available information on cod movement patterns in the ESS. Currently, we are exploring the detection efficiency of the VMT's through an analysis of the grey seal GPS tracking data. The high-resolution GPS data are being used to provide an expected number of seal-to-seal (or VMT-to-VMT) detections that can then be compared to the actual seal-to-seal detections obtained via the bioprobe deployments. Preliminary estimates of VMT-to-VMT detection range were obtained by combining the observed VMT detections with concurrent GPS location data. Average detection ranges for the 2009 and 2010 VMT deployments were approximately 200 m and 325 m, respectively, but there was substantial variability with detections occurring up to nearly 2 km (Fig. 3). Additional analyses will link expected and observed detections to factors such as seal behaviour and environmental conditions (obtained from project I.1.2) to better understand how VMT detection range and efficiency varies. Combined, this information on detection efficiency of VMT receivers will be used to help scale expected detection rates in simulations aimed at improving the design of OTN tagging studies throughout this and other OTN Canada Arenas, but also to provide information for other OTN Global tagging studies being developed.

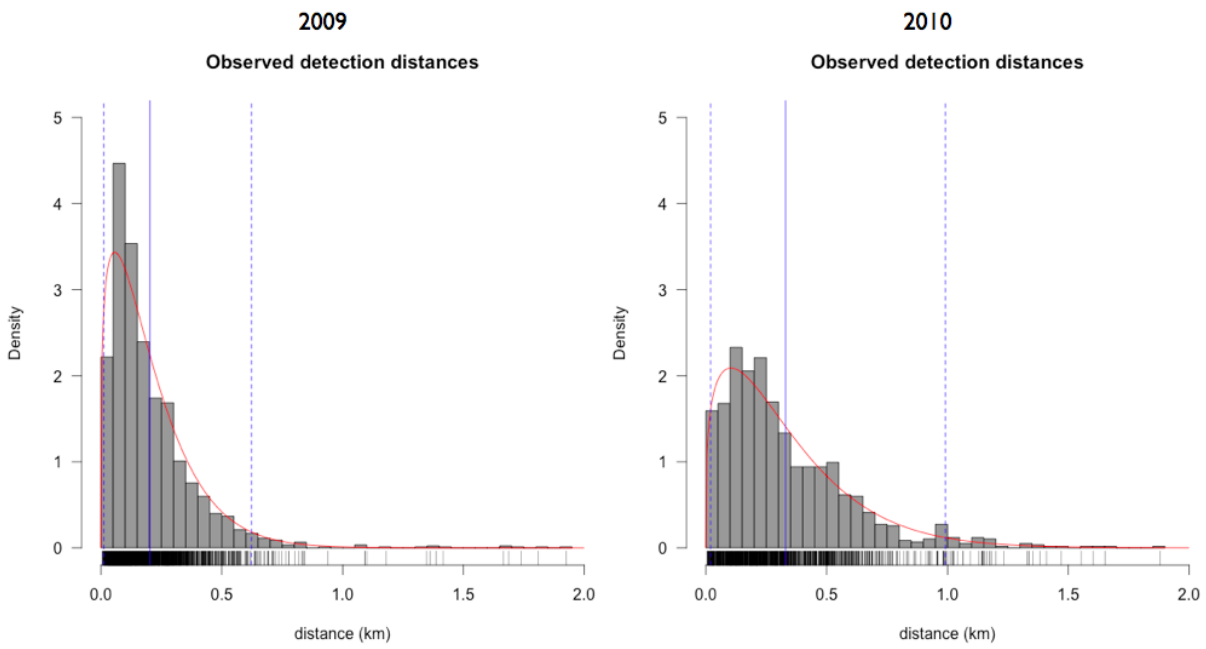


Figure 3. Estimated VMT-to-VMT detection ranges from 2009 and 2010 deployments. Weibull distribution fit (red lines) and estimated mean detection range (blue) and 95% CI (dashed blue).

xi. To develop statistical (eg. mark- recapture) methods for estimating movement rates and survival of acoustic-tagged species

Together with J. Mills Flemming, MSc student Stuart Carson will be defending his thesis on 9 December 2011. He has completed a spatial point process analysis of seal-to-seal encounters off Sable Island. The analysis confirms that the encounters are not distributed randomly on the Scotian Shelf, but rather clustered on offshore banks (namely Middle, French, Sable and Canso Banks). Furthermore the seals do not appear to travel together but do appear to each have their own preferences for particular banks/areas. Furthermore, the addition of a spatial point process approach to the overall Bioprobe projects allows the testing of hypotheses of interest while at the same time providing a nice probabilistic description of the encounters by way of some informative visuals. This work will be written up and submitted for publication in January of 2012. A second paper presenting a full analysis of multiple years of encounter data (2009-2011) will be prepared early in 2012. These results will inform other OTN Canada studies being planned and conducted.

S. Carson will commence his PhD research on 1 January 2012. His initial work will be directed at obtaining a more complete understanding of tag performance and the feasibility of detecting acoustic-tagged species via grey seal bioprobes and other platforms such as gliders. S. Carson will also investigate the possibility of using spatial point process approaches on data that have been collected by Chris Taggart (project I.1.1). A full PhD thesis proposal will be available in August of 2012.

Undergraduate honours student Joey Hartling designed a "Seal-Cod" Interaction simulation using the R programming language. The simulation run time was substantially reduced by re-coding certain portions using the C programming language and dynamically linking it with R. J. Hartling fell ill partway through the summer and required surgery. In an effort to finish this project up J. Mills Flemming has allowed him to complete this simulation tool as his course project for STAT5620 (which he is taking presently).

J. Mills Flemming gave a keynote talk at the University of Toronto Research Day in April of 2011. This resulted in collaboration with Dr. Wayne Oldford (Waterloo) who is an expert in data visualization. Dr. Oldford is anticipated to visit Dalhousie in late 2011/early 2012. In the interim J. Mills Flemming has worked with Adrian Waddell (MSc student of Dr. Oldford) to develop a prototype visualization tool.

J. Mills Flemming met with Simon Bonner (University of Kentucky) while attending the meetings of the Statistical Society of Canada. S. Bonner is extremely keen to be involved in the OTN and is an expert in mark-recapture methods. He was invited to visit Dalhousie to give a seminar and meet various potential collaborators on 3 November 2011. Along with the bioprobe co-PIs, we plan to develop a potential collaborative research project targeted at objective xi above.

c) Describe and justify any significant deviations from the original objectives or plans, including any revised goals, new projects, or deleted projects.

We expect to make progress on objective iv as more fish are (and have been) tagged and detected and with the recovery in 2012 of the currently deployed VMTs. This remains a goal of the project over the next few years.

Section 6 below describes revised plans for tag deployments over the next year.

It is anticipated that a significant portion of S. Carson's PhD thesis will be devoted to calibrating VMT performance. This was not anticipated but is essential before one can draw substantive ecological/biological conclusions from VMT data.

d) *Describe how the work of the project's co-investigators and collaborators was coordinated and integrated*.

The co-investigators and all HQP involved in the bioprobe projects have participated in regular (monthly) meetings that will continue throughout the coming year and with a few modifications so as to formalize all future and expanding aspects of collaborative efforts (authorships, precise division of interrelated projects, etc.).

Doug Swain (DFO, Gulf Region) and Luke Comeau (DFO, Gulf Region) organized and conducted the surgery on cod in the Gulf of St. Lawrence. Sean Smith (DFO, Maritime Region) was responsible for organizing the cod tagging and conducting the surgery to implant the tags in Atlantic cod on the eastern Scotian Shelf.

e) Describe the benefits of conducting this research as part of a network rather than as a separate project (e.g., scope of the research, cross disciplinary collaborations, new synergies and research opportunities, access to ship time, planning and coordination of research activities, exchange of information and data, benefits to students and technical staff).

The success and development of this project has been largely dependent upon the efforts of our collaborations as part of a network but also with our other collaborators within the Network. The DFO has played a vital role in the successful tagging of adult grey seals on Sable Island. Although this site provides excellent opportunities for the deployment and successful recovery of telemetry instruments on seals, financial support and expertise with handling these large mammals as well as knowledge of their behavioural ecology are vital for successful deployment and are provided by DFO. The deployment work with seals on Sable Island has also provided unique opportunities for S. Heaslip, PhD student, to work with knowledgeable researchers and gain valuable experience in fieldwork, handling large mammals and in the deployment of telemetry instruments. In 2010 and the current year, this knowledge was further passed on through S. Heaslip and D. Lidgard by giving lectures to undergraduates enrolled in the SEASIDE summer course on Field Methods in Marine Mammal Ecology. Discussions with especially Arctic (and eventually Pacific) co-PIs are leading to the transfer of our experience and knowledge gained to deploying tags and analyzing data in their projects. Collaboration with DFO has been critical in testing hypotheses concerning prey selection and impacts of grey seal predation on continental shelf ecosystems through the deployment of acoustic transmitters on hundreds of individuals of several stocks of Altantic cod. DFO is contributing financially towards achieving this, as well as providing the logistical support (ship time and access to fishermen) and knowledge and expertise required. Through the collaboration of the grey seal bioprobe projects (1.2.4 and I.2.5) and Atlantic salmon projects (1.2.1) we will better understand the predator–prey dynamics between grey seals and Atlantic salmon as well as the movement of salmon in the Atlantic Ocean. Finally, the oceanographic data (sea temperature and light-level profiles) collected by the instrumented grey seals are being used by our oceanographic partners (projects I.1) both for model validation and to prepare for the start of objectives v through viii.

f) Describe the scientific and/or engineering significance of the results to date.

The three encounters with bluefin tuna and salmon smolts clearly demonstrate that the concept of tagging both the predator and prey to use the predator as a mobile receiver to complement fixed OTN arrays, and to better understand predator-prey dynamics, works. The large number of seal-seal acoustic encounters also contributes toward the proof of concept and our understanding of grey seal foraging behaviour, identification of foraging hotspots, and potential impacts of seal predation on prey recourses.

S. Carson's MSc thesis has determined the appropriate statistical methodology for the analysis of bioprobe data and use of VMTs. This work is crucial given the novel nature of these types of data. In coming months its utility will be demonstrated using more recent bioprobe data as well other types of encounter data from within the OTN projects as a whole.

All collaborators have agreed that data visualization tools are substantially lacking. Via collaboration with W. Oldford and others, we are now moving towards seriously addressing this issue. All of our efforts at simulation will fit nicely in here.

6. Difficulties encountered

a) Identify the main difficulties encountered in carrying out the research during the reporting period from the list below:

- **X** Scientific problems/difficulties
- ❑ Equipment and technology issues (e.g., delivery and malfunctioning of equipment, etc.)
- ❑ Personnel problems
- ❑ Involvement of partners
- ❑ Other (specify): _____
- ❑ No problems occurred during this instalment of the grant

b) For each checked box, describe the difficulties identified above and the steps taken to resolve them.

Scientific problems/difficulties

To date, 202 cod have been tagged on the ESS and 200 cod tagged in the Gulf of St. Lawrence. We have recovered 35 paired VMT-GPS transmitters deployed on seals on Sable Island, with an additional 20 to be retrieved in Jan 2012. Of the first 35 VMTs deployed, no detections of cod were recorded despite numerous seal-seal encounters and encounters with two other species of fish. These results suggest

that either more cod need to be tagged to increase the probability of detection by tagged seals, or that the real-time distribution of cod and grey seals does not overlap to the extent it has been believed. In fact the documented seal movements in relation to known cod aggregations, actually suggest that grey seals may in fact not be targeting cod, a finding consistent with previous and concurrent diet studies, but which are ignored by fisheries managers and public assumptions. The confirmation of these findings will be extremely informative and important to guiding management actions being proposed for the Scotian Shelf ecosystem.

Thus, it would be most important scientifically, to tag both other known key prey species of grey seals, as well as more cod in critical areas. However, unfortunately there is no budgetary allowance under the conditions of the NSERC SNG to purchase tags. Given DFO's greatly reduced budget, there are no resources to best support the optimal scientific plans. Given that CFI resources have all been fully committed and the unanticipated budgetary constraints on DFOs current ability to contribute, we would like to make a recommendation to the SAC to consider changing the conditions of the NSERC SNG in future years for OTN Canada budgets to allow for some purchase of tags for fish deployments, an expense that is normally NSERC allowable (for instance on Discovery Grants).

In the meantime, under the current mandates of the SNG conditions, we propose the following:

1) Previous seal deployments have targeted both females and males. However the results to date on the movements of seals from Sable Island suggest that females are more likely to encounter tagged cod than males. Thus, we intend to only tag females to increase the probability of detecting tagged cod. In June 2011, 20 female grey seals were deployed with telemetry instruments.
2) Sable Island is an ideal site for the deployment of telemetry instruments on grey seals (and the beta-testing of VMTs for all OTN projects hoping to use them) since there is a very high probability of instrument recovery. However, seals tagged in 2009 and 2010 have shown preference to offshore banks for foraging and avoided coastal areas and the Gulf of St. Lawrence where cod have been tagged (five females from the 2011 deployment have spent considerable time in the southern Gulf region). Therefore, we propose to deploy instruments on grey seals that inhabit coastal areas of the Eastern Scotian Shelf or the southern Gulf. This has not been possible to date since we need to recover instruments from seals to retrieve the data, and Sable Island is the only place that ensures a high probability of achieving this. However, through discussions with VEMCO and the Sea Mammal Research Unit (SMRU), St Andrews, Scotland, there is strong interest in developing a VMT that can communicate, via Bluetooth technology, with the satellite tag for transmission of detection data and thus eliminate the need to recover tags. Several of the co-PIs have met with Vemco and SMRU and we intend to work with both companies to facilitate the development of this tag for a summer 2012 deployment on seals on Sable Island, Hay Island (coastal Cape Breton) and in the southern Gulf of St. Lawrence.

Plans for this incorporated tag have begun and development is underway. Once this new technology is available, the use of VMTs will be extended to the Arctic and Pacific Arenas, especially in plans for Phase II of the SNG.

7. Networking and outreach

Discuss the extent of networking and outreach by the project, both within the OTN Canada Network and with the broader community, by co-PIs, collaborators and HQP. Describe how the project's research has been impacted by, and contributed to, the research carried out by other projects from across the Network. This is a critical section! Please review the comments on your last year's report.

S. Iverson and D. Bowen, and D. Lidgard and S. Heaslip (HQPs), were all involved in the week-long Zonal Advisory Process and meetings on the Impacts of Grey Seals on Cod Populations in Eastern Canada conducted by DFO in October 2010. During these meetings, the grey seal bioprobe project overview and current results were presented, and discussions and plans were made on future deployments with collaborators M. Hammil and D. Swain (DFO Gulf region).

S. Iverson attended the "Census of Marine Life and Beyond" workshop in Ottawa in Jan 2011 and presented both the concept of OTN Canada's research programs and the initial results of the bioprobe project and design concepts to other Canadian Networks and discussed potential collaborations and the future of some of the Networks. S. Iverson also attended the 1st Northwest Atlantic OTN Regional Meeting in Feb 2011 and discussed the research programs of OTN Canada and links with other agencies.

I. Jonsen gave a keynote presentation at the 4th International Science Symposium on Bio-logging (March 2011; Hobart, AU), partly focusing on the novelty of OTN bioprobe data and the need for development of new analysis tools.

I. Jonsen co-organized and co-hosted with Katja Fennel (I.1 projects) an Atlantic Arena OTN meeting in Halifax (April 2011) to explore strategies for enhancing integration across Atlantic Arena projects. All bioprobe co-PIs and HQP attended the meeting, which brought together most PIs working in the Atlantic arena and their HQP. The format included brief presentations from all seven Atlantic Arena projects (including the bioprobe projects) and updated participants about the current status and results obtained so far. These were followed by extensive discussions on integration of projects within and across the Atlantic Arena, and the potentials and plans for connecting to other Arena projects. This meeting was also used to help brainstorm about the schedules for the networking sessions at the upcoming OTN Canada-wide June Symposium.

S. Iverson, together with representative members of OTN Canada - Steven Cooke (Pacific, lead author), Michael Stokesbury (Atlantic), Scott Hinch (Pacific), Aaron Fisk (Arctic), David Vanderzwaag (Theme 5), Richard Apostle (Theme 5), Fred Whoriskey (OTN Global) – submitted an invited paper in May 2011 to "Fisheries" (sponsored by the Canadian Aquatic Resources Section of the American Fisheries Society) entitled: "Ocean Tracking Network Canada: A network approach to addressing critical issues in fisheries and resource management with implications for ocean governance". In this paper, S. Iverson's contribution helped to summarize OTN Canada's research program and wrote the section under "case studies" on the Atlantic bioprobe projects. This manuscript has been accepted and is now in press.

Also in May 2011, S. Iverson (lead), together with Daniela Turk (OTN Canada Network Manager) submitted a proposal for hosting a special session at the 2012 Ocean Sciences Meeting (20-24 Feb 2012) in Salt Lake City, Utah: "Integrating Oceanography and Animal Tracking – the Ocean Tracking Network". This has been accepted and > 20 abstracts have been submitted for this session (October 2011). S. Iverson will be presenting the abstract: "Bioprobes and recievers in the ocean tracking network (OTN): grey seals as biological and oceanographic samplers" by Iverson, S. J., Lidgard, D. C., Bowen, W. D., Jonsen, I.D., Mills Flemming, J., and Fennel, K. This talk will speak to the spatial-temporal patterns of social interactions and prey encounters by a wide-ranging, large marine predator, as well as their movements and foraging distribution in relation to fine-meso-scale seasonal oceanography in eastern Canada.

All bioprobe co-PIs and HQP, and many collaborators, attended the 1st Annual OTN Canada-wide Symposium in Halifax, as well as some of the OTN workshops that were held in conjunction, in June 2011.

- I. Jonsen is working with Fred Whoriskey (OTN Executive Director) and Jinyu Sheng and Keith Thompson (I.1 projects) to lead OTN Canada's involvement in developing a web-based data visualization, analysis and collaboration tool – the Platform for Ocean Knowledge Management (POKM). The POKM was demonstrated to OTN Canada researchers at the June Symposium and efforts by I. Jonsen have now turned to incorporating a suite of analysis tools for OTN acoustic data that are relevant to the current needs of OTN Canada researchers. Ultimately, POKM will be a tool for all OTN Canada researchers to access and query their tracking data, too conduct specialized analyses and visualizations, and to share data, analysis tools, and results across the Network.
- I. Jonsen and J. Mills Flemming also co-lead a data analysis and visualization workshop as part of the OTN June Symposium, which was attended by almost all of OTN Canada co-PIs and HQP.
- I. Jonsen has developed two state-space movement model applications for the grey seal tracking data, and provided training for D. Lidgard and S. Heaslip on their implementation. I. Jonsen is assisting several other OTN HQP (E. Halfyard – salmon I.2.1; M. Béguer – eels I.2.2) with data analyses, facilitating their implementation and integration within OTN via POKM.

- Both D. Lidgard and S. Carson (HQPs) gave presentations at the June Symposium and S. Carson also prepared a poster for the Statistical Society of Canada Annual General Meetings (also in June of 2011).
- As part of Dalhousie's Oceans Week, which the OTN Canada June Symposium kicked off, S. Iverson gave one of three widely advertised evening public lectures, in which she focused on both OTN Canada's research and the grey seal bioprobe study and results.

J. Mills Flemming gave a keynote lecture at the University of Toronto Statistics Research Day in April of 2011. Since that time two Statistics MSc students have contacted her regarding PhD supervision and both are planning to apply to Dalhousie in January of 2012 to commence the following fall. J. Mills Flemming also gave an invited talk at the Statistical Society of Canada Annual General Meetings (at Acadia) in June of 2011. There was a formal discussion following the talk and potential collaborations with Wayne Oldford (University of Waterloo), Simon Bonner (University of Kentucky) and Stephen Smith (BIO-DFO, I.1.1) ensued. S. Smith has since visited Dalhousie and given a talk in the Statistics Colloquium. Simon Bonner visited the week of November 3 2011. Arrangements for a visit by W. Oldford and his student Adrian Waddell are in the final planning stages. J. Mills Flemming gave a brief presentation to representatives from VEMCO, Dalhousie's Dean of Science Chris Moore, and Dalhousie's two new Industrial Research Chair (IRC) candidates about the bioprobe projects and related research being conducted on campus. This involved some earlier discussions with Chris Taggart (project I.1.3) and some of his students.

S. Heaslip and D. Lidgard will present data from the first year of the bioprobe projects at the 19th Biennial Conference on the Biology of Marine Mammals in November 2011 in Tampa, FL. The two encounters with salmon smolt have contributed toward a better understanding of predator-prey dynamics between seals and salmon, and provided some insight into the summer distribution of salmon smolts, thus linking the salmon projects and seal components of OTN.

Don Bowen has written a short semi-popular article describing the objectives and initial results of the grey seals bioprobe component of OTN. This internet article will appear in DFOs biennial review of the Center for Marine Mammal Expertise.

Katja Fennel and one of her PhD students (Karl Lagman) from oceanography project I.1.2 are now regularly attending the bioprobe project's team meetings. This will move ahead the incorporation of oceanographic data into both visualization tools and accompanying models of predator and prey movements.

J. Mills Flemming will be giving a keynote lecture at the International Statistical Ecology Conference in Olso in June of 2012. The contents of this lecture have already been posted on the conference website so as to generate further interest.

8. Dissemination of information and results

List refereed journal articles (accepted/published, submitted) and conference presentations (invited, contributed). All other dissemination is included in section #9 (Other contributions and deliverables).

Note: Deliverables from collaborators are listed in their respective reports and not repeated here.

Refereed Journal Articles (1 total)- *Accepted/Published*

Cooke, S.J., Iverson, S.J., Stokesbury, M.J.W, Hinch, S.G., Fisk, A.T., VanderZwaag, D.L., Apostle, R. and Whoriskey, F. (*in press*) Ocean Tracking Network Canada: A network approach to addressing critical issues in fisheries and resource management with implications for ocean governance. Fisheries *in press*

Refereed Journal Articles (2 total)- *Submitted*

Carson, S. and Mills Flemming, J. (to be submitted Jan 2012) A Spatial Point Process Approach to Encounter Data. Envirometrics.

Lidgard, D.C., Bowen, W.D., Jonsen, I.D. and Iverson, S.J. (to be submitted Dec 2011) A novel approach to studying at-sea associations in marine predators. PlosOne.

Invited Conference and Seminar Presentations (1 total)

Jonsen, I.D. (2011) A quantitative approach to animal movement and ecology. 4th International Science Symposium on Bio-logging, Mar 2011, Hobart, AU.

Iverson, S.J. (2011) What top predators can tell us about ocean ecosystems. Ocean Power Public Lecture Series, Dalhousie University Oceans Week, June 2011, Hailfax, NS.

Mills Flemming, J. (2011a) Challenges in Marine Statistical Ecology – From Sea Cucumbers to Grey Seals. University of Toronto Statistics Graduate Student Research Day in Computationally Intensive Problems in Statistics, Fields Institute, University of Toronto, ON, April 2011. (Invited Talk)

Mills Flemming, J. (2011b) The Ocean Tracking Network: A Data Perspective. Statistical Society of Canada Meetings, Wolfville NS, June 2011. (Invited Talk)

Mills Flemming, J. (2012) The Ocean Tracking Network - Visualization tools and novel
analyses for acoustic tracking data. International Statistical Ecology Conference, Olso, June 2012. (Invited Talk)

Contributed Conference Presentations (7 total)

Carson, S.(2011). A Spatial Point Process Approach to Modelling Seal Interactions. MSc Thesis, Dalhousie University, Dec 2011, Halifax, NS.

Carson, S. and Mills Flemming, J. (2011)) Analyzing At Sea Interactions among Sable Island Grey Seals. 1st OTN Canada Symposium, June 2011, Halifax, NS.

Iverson, S.J., Lidgard, D.C., Bowen, W.D., Jonsen, I.D., Fennel, K. (accepted, 2012) Bioprobes and receivers in the Ocean Tracking Network (OTN): Grey seals as biological and oceanographic samplers, 2012 Ocean Sciences Meeting, February 20 – 24, Salt Lake City, UT.

Lidgard, D.C., Bowen, W.D., Jonsen, I.D. and Iverson, S.J. (2011a) A novel approach to studying the foraging ecology of a marine predator. 1st OTN Canada Symposium, June 2011, Halifax, NS.

Lidgard, D.C., Bowen, W.D., Jonsen, I.D. and Iverson, S.J. (2011b) At-sea associations in a marine carnivore, the grey seal: insights from a new data-logger. 19th Biennieal Conference on the Biology of Marine Mammals, Nov 2011, Tampa, FL.

9. Other contributions and deliverables

Production of a video, blog, webinar, podcast, webpage, etc.

- Contributed summary of grey seal and cod project with results to date for OTN website and DFO review of the Center for Marine Mammal Expertise.
- Contributed to the on-going development of a web-based data-fetching, visualization, analysis and collaboration platform (Platform for Ocean Knowledge Management; POKM)

Radio or television interview or contribution to a programme/documentary, etc.

- CBC, Close to Home, Carmen Klassen: phone interview, Sable Island, brief discussion on the use of grey seals as bioprobes
- Rural Report for Northern Tasmania: radio interview associated with Bio-logging conference; discussed the role of OTN in advancing our understanding of marine animal movement patterns and the potential influence of climate change on these patterns

Invited or contributed presentation/contribution at a seminar series.

- S. Iverson June 2011. Keynote Lecture at Ocean Power Public Lecture Series, Dalhousie University Oceans Week, June 2011, Hailfax, NS.

Invited or contributed presentation/contribution at a conference.

- Marine Mammal Society Conference, Tampa, Nov. 2011: Presentation contribution on use of acoustic technology to understand foraging ecology of grey seals

- OTN Symposium, Halifax, June 2011: Presentation of results from first year of data, on use of acoustic technology to understand foraging ecology of grey seals
- 4th International Science Symposium on Bio-logging, Hobart, AU, March 2011: Keynote presentation on quantitative approaches for animal movement ecology

Data reports, technical reports, manuscript reports, advisory documents, briefing notes, handbook or guide, checklist, barcode, CTD casts, Glider runs, and/or data deposition to an agency/database (e.g., MEDS, GenBank, OBIS, etc.), as well as a contribution to a larger piece of work in any of the former.

- Preparation of a manuscript for a peer-reviewed journal on the use of grey seals as bioprobes.

A new technology, method, protocol, measure, analytical technique, algorithm, operational or numerical model, or predictive tool. Include the validation of any of the former and their practical application.

- We are in discussion with VEMCO and the Sea Mammal Research Unit, Scotland to develop a VMT that is capable of communicating with satellite- GPS tags to remove the need to re-capture seals for recovery of data. This will increase the number of potential sites for deploying seals with acoustic transceivers.

10. Collaborations with Industrial and Government Partners

a) Please describe which partners are actively involved in management, research, and knowledge transfer within the network and the specifics of their involvement.

The Department of Fisheries and Oceans, Canada continues to be integral to the deployment of telemetry and data-logging instruments on grey seals through arranging fieldwork on Sable Island and providing the equipment necessary for deployment. VEMCO have manufactured the VEMCO Mobile Transceivers, had them ready in ample time for deployment and have improved the firmware based on data obtained from 2010. PIs, Co-PIs and HQP are working with VEMCO to assist with the development of a VMT that can communicate with the GPS-satellite tag to remove the necessity of capturing animals to retrieve data.

b) Please complete the following chart on the use of cash and in-kind contributions from partners for year 2.

Name of supporting organization: DFO	**Year 2** 2011
Cash contributions to direct costs of research	
In-kind contributions to direct costs of research	
Salaries for scientific and technical staff	35,000
Donation of equipment, software	9,000
Donation of material	
Field work logistics	10,000
Provision of services	
Other (specify): _____	
In-kind contributions to indirect costs of research	
Use of organization's facilities	2,000
Salaries of managerial and administrative staff	
Other (specify): _____	
Total of all in-kind contributions	56,000

10. Expenditures and Support

a) Indicate your approved year 2 budget, your actual expenditures from 1 January to 30 Sep 2011 and your projected expenditures for the remainder of this installment (through to 31 December 2011).

Year 2	Proposed	Actual Expenses 1 Jan-30 Sep 2011*	Total Balance 30 Sep 2011*	Projected Balance 31 Dec 2011**
1) Salaries and benefits				
a) Students	21,000	2,272	**18,728**	**5,394**
b) Postdoctoral fellows	90,000	73,032	**16,968**	**-6,874**
c) Technical/professional assistants	15,450	0	**15,450**	**0**
d) other (specify)	0	0	**0**	**0**
2) Equipment or Facility				
a) Purchase or rental	18,180	9,510	**8,670**	**1,034**
b) Operation and maintenance costs	28,256	14,781	**13,475**	**1,608**
c) User fees	0	0	**0**	**0**
3) Material and supplies	11,927	6,239	**5,688**	**2,826**
4) Travel				
a) Conferences	4,000	2,667	**1,333**	**-999**
b) Field work	24,359	12,742	**11,617**	**1,386**
c) Collaboration/consultation	0	0	**0**	**0**
5) Dissemination costs				
a) Publication costs				
b) Other activities				
6) Other (specify)				
a)				
b)				
Total	**213,172**	**121,243**	**91,929**	**4,375**

The original year 2 budget listed in the table (revised from the original proposal based on the minor year 2 funding cut) encompasses the following:

1) Salaries:
a) 1 PhD student (I.2.5)
b) 2 PDFs/RAs (I.2.4 and I.2.5)
c) part time technical and lab support

2) Equipment or facility
a) Purchase or rental: VHF transmitters for tag retrieval, workstation, laptop
b) Operation and Maintenance: Argos satellite fees

3) Materials and supplies: field work and lab supplies, analyses, protective clothing and food for fieldwork, ATV fuel

4) Travel
a) Conferences for HQP
b) Field work: helicopter flight contributions for field work

b) Below, explain any significant deviations from the proposed expenditures. (Note: Changes of >20% from budget categories require advance approval from the Reprofiling Committee and NSERC, and must come first to S. Iverson).

1 Salaries:
a) Student salary for PhD student S. Carson was paid for by an unexpected fellowship from the Mathematics and Statistics Department until 30 Sept 2011. Thus some of this stipend was used for summer support of J. Hartling honours student who is now beginning on his MSc thesis with projects I.2.4 and I.2.5. S. Carson's stipend will come from the bioprobe budget for Oct-Dec 2011 (and in the future).
b) Salaries for two full-time PDF/RA positions were slightly higher than estimated due to new regulations in benefits support.
c) Partial salary for previous technical assistance and laboratory work for this project by S. Al Shaghay was taken out of another account and remains to be transferred, along with continued part-time lab work for the next 3 months and will come to zero balance.

2b), 3) and 4b) A large portion of the expenditures listed under 2b, 3, and 4b are encompassed under a Joint Project Agreement (JPA) between Dalhousie and DFO, and allow for large savings for Dalhousie in things such as Coast Guard helicopter flights, as well as centralizing purchases for Argos fees, fieldwork etc. Thus, summed across these categories 2b, 3, and 4b, $43,272 was recorded as spent out of $82,722 proposed. More has currently been spent than this, but we have yet to receive some of these bills. It is expected that most of the past expenses, and for the next 3 months especially for the upcoming Dec/Jan field trip, will be charged to this account by Dec 2011.

4 Travel:
2 conferences attended by 2 HQP came in slightly over estimated but are balanced by the rest of the budget.

11. Year 3 (Jan-Dec 2012) Budget – proposed and justified

a) Indicate your approved year 3 budget and any revisions to that original budget that you are proposing for year 3, noting that it must sum to ≤ the original total.

Year 3	Original	Revised	Carry Over Requested
1) Salaries and benefits			
a) Students	42,000	42,000	0
b) Postdoctoral fellows	90,000	90,000	0
c) Technical/professional assistants	15,900	15,900	0
d) other (specify)	0	0	0
2) Equipment or Facility	0		
a) Purchase or rental	6,365	6,365	0
b) Operation and maintenance costs	29,722	29,722	0
c) User fees	0	0	0
3) Material and supplies	12,564	12,564	0
4) Travel	0		
a) Conferences	11,000	11,000	0
b) Field work	24,720	24,720	0
c) Collaboration/consultation			0
5) Dissemination costs			
a) Publication costs	5,120	5,120	0
b) Other activities	0	0	0
6) Other (specify)			
a)	0	0	0
b)	0	0	0
Total	**237,391**	**237,391**	**0**

No revisions.

b) Provide a detailed justification for your year 3 budget. You may use your original justification (just as submitted in the proposal) and state that it remains on track if that is the case. For budget items that you are proposing to change, you must give a clear explanation/justification of why; these proposed changes must be approved by the SAC.

There are no proposed changes to the original budget in the approved SNG. This is repeated below just for information and reference:

1) Salaries and benefits

a) Students

Two Ph.D. students. S. Carson (started in Year 1) has conducted a spatial point process analysis of seal-to-seal encounters off Sable Island and future work will be directed at obtaining a more complete understanding of tag performance, detecting acoustic-tagged species via bioprobes and other platforms such as gliders, as well as investigating the possibility of using spatial point process approaches on data that have been collected in project I.1.1. J. Hartling will work on improving predictions and visualizations of behavioural foraging models and interactions.

b) Postdoctoral fellows

Two post doctoral fellow/RA positions: D. Lidgard and S. Lang (shared) and I. Jonsen will continue their initiated work examining the spatial and temporal patterns of predator and prey encounters and predation rates on tagged fish species by grey seals, developing statistical methods for estimation of encounter probabilities, and analyzing detection efficiency of VMT receivers to help scale expected detection rates in simulations aimed at improving the design of OTN tagging studies throughout all of OTN Canada Arenas, but also to provide information for other OTN Global tagging studies being developed. (note: increased required benefits at Dalhousie for salaries, which were implemented since the initial proposal, will be covered through any surpluses from other categories.)

c) Technical/professional assistants

Technical and laboratory assistance with the bioprobe projects and for analysis of collected grey seal and prey samples for diet analyses, organization and upkeep of the prey database, and support of fieldwork.

2) Equipment or facility

a) Purchase or rental

Year 3: purchase of 20 grey seal VHF transmitters (~$318/unit = $6,365/yr) to locate instrumented animals when they return to Sable Island.

b) Operations and maintenance costs

ARGOS satellite fees for grey seal satellite tags for Year 3 at $8.74/d x 170d x 20 units ($29,722/yr).

3) Materials and supplies

Grey seal fieldwork supplies includes 15-20 doses of Telazol; syringes, needles, biopsy tools, scintillations vials, vacutainers, cryovials, 5-min epoxy at $500/yr. Protective clothing for HQP in the field (oilskins, boots, anorak, gloves) at $500/yr. Food for two students on Sable Island for 30

days in January for instrument recovery ($1,080/yr); (note: for any Gulf of St. Lawrence work implemented in Year 3, support for HQP would come from that allocated above). ATV running cost on Sable Island at $30/d/bike for the two seasons for two students ($2,250). Fatty acid analyses at 80/yr and $75/sample ($6,000/yr); stable isotope analysis at 40/yr at $15/sample ($600). Office supplies including printer cartridges, paper, media.

4) Travel

a) Conferences

Travel for four HQP to attend one conference each and funding to bring in/or visit collaborators in data visualization work.

b) Field work

Grey seal field work: one 212 helicopter flight out and one return from Sable Island in June to instrument adults at $5,500/flight plus Sable Island landing fees at $500/flight. One 212 out and back in January to recover instruments at $5,500/flight plus Sable Island landing fees at $500/flight. (All other flights for these two field trips - approximately 6 out and 4 return - are covered by DFO.)

5) Dissemination costs

a) Publication costs

Page and colour figure charges for 4-5 publications for years 3.

Arctic Arena II.1-5

1. Project Number: Arctic Arena Projects II. 1-5

2. Project Title:

II.1. Testing and Applying New Technology to the Arctic Marine Ecosystem
II.2. Oceanography of the Arctic Arena
II.3. Movement of Arctic char and sculpin in relation to physical variables in the Canadian Arctic: Frobisher Bay/Lancaster Sound
II.4. Monitoring Bay- and Basin-Scale Movements of Arctic Cod in Relation to Abiotic Habitat across Diverse Time-Scales: Lancaster Sound (Resolute)
II.5. Trophic Interactions and Movements of Arctic Fish and Marine Mammals in a changing Cumberland Sound Ecosystem

3. Project Leader(s):

II.1. T. Dick (Manitoba) and S. Vagle (DFO-Winnipeg, UVictoria)
II.2. S. Vagle (DFO-Winnipeg, UVictoria). E.Carmack (DFO, UBC)
II.3. T. Dick (UManitoba)
II.4. T. Dick (UManitoba)
II.5. A. Fisk (UWindsor), S. Ferguson (DFO-Winnipeg, UManitoba)

Collaborator(s):

II.1 D. Webber (Vemco)
II.2 T. Dick(UManitoba), A. Fisk (UWindsor), D.Turk (Dalhousie).
II.3 A. Fisk (UWindsor)
II.1-4 A. Fisk (UWindsor), R.Crawford (UManitoba), D.Turk (Dalhousie- OTN)
II.5. T. Dick (UManitoba), S. Vagle (DFO-Winnipeg, UVictoria), K. Hedges (DFO-Winnipeg), M. Treble (DFO-Winnipeg), S. Kirchloff (Dalhousie – OTN)

4. Training of Highly Qualified Personnel:

a) List of the HQP and level of their salary support by SNG.

Personnel	*Title*	*%Time involved in project*	*%supported from SNG*	*Dates*
Nigel Hussey	PDF	100	100	1 Oct 2010 – 30 Sep 2011
Marianne Marcoux	PDF	20	0	1 Oct 2010 – 30 Sep 2011
Sebastian Luque	PDF	20	0	1 July 2011 – 1 Sept 2011
Daniela Turk	RA	20	100	1 July 2011 – 30 Sep 2011
Jeanette Bedard	PhD	100	80	1 May 2011 – 30Sep 2011
Cory Matthews	PhD	10	0	1 Oct 2010 – 30 Sep 2011
Iva Peklova	MSc	100	57	1 Oct 2010 – 30 Sep 2011
David Yurkowski	MSc	100	60	1 May 2011 – 30 Sep 2011
Jordan Matley	MSc	100	100	1 Oct 2010 – 30 Sep 2011
Eric Primeau	undergraduate	15	100	1 July – 30 Aug 2011
Bernard LeBlanc	Technician	10	0	1 Oct 2010 – 30 Sep 2011

b) Explain the role, activities and opportunities for training of technical staff in your project.

PDFs and graduate students take a lead in the design and implantation of all research. This has included travelling to the arctic to carry out the research. These HQP are also leading the analysis and interpretation of data, presenting of data at conferences and meetings and the writing of manuscripts. Technicians and undergraduates have mainly assisted with field logistics but also with technical aspects of the equipment.

5. Progress towards Objectives/Milestones (1 Oct 2010 – 30 Sep 2011)

a) Please provide brief description of the overall objectives of this project (max ½ page).

Project II.1-4

1. Test and Apply New Technology to the Arctic Marine Ecosystem.
2. Monitor and describe oceanography of the Arctic Arena.
3. Study movement of Arctic char and shorthorn sculpin in relation to physical variables in the Canadian Arctic: Frobisher Bay.
4. Monitor Bay- and Basin-Scale Movements of Arctic Cod (*Boregadus saida*) in Relation to Biotic and Abiotic Habitat across Diverse Time-Scales: Lancaster Sound (Resolute).

Project II.5.

1. Assess location and biomass of Capelin in Cumberland Sound in the summer using trawls directed by locations of arctic char and Greenland halibut determined from objectives 2 and 3 below.
2. Establish the seasonal movements of Arctic Char in Cumberland Sound using acoustic (V6) tags and the diver glider and VR2W receivers. Charr will also be fitted with chat tags in 2011 to provide receiving and sending capabilities among tagged animals, glider, and curtain.
3. Establish the seasonal and yearly movements of Greenland halibut in Cumberland Sound during the summer using acoustic tags and the dive-glider and VR2W receivers and satellite pop-off tags. Halibut will also be fitted with chat tags in 2011 to interact with other tagged animals.
4. Establish the seasonal and yearly movements of the Greenland shark (*Sominous microcephalus*) using acoustic tags and the dive glider and VR2W receivers, and satellite pop-off tags to correlate their depth movements in the Sound with those of turbot, charr and marine mammals. Sharks will also be fitted with chat tags in 2001 to interact with other tag animals.
5. Ringed seals will be tagged with satellite telemetry tags to determine oceanographic information (CTDs) and seasonal movements, dive behavior, and foraging. With the development of chat tags in 2011 by Ocean Tracking Network – Global we plan to tag seals and fish to monitor predator-prey behavior and better understand the trophic consequences of invasive prey (i.e., capelin).
6. Beluga will be surveyed to determine distribution and habitat use and tagged with satellite transmitters to determine movements, dive behavior, and feeding patterns. Acoustic C-pods will be deployed along the acoustic curtain and at a number of key sites within Cumberland Sound to record feeding behavior at depth and over time and matched with halibut seasonal movements to determine predator-prey behavior.
7. Harp and ring seals, beluga and narwhal will be collected as part of Community-based Monitoring project, and key invertebrate, primary producers, and fish will also be collected for use in establishing food web interactions using chemical tracers. This will be compared with current research on the Cumberland Sound food web structure to assess changes associated with invasive species and climate change and provide current data to compare with movement data.

b) Describe progress towards meeting the project's objectives and specific milestones for the project.

II.1-4. Overall fieldwork was highly successful providing important baseline data and information on logistics for the implementation of the 2012 research schedule. Unfortunately, the team was unable to locate and catch Arctic cod likely as a result of no ice conditions – a scenario previously unheard of in this region at this time of year. The highlights of the 2011 field season include; (i) extensive

hydroacoustic surveys of Arctic cod coupled with directed gill net fishing in Maxwell Bay, Resolute Bay and Becher Bay, (ii) deployment of two deep-water long-lines for Greenland Sharks and associated tagging/sampling of 6 sharks (SAT and acoustic); (iii) collection of oceanographic data; (iv) deployment of a 16km line of VR4/VR2W 180s outside Maxwell Bay; (v) bird and marine mammal surveys (vi) stomach contents of seal and whale were collected and tissue samples taken for stable isotope and genetic analyses and; (vii) positive communication established with Resolute HTA. Time in the Arctic: J. Matley (3 weeks), Nigel Hussey (2 weeks), R. Crawford (2.5 weeks), Duncan Bates (2 weeks). Personnel from Resolute community; B.Iqaluk (2 weeks). The project is moving forward in the right direction and will achieve the project goals.

1. Extensive hydroacoustic surveys were undertaken following a series of transects throughout the area of Maxwell Bay, in Resolute Bay following predefined transect lines from historical surveys and in Becher Bay. These data complement historical datasets from previous work undertaken by R. Crawford to further our understanding of the spatial and temporal distribution of Arctic cod in the region. Although no Arctic cod were detected or caught in Maxwell Bay, Becher Bay appeared promising for 2012 fieldwork. These data in conjunction with 2010 Allen Bay acoustic tag data are important for guiding the large-scale acoustic tagging work of Arctic cod over the coming years.

2. Gillnet surveys were conducted in Maxwell and Becher Bay. Numerous sculpin were caught but no Arctic cod. Fishing data was in agreement with hydroacoustic data from Maxwell Bay. We suggest that the lack of ice was an important factor determining the absence of cod. This may indicate that basin scale movements of Arctic cod are taking place.

3. Two deep water long-lines were set, one at the entrance to Maxwell Bay and the second at the entrance to Resolute Bay. On the first line, we caught a total of 37 sharks – the first known capture of Greenland sharks in this region. A total of six sharks were implanted with V16 acoustic tags (surgery) and additionally three were fitted with pop up archival (MK10) satellite tags. To date, one of these satellite tags has reported and is currently transmitting data. The shark swam approximately 150 miles east towards Baffin. The data from these tags will provide detailed information on vertical diving activity and temperature preferences. The high catch rate of sharks also resulted in depredation by other sharks. We therefore took muscle/fin samples for stable isotope and genetics work respectively from depredated animals. Again, these samples form a unique dataset for this region, which will be expanded on in 2011-2012.

4. Oceanographic data were collected from multiple CTD casts in Maxwell Bay, Resolute Bay and Becher Bay.

5. Considering future basin-scale planned work on movements of Arctic cod and the tagging of Greenland sharks in Resolute and Cumberland Sound, a 16km line of VR4 monitors (n = 12) were deployed (1.5 km apart) and three VR2W180 were deployed between the first 3 sets of VR4s at distances of 375m. The VR4s are ideal for long-term deployments considering logistical difficulties at this latitude.

6. Bird and Marine Mammal surveys were conducted in Maxwell Bay and Becher Bay complementing previous surveys undertaken in Allen Bay in 2010.

7. Stomach content data was collected from seals and belugas (purchased from hunters) as part of the overall description of the local food web and tissue collected for stable isotopes and genetics studies (for the International Bar Code of Life project, UGuelph).

6. A meeting was held with the chairmen of the Resolute HTA. Communication was positive and a meeting is planned soon to further develop the ideas discussed at that meeting to assist the Inuit in addressing questions important to the community.

II.5. The Cumberland Sound field season was exceptionally productive and built on the 2010 work. This work highlights the multidisciplinary components of the Cumberland Sound research project The highlights of the 2011 field season include; (i) testing equipment in the Arctic environment; (ii) the use of new equipment and long-term testing (VMTs); (iii) deployment of extensive acoustic arrays; (iv) acoustic tagging of large numbers of Greenland Halibut, Arctic skate and Greenland shark; (v) satellite tagging of Greenland Halibut, Arctic skate and Greenland sharks; (vi) Extensive oceanographic work and deployment of 12-month fixed stations with oceanographic monitors; (vii) deployment of CPODs and AURALS for monitoring marine mammals; (viii) boat-based marine mammal surveys; (ix) Attachment of a satellite tag to ring seal; (x) stomach content and tissue samples from marine mammals for continued stable isotope and genetic analyses and; (xi) continued good relations with the Cumberland Sound HTA. Time in the Arctic: A. Fisk (3 weeks), Nigel Hussey (4 weeks), K. Hedges (4 weeks), J. Bedard (6 weeks), I. Peklova (3 weeks), D. Yurkowski (2 weeks), M. Marcoux (4 weeks), E. Primeau (4 weeks), S Ferguson (2 weeks), Kevin Hedges (6 weeks), Sebastian Lugue (2 weeks) and Daniela Turk (1 week). Personnel from Resolute community include three locas, Noah Metuq (1 week), Mike Kisa (10 days) and Robert Kisa (10 days). The project is made significant progress and is well ahead of schedule to meet the project goals.

1. Testing equipment in the Arctic environment is of extreme importance given the unique environmental conditions (ice cover/ salinity gradients etc). Three 12-month range test stations were established at different depths (800m / 400m / 150m) to test the range of various tags (V6, V9, V13 and V16) and VR2W69, VR2W180 and VMT receivers under these varying conditions. In

addition extensive field range tests were undertaken which revealed a donut effect for high-powered V16 tags. These data are currently being analyzed and a note prepared for publication.

2. Considering the depth of our study animal (1000m), we undertook the first deployment of VMTs (as fixed receivers) to monitor fish movements. Coupled with extensive range tests (point 1) and oceanographic data (Project II), there should be extensive data next year to assess the effectiveness of these monitors at this depth; an important advancement for the future study of deep water fishes.

3. A total of 12 deep-water VMT monitor stations were deployed in the summer fishing ground and 12 VR2W69s were deployed in the winter fishing ground in fixed predetermined arrays. Five VR2Ws were deployed in a gate across a deep water channel joining the two fishing grounds, a further monitor was deployed near the kikistan Islands and one in the deep water channel at the entrance to Cumberland Sound. These monitors will detect acoustically tagged Greenland halibut to determine if there is spatial sub-structure within the summer fishing ground and to reveal if movement of fish occurs between the two fishing grounds. In addition tagged Arctic skate and Greenland sharks will provide detailed information on their spatial and temporal distributions across both fishing grounds.

4. A total of 150 Greenland Halibut, 70 Arcyic skate and 20 Grenland sharks were acoustically tagged (transmitters internally inserted through surgery). All fish were healthy on release and a Greenland Halibut as since been caught in good condition in the commercial fishery. In addition, a tagged Greenland shark and two Greenland Halibut tagged in 2010 were detected on opportunistic deployments of VR2Ws on fishing sets.

5. A total of 3 Greenland Halibut, 6 Arctic skate and 3 Greenland sharks were equipped with satellite tags (miniPATs and MK10s). Deployment periods ranged from 40 to 300 days. All three tags on Greenland sharks have popped off on the expected date and data is currently downloading to satellite. A manuscript including detailed analysis of this data is expected in early 2012. Tags programmed for short-term deployments on Arctic skate have also transmitted.

6. Extensive CTD casts were undertaken over a 6-week period in Cumberland Sound. These oceanographic measurements were made throughout the whole region (summer and winter fishing grounds) and near long-term fixed range tests. These data will be used to examine the effects of environmental conditions on tag range and detection. Additionally, 3 fixed 12-month moorings were deployed with oceanographic monitors – these were also strategically positioned to provide data to complement long-term range tests. Field collected data are currently being analyzed. The first measurements of water pCO2 in the Cumberland Sound were also performed using a moored SAMI-

pCO2 and collecting profiles of discrete water samples in the upper 50m. The pCO2 measurements will be combined with physical observations and satellite chlorophyll estimates to study the impact of environmental conditions on the sources and sinks of carbon dioxide in this area of the Arctic.

7. Three fixed stations equipped with CPODs and AURALs were deployed for a one month period to record the presence and behavior of marine mammals. Data were downloaded and in conjunction with data from 2010 is currently being analyzed. The three stations were then redeployed for a 12-month period.

8. During August 2011, researchers were based at Pangnirtung, Cumberland Sound to conduct research on beluga, bowhead, and killer whales. Objectives included deploying satellite transmitters, collecting biopsies and photographs for use in diet, movement, and genetics studies of all three species in the eastern Canadian Arctic. Six transects of Cumberland Sound were conducted, during which various seabird and marine mammal species were observed. 54 biopsies were collected from bowhead whales, largely at the mouth of Kingnait Fiord. No beluga or killer whales were observed during the field trip. 9. The capture and attachment of a single satellite tag to a ringed seal. This tag is transmitting data on a daily basis providing a detailed profile of spatial and vertical movement behavior.

10. Stomach content data was collected from seals and belugas (purchased from hunters) as part of the overall description of the local food web and tissue collected for stable isotopes and genetics studies.

11. Field derived biopsy samples were taken from 12 bowhead whales for both genetic and stable isotope analyses.

12. Continued communication with Cumberland Sound HTA regarding current and proposed research activities.

c) Describe and justify any significant deviations from the original objectives or plans, including any revised goals, new projects, or deleted projects.

II.1-4. As previously stated, the only addition to the original plan was the assessment of the arctic cod populations using hydroacoustic technology. This was an important decision as we are now able to use this technology to not only assess arctic cod populations but we will be able to apply it to capelin/cod interactions in other areas of the arctic. The opportunity to have Dr. Crawford, a leading US expert on this technology, to work on arctic cod for a modest price is a real coup.

In terms of objective 3, the Arctic char study, the first phase of this research was completed in 2008 and 2009 in Frobisher Bay, although not funded by OTN. We know that a few char move among rivers but there is strong freshwater site fidelity for the majority of char. We also know from this research that char prefer higher temperatures and move with the tidal cycle. The hypothesis is that char use little energy in general movements (baseline energy requirements are low) and most energy is utilized for digestion and energy storage during the short annual marine feeding phase. These processes are affected by water temperature and quality of food (digestible energy). We also know that as char diet shifts from invertebrates to fish such as arctic cod char growth increases (Dick unpubl.). Extensive Arctic charr work is planned in 2012 (see below) along a south/north gradient from Frobisher Bay through Cumberland Sound to Lancaster Sound.

II.5. Excellent progress was made towards objectives 3-7 of this project. For objectives 1 and 2 on Capelin and Arctic charr, collaborations and communication has been established with Ross Tollman at DFO, Winnipeg and with both Cumberland Sound and Resolute HTA regarding tagging work. We anticipate that a PhD student and PDF will begin the Arctic charr tagging work in 2012. The lack of key technology, such as the chat-tags, has limited the progress of this work.

d) *Describe how the work of the project's co-investigators and collaborators was coordinated and integrated*.

II.1-4. All co-investigators (A. Fisk, D. Webber, S. Vagle) provided intellectual contributions to develop and establish the research plan for 2011. There are regular phone and email communication to discuss logistics, progress and problems with other co-investigators.

II.5. All co-investigators (A. Fisk, D. Webber, S. Vagle, M. Mallory, S. Ferguson, D. Turk) provided intellectual contributions to develop and establish the research plan for 2011. There has been continuous communications with S. Vagle on deployment and data acquisition by the CTDs and other oceanographic monitors and with D Turk over deployment of the CO2 sensor.

Extensive discussion with D. Webber and VEMCO staff over the design of acoustic monitor arrays, tag types and long-term range tests including meeting between A Fisk and D. Webber in Halifax.

K. Hedges (DFO) is part of the field research team, providing value expertise on fishing and tagging of the animals.

e) Describe the benefits of conducting this research as part of a network rather than as a separate project (e.g., scope of the research, cross disciplinary collaborations, new synergies and research opportunities, access to ship time, planning and coordination of research activities, exchange of information and data, benefits to students and technical staff).

Within the Arctic Arena, combining technology development, fisheries, marine mammal and oceanographic projects has broadened the scope of each of these components. For example, extensive range testing of Vemco tags and receivers has been coupled with the collection of oceanographic data (CTD casts), including a 1-year deployment of range tests and oceanographic equipment. The range testing has been called the most comprehensive test carried out to date (Dale Webber, personal communication), and the oceanographic data will be critical to interpreting the results due to ice cover and large tides (second largest in the world). All components of the project are organized in a synergistic fashion, for example we have designed marine mammal listening devices (C-PODs) to be in the same regions where acoustic (for monitoring tagged fish) and oceanographic moorings have been placed. We have also coordinated ship time to deploy acoustic and oceanographic stations, with HQP working together to deploy each other's equipment. Thus HQP are learning about other types of research, the methods used and the types of data that will be collected. For example, CTD casts require at least 2 HQP to prep and deploy and there was consultation between HQP on the ship about timely and location of these cast. As well, all HQP examined the CTD profiles and there was much discussion about the data and how it might effect acoustic tag performance and even the movement and behavior of fish and marine mammals.

Within the larger OTN project, interacting and discussing logistics and mooring placements and tags with researchers from other OTN arenas have proven to be invaluable. Preliminary discussions about collaborating on salmonid movements on the east coast have begun. Given the large amount of data collected in the second year of the project, particularly oceanographic, we anticipate greater interactions with other groups in the coming years.

f) Describe the scientific and/or engineering significance of the results to date.

II.1-4. This is the first time Greenland sharks have been caught in the Lancaster Sound region. Satellite tags will provide unique high-resolution data on the vertical diving profiles of this large Arctic apex predator. Acoustic tagged sharks and monitor deployments in conjunction with the Cumberland Sound Research program will provide long-term insights in to the large-scale movements and residency patterns of these difficult to study animals. Extensive hydroacoustic surveys provide the necessary baseline data to build a feasible basin wide Arctic cod tagging and tracking program in 2012.

Oceanographic data builds on that collected in 2010 and presents unique and important data for understanding changing climates and ocean conditions.

II.5. This is the first extensive long-term acoustic monitor study that has been established in the Arctic arena. Data from preliminary monitors in 2010 and satellite tags revealed that Greenland Halibut moved from the deep water fishing grounds to shallow waters in the winter. This data is critical for the effective management of Greenland Halibut stocks and current monitor arrays will provide this required data. In addition, the three long-term Arctic range tests are the first to be undertaken and will provide data for all future Arctic telemetry studies. The deployment of VMTs in deepwater advances our understanding of the potential of new acoustic equipment. Extensive oceanographic data is a first for this region and will complement acoustic tag and range-test work. Ongoing marine mammal studies are providing important baseline data in this changing environment.

6. Difficulties encountered

a) Identify the main difficulties encountered in carrying out the research during the reporting period from the list below:

- ❑ Scientific problems/difficulties
- ❑ Equipment and technology issues (e.g., delivery and malfunctioning of equipment, etc)
- ❑ Personnel problems
- ❑ Involvement of partners
- **X** Other (specify): _ship support_____
- ❑ No problems occurred during this instalment of the grant

b) For each checked box, describe the difficulties identified above and the steps taken to resolve them.

II.1-4. Logistical support, in particular ship time will be a significant issue for the coming years for the Resolute component of Arctic OTN. The chartered ship had to transit from Labrador to Resolute for fieldwork operations and arrived several days late. Although this operator has agreed to work next year – ship logistics are complex in Resolute. We are currently pursuing the possibility of refurbishing an old DFO boat for localized field operations.

II.5. In Cumberland Sound, funding for ship time has been secured through the Nunavut government to use the new Nunavut research vessel over the coming years. This year, however, was the first season for this research boat and there were several delays - boat arrival and shipping delays are common occurrences in the Arctic region and will continue to present difficulties.

7. Networking and outreach

Discuss the extent of networking and outreach by the project, both within the OTN Canada Network and with the broader community, by co-PIs, collaborators and HQP. Describe how the project's research has been impacted by, and contributed to, the research carried out by other projects from across the Network.

Intra-Network Collaboration and Partner Meetings

Preliminary discussions with OTN-Atlantic collaborators Ian Fleming and Fred Whorisky on collaborative research on Atlantic salmon and arctic charr interactions were initiated. Fisherman are reporting Atlantic salmon in northern Quebec rivers where previously only charr were caught. Plans for a new OTN acoustic line in northern Labrador to monitor charr and salmon, and tagging of these species in this area, are being planned. Arctic charr project will span the Canadian Arctic and into the northern reaches of the Atlantic region.

PI Fisk and HQP attended the 1st OTN Canada Symposium, June 2011 in Halifax. Fisk and HQP Hussey, Matley and Peklova gave talks and Bedard presented a poster.

A number of peer-reviewed papers have been submitted to journals and HQP have made and will make a number of conference presentations in 2011.

Interaction/Outreach to Broader Community

We had numerous interactions and positive communication with Inuit community in Resolute Bay and Pangnirtung, which is crucial for the success of the Arctic arena work. A meeting was held with a chairman of the Resolute Hunters and Trappers Association (HTA) in August 2011 and approval for research in the Resolute Bay area was given by the HTA. Another meeting is planned for early 2012 to further develop the ideas discussed and to assist the Inuit in addressing questions important to their community. A major concern and interest in Resolute Bay are the arctic charr, which will be a focus of research across the arctic and into the Atlantic region.

Resolute Community member participated in the fieldwork in Maxwell Bay in August 2011. We also hired Labrador fisherman and Inuit Joey Anaglok and his ship for work in Resolute in 2011, with plans to work with Joey in 2012-2014.

Research in Pangnirtung included hiring local Inuit hunters and fishermen Noah Metuq, Mike Kisa, Robert Kisa, Peter Kilabuk and Robert Kilabuk. Members of the Government of Nunavut (R. Brown)

joined the cruise in the Cumberland Sound for a week. The Arctic team, Gov't of Nunavut (Ron Brown & Brian Burke) and DFO (Kevin Hedges, Ross Tallman) have had numerous discussions for improvements of the new Nunavut research vessel for future field seasons and will meet in Ottawa Dec 7 and 8, 2011. These discussions also include the management of commercial fisheries and by-catch in Cumberland Sound and include Pangnirtung Fisheries Incorporated (Don Cunningham and Kendra Ulrich).

PI Fisk research for OTN-Arctic was carried by a number of newspapers across Canada and was the focus of an interview to CBC radio station in Windsor in 2010. Several film crews, including a potential Discovery channel documentary interviewed members of the research team in Cumberland Sound. We have also interacted and gained approval for the research from the Hunters and Trappers Association of Pangnirtung NU through written correspondence and meeting with community (Kevin Hedges and Steve Ferguson).

8. Dissemination of information and results

List refereed journal articles (accepted/published, submitted) and conference presentations (invited, contributed). All other dissemination is included in section #9 (Other contributions and deliverables).

Refereed Journal Articles (2 total)- *Accepted/In revision*

Cooke, S.J., S.J. Iverson, M.J.W. Stokesbury, S.G. Hinch, A.T. Fisk, P. Smith, D. VanderZwaag, J. Brattey and F. Whoriskey. 2011. Ocean Tracking Network Canada: A network approach to addressing critical issues in fisheries and resource management with implications for ocean governance. Fisheries In press, accepted 07/25/11.

Matley, J.K., Fisk, A.T., and Dick, T.A. Seabird predation on Arctic cod (*Boreogadus saida*) and their interactions during summer in the Canadian Arctic. Marine Ecology Progress Series (Resubmitted on Sep 19, 2011, submission number: 201105040, 34p.)

Refereed Journal Articles (3 total)-*Submitted*

MacNeil, M.A., B.C. McMeans, N. Hussey, P. Vecsei, J. Svavarsson, K. Kovacs, C. Lydersen, M. Treble, et al. & A.T. Fisk. 2011. Biology of the Greenland Shark. J. Fish Bio. In revision.

Matley, J.K., Crawford, R., and Dick, T.A. The application of hydroacoustics to study the distribution of Arctic cod (Boreogadus saida) and behaviour of shallow-diving seabirds in the Canadian Arctic. Polar Research (Submitted Jul 28, 2011, submission number: POR-07-11-0031-FRA, 35p.)

Matley, J.K., Crawford, R., and Dick, T.A. Observation of common raven (Corvus corax) scavenging Arctic cod (Boreogadus saida) from seabirds in the Canadian High Arctic. Polar Biology (Submitted Sep 20, 2011, submission number: POBI-D-11-00208, 12p.)

Contributed Conference Presentations (6 total)

Matley, J.K., Crawford, R., Fisk, A.T., and Dick, T.A. (2010) The interactions of marine seabirds feeding on Arctic cod (Boreagadus saida). ArcticNet Annual Conference, Ottawa, ON (Oral presentation)

Matley, J.K., Crawford, R., Fisk, A.T., and Dick, T.A. (2011) Arctic cod (Boreogadus saida) predation by seabirds and their interactions during summer in the Canadian Arctic. Prairie University Biology Symposium (PUBS), Saskatoon, SK (Oral presentation)

Matley, J.K., Fisk, A.T., and Dick, T.A. (2011) Foraging behaviour and trophic ecology of marine mammals in the Canadian Arctic. Society for Marine Mammalogy Biennial Conference, Tampa, FL. (Accepted - Poster presentation)

Peklova, I., Fisk, A.T., Hedges, K.J. , Dick, T.A. and Hussey, N.E. (2011) Depth and temperature preference of deep water fish species in Arctic marine ecosystems. Joint Meeting of Ichtyologists and Herpetologists, Minneapolis, MN. (Accepted - Oral presentation)

Bedard, J.M.; Vagle, S.Williams, W.Klymak, J.M.; Physical oceanography in Cumberland Sound; An Important OTN Study site, 2012 Ocean Sciences Meeting, February 20 – 24, Salt Lake City, UT.

Turk, D.Bedard, J.M.; Thomas, H.Vagle, S.McGillis, W.R.; Summertime pCO2 in the Cumberland Sound in the Eastern Arctic, 2012 Ocean Sciences Meeting, February 20 – 24, Salt Lake City, UT

9. Other contributions and deliverables

Print-media contribution: international, national, local, university, etc.

- Research by MSc Dave Yurkowski on ringed seals was highlighted in the University of Windsor Daily news on October 10, 2011.
- Casey Lessard, Northern News Services, Published Monday, Oct. 17, 2011 Released a story on turbot, shark populations to be tracked; goal is to build sustainable fisheries, government official says.

Invited or contributed presentation/contribution at a workshop.

Matley, J.K.*, Fisk, A.T., and Dick, T.A. (2011) Trophic feeding of marine mammals in Allen Bay, Nunavut. Ocean Tracking Network Annual Symposium, Halifax, NS (Poster presentation).

Matley, J.K.*, Crawford, R., Fisk, A.T., and Dick, T.A. (2011) Seabird predation on Arctic cod (Boreogadus saida) and their interactions during the summer in the Canadian Arctic. Ocean Tracking Network Annual Symposium, Halifax, NS (Oral presentation)

Overgaard, D., Matley, J.K.*, Fisk, A.T., and Dick, T.A. (2011) Preliminary assessment of the fish tagging program in Lancaster Sound (Allen Bay). Ocean Tracking Network Annual Symposium, Halifax, NS (Oral presentation)

Matley, J.K.*, Crawford, R., and Dick, T.A. (2011) The application of hydroacoustics to study the distribution of Arctic cod and seabirds in shallow Arctic bay. Ocean Tracking Network Annual Symposium, Halifax, NS (Poster presentation)

Yurkowski, D. J., Ferguson, S. H., Luque S. P, and Fisk. A.T. 2011. Diet and seasonal habitat use of ringed seals (*Phoca hispida*) in a changing Cumberland Sound. 1st Ocean Tracking Network Symposium, Halifax, Nova Scotia. June 1-3, 2011.

Fisk, A.T. 2011. Marine animal movements in the Arctic: The challenges for Arctic-OTN. 1st Ocean Tracking Network Symposium, Halifax, Nova Scotia. June 1-3, 2011.

Peklová, I., K.J. Hedges, T. Dick, N.E. Hussey and A.T. Fisk. 2011. Depth and Temperature Preferences of Arctic Skate (Amblyraja hyperborea) and Greenland Halibut (Reinhardtius hippoglossoides) in a deep water Arctic Marine Ecosystem. 1st Ocean Tracking Network Symposium, Halifax, Nova Scotia. June 1-3, 2011.

Hussey, N., D. Webber, J. Bedard, T. Dick, S. Vagle and A. Fisk. 2011. Long-term acoustic telemetry range tests in the Arctic environment. 1st Ocean Tracking Network Symposium, Halifax, Nova Scotia. June 1-3, 2011.

6. Invited or contributed presentation/contribution at a seminar series.

Peklova, I.* (2011) Movement and behaviour of deep water fish species in Arctic marine ecosystems. Seminar course, University of Windsor, ON, (Accepted -Oral presentation)

Peklova, I.* (2011) Movement and behaviour of deep water fish species in Arctic marine environments. GLIER colloquium, Windsor, ON (Accepted - Oral presentation)

Matley, J.K.*, Crawford, R., Fisk, A.T., and Dick, T.A. (2010) The interactions of marine seabirds feeding on Arctic cod (Boreagadus saida). Crackerjack Seminar Series, Winnipeg, MB (Oral presentation)

Invited or contributed presentation/contribution at a conference.

- See section #8 above.

Invited or contributed consultation with an agency; public or private

- The research in Cumberland Sound is directly contributing to generating data for the management plan being developed for the emerging Greenland Halibut summer fishery. We have had numerous discussions with Government of Nunavut scientists, DFO scientists and Pangnirtung Fisheries representatives over the results of our work and future directions of the research. Government of Nunavut and DFO are directly supporting our research effort with ship time, logistics and purchase of acoustic tags.

A spin-off from the research that provided a new opportunity or new initiative

- The experience and knowledge gained from the OTN has allowed A. Fisk to apply for and receive a NSERC RTI grant ($68,000) for acoustic equipment to be used in the Great Lakes.
- PI Fisk included acoustic telemetry in his 2011 NSERC Discovery grant application.

10. Collaborations with Industrial and Government Partners

a) Please describe which partners are actively involved in management, research, and knowledge transfer within the network and the specifics of their involvement.

- Dale Webber (Vemco) had direct involvement with the experimental design and range-testing testing of equipment, which is continuing.
- Wildlife computers provided assistance with satellite tag programming and study design.
- Bernard Blanc (DFO-Winnipeg) assisted students in download of ARGOS derived satellite tag data.
- Don Cunnigham (Pangnirtung Fisheries) provided advice over monitor deployments and is acting as liaison with commercial fishing boats over tag return. D Cunningham also relayed monitor locations to fishermen to prevent gear entanglement.
- Devon Imrie/Angela Young (Government of Nunavut) provided field logistical assistance and assisted with the shipping and collection of equipment.

b) Cash in-kind contributions from partners for year 2.

Name of supporting organization: **Government of Nunavut**	**Year 2** 2011
Cash contributions to direct costs of research	
In-kind contributions to direct costs of research	
49) Salaries for scientific and technical staff	
50) Donation of equipment, software	24,000
51) Donation of material	
52) Field work logistics	
53) Provision of services	
54) Other (specify): _____	
In-kind contributions to indirect costs of research	
25) Use of organization's facilities	57,750
26) Salaries of managerial and administrative staff	
27) Other (specify): _____	
Total of all in-kind contributions	57,750

Donation of equipment: Purchase of 60 Vemco V13 acoustic tags for Greenland halibut.
Use of organization's facilities: Use of Nunavut research vessel for 1.5 weeks.

Name of supporting organization: **DFO**	**Year 2** 2011
Cash contributions to direct costs of research	
In-kind contributions to direct costs of research	
55) Salaries for scientific and technical staff	
56) Donation of equipment, software	
57) Donation of material	
58) Field work logistics	
59) Provision of services	
60) Other (specify): _____	
In-kind contributions to indirect costs of research	
28) Use of organization's facilities	57,750
29) Salaries of managerial and administrative staff	
30) Other (specify): _____	
Total of all in-kind contributions	57,750

Use of organization's facilities: Use of Nunavut research vessel for 1.5 weeks.

11. Expenditures and Support

Year 2 (2011)

a) Indicate approved year 2 budget, actual expenditures from 1 January to 30 Sep 2011 and projected expenditures for the remainder of this installment (through to 31 December 2011).

Year 2 (2011)	Proposed	Actual Expenses 1 Jan-30 Sep 2011*	Total Balance 30 Sep 2011*	Projected Balance 31 Dec 2011**
1) Salaries and Benefits				
a) Students	89,100	46,265	**42,835**	**37,835**
b) Postdoctoral Fellows	45,000	57,000	**-12,000**	**-12,000**
c) Technical/Professional Assistants	45,000	2,729	**42,271**	**36,271**
d) Other (specify)	40,100	27,438	**12,662**	**7,662**
2) Equipment or Facility				
a) Purchase or Rental	10,775	11,217	**-442**	**-442**
b) Operation and Maintenance Costs	18,600	20,000	**-1,400**	**-1,400**
c) User Fees	-	-	**-**	**-**
3) Material and Supplies	17,300	38,631	**-21,331**	**-21,331**
4) Travel				
a) Conferences	4,000	-	**4,000**	**4,000**
b) Field Work	55,806	85,225	**-29,419**	**-29,419**
c) Collaboration/Consultation	-	-	**-**	**-**
5) Dissemination Costs				
a) Publication Costs	-	-	**-**	**-**
b) Other Activities	-	-	**-**	**-**
6) Other (specify)				
a) Carry over from 2010	-	-	**27,077**	**27,077**
b)	-	-	**-**	**-**
Total expenditures	**325,681**	**288,505**	**60,253**	**48,253**

b) Below, explain any significant deviations from the proposed expenditures. (Note: Changes of >20% from budget categories require advance approval from the Reprofiling Committee and NSERC, and must come first to S. Iverson).

The total arctic budget is projected to be under-spent by a total of $48,253 in 2011 ('2011 Year 2 balance $21,176' + 'unspent money of Terry Dick includes a carry-forward from 2010 $27,077'). If not

for the carry over amount from 2010 of $27,077, our Year 2 expenditures would not have deviated more than 7% from that proposed for Year 2. The resignation of co-PI Terry Dick from OTN in 2011 is the main reason for this project being under-spent and slightly behind schedule on 2 of the 5 projects in the Arctic Arena. However, the remaining PIs on the project (Fisk, Vagle and Ferguson, along with collaborators Hedges and Tallman (both DFO) have committed to the proposed research plan and will be expanding their obligations to the project. As well, Terry Dick will continue to collaborate on the project by being involved in research planning, interpretation of data and mentoring of students.

The $48,253 represents a carry over of less than 15%, and we are asking that this money be carried forward for 2012. Of this money, $32,880 will be held over for support of PDFs and students in 2012, as original planned for these funds. Because of the unexpected resignation of co-PI Terry Dick, a number of projects are behind schedule and we have hired additional PDFs and plan to recruit a new PhD to get these projects caught up, which this extra $32,880 will be used. The remaining $15,373 we are asking to be re-profiled into equipment to purchase additional oceanographic instruments in support of a MSc student starting and working in the Resolute area (this will also support research on arctic cod and arctic charr that is to begin in 2012, and thus supports an additional 2 PDFs, 1 PhD and 1 MSc). Arctic OTN continues to exceed the number of HQP that were to be support through additional funds secured by PIs Dick, Fisk and Ferguson.

As of September 30, 2011, co-PI Terry Dick has a total of $74,586 unspent money, almost all of it is in the Salaries and Benefits section. PI Fisk is overspent by approximately $12,000, almost all of this is in Salaries and Benefits. With anticipated hiring of technical staff by Fisk, to finish analytical work for 2010 and 2011, Fisk's budget deficit will grow to $27,000.

We are requesting that Dick's unspent $74,586 be transferred to Fisk's budget, to cover his $27,000 short fall, with remaining money to be carried forward to 2012 as discussed above.

Deviations from Budgets

1) Salaries and Benefits: This section was under-spent a total of $69,768 (31.8%), with the approved reprofiling of $23,400 for Vagle student salary to Fisk equipment (*see below*).

a) Students: A total of $37,835 will be unspent for students in this project, which is a 42.4% reduction in projected costs. This was due in large part to co-PI Svein Vagle, who under-spent by $23,400 (so this section was only under-spent by $14,435). Originally, Vagle was to have 2 graduate students in 2011, but PhD Bedard did not start until May and the second student has not been recruited. These extra funds were converted to materials and supplies and were approved by OTN SAC through a reprofiling request in June. The remaining un-spent money is related to co-PI Dick, MSc Dave Ovargaard left the

project in early 2011 and co-PI Dick secured additional funding from the Kenneth Molson Foundation for MSc Jordan Matley.

The reduction of funds for HQP support in year 2 did not reduce the Arctic-OTN commitment to NSERC for the training of HQP. Arctic-OTN is meeting its HQP obligations, having already filled more than half the HQP that are to be supported by NSERC funds, even though the project is only 2 years into its 6 year term.

Former co-PI Dick (to leave OTN end of 2011), has requested $5,000 for MSc Jordan Matley, this has been included in the 2011 budget.

b) Postdoctoral Fellows: This section was overspent by $12,000 (26.7%) and this was due to benefits paid by Fisk to PDFs Hussey (fully supported by OTN) and to McKinney (salary covered by NSERC PDF award).

c) Technicians: This section was under-spent by $36,271 (80.6%). This technician was to be employed by co-PI Dick but was not hired. Some of this funds have been requested by co-PI Fisk for November and December to support laboratory technicians to work on samples for co-PIs Fisk, Dick and Ferguson and for a technician to prepare equipment in Pangnirtung for the winter.

d) Other: This section was under-spent by $7,662 (19.1%). These funds were to be use to hire local hunters and fisherman in the Arctic, and this section was under-spent by co-PI Terry Dick. This was mainly because the in 2011 the project moved from Allan Bay to Maxwell Bay, which is a much greater distance from the community of Resolute Bay and made hiring local fisherman to work untenable.

3) Materials and Supplies: This section appears to be overspent by $21,331, but with the approved re-profiling of Vagle student to Fisk Materials of $23,400, this section is within 12% of that budgeted for 2011.

4) Travel: This section is overspent by $25,419 (29.8%) and is due mainly to co-PI Dick, who had supported additional travel to Resolute Bay (e.g., OTN technician). As well, flight costs to Resolute were $2,000-$2,500 higher than budgeted which explains this over-spending.

Year 3 (2012)

a) Using the same excel form provided, indicate your approved year 3 and any revisions to that original budget that you are proposing for year 3, noting that it must sum to ≤ the original total.

Year 3 (2012)	Original	Revised	Carry Over Requested
1) Salaries and Benefits			
a) Students	120,300	86,100	
b) Postdoctoral Fellows	45,000	110,000	32,880
c) Technical/Professional Assistants	45,000	15,000	0
d) Other (specify)	22,000	21,200	0
2) Equipment or Facility			
a) Purchase or Rental	10,675	13,125	15,373
b) Operation and Maintenance Costs	24,040	24,040	0
c) User Fees	0	0	0
3) Material and Supplies	17,500	18,500	0
4) Travel			
a) Conferences	4,000	4,000	0
b) Field Work	63,684	63,684	0
c) Collaboration/Consultation	0	0	0
5) Dissemination Costs			
a) Publication Costs	2,000	1,000	0
b) Other Activities	3,450	1,000	0
6) Other (specify)			
a)	0	0	0
b)	0	0	0
Total expenditures	**357,649**	**357,649**	**48,253**

The total budget for the Arctic Arena has remained the same as originally proposed ($357,649). The amounts distributed to each of the major categories (e.g., Salaries) has remained the same for **Salaries and Benefits ($232,300)** and **Travel ($67,684)** but we have made small changes (total amount moved is $3,450) to the amounts of money for **Equipment and Facility (Original: $34,715; Revised: $37,165; a**

7.1% increase), **Materials and Supplies (Original: $17,500; Revised: $18,500; a 5.7% increase**) and **Dissemination Costs (Original: $5,450; Revised: $2,000; a 55% decrease**).

Within the **Salaries and Benefits** section there has been a significant change in the distribution of funds to the various subsections. These changes are documented in the following table:

	Original Budget	Revised Budget	% change
a) Students	$120,300	$86,100	28.4 decrease
b) PDFs	$45,000	$110,000	144.4 increase
c) Tech/ prod assist	$45,000	$15,000	66.7 decrease
d) Other	$22,000	$21,200	3.6 decrease

IMPORTANT: Due to the resignation of Terry Dick from the OTN project there has been a major change in the distribution of funds to the remaining PIs (Fisk, Vagle and Ferguson), these changes are documented in the following table:

PIs	Original Budget	Revised Budget
Dick	$215,640	$0
Fisk	$93,109	$281,649
Vagle	$48,900	$56,000
Ferguson	0	$20,000

b) Provide a detailed justification for your year 3 budget. You may use your original justification (just as submitted in the proposal) and state that it remains on track if that is the case. For budget items that you are proposing to change, you must give a clear explanation/justification of why; these proposed changes must be approved by the SAC.

Salaries and Benefits

Major changes to the structure of **Salaries and Benefits** section of the Arctic Arena budget are due in large part to the resignation of Arctic Arena lead-PI Terry Dick from OTN. It should be stressed that all proposed projects and objectives for the Arctic Arena are moving forward as planned but a redistribution of responsibilities and leadership to the other PIs is necessary. Originally 5 PhD, 1 MSc, 1 PDF and 1 technician were to be supported by the Arctic OTN budget, under the new budget 3 PhD, 4 MSc, 3 PDF and 1 technician will be supported. This net gain of 2 HQP has been accomplished by additional funding secured by PI Fisk (Molson Foundation and CRC) and former PI Dick (Molson Foundation) and by partnerships with DFO (Ross Tallman) to co-support a PDF.

A total of $34,200 was moved from the **Students** to the **Postdoctoral** sub-section. This is a net loss of 2 PhD for year 3 but will partially support a PDF (Steve Kessel will begin January 1, 2011 at the University of Windsor). These two PhD would have been based at the University of Manitoba under former PI

Dick and would have worked on arctic cod and predators in the Resolute Bay area. Given the complexities of working in this area, and the new responsibilities of PI Fisk, it is felt that hiring a PDF is the best option to lead this project, as problems with setting up in a new area could jeopardize a PhD dissertation. As well, we are seeking 2 MSc to work in the Resolute Area (oceanography and arctic cod) and a PhD to work on Arctic charr to begin in May 2012.

A total of $65,000 was moved to the **Postdoctoral fellows** from **Students ($34,200)** and **Technician ($30,800)** subsections. These funds will support three PDFs (Nigel Hussey 100%; Steve Kessel 100%; Jonathon Moore 40% with additional funds from DFO). Given the set back by the resignation of PI Dick, it was decided that a dedicated PDF to work in the Resolute area was a better option than hiring a technician (one had not been identified or hired as of Oct 2011 by former PI Dick), as they could take a more scientifically-experienced role in leading the research. The third PDF (Moore) will be partially supported by DFO and will focus on the Arctic charr project. This project will be based in Cumberland Sound, Cambridge Bay and Resolute, and the decision to fund this PDF was due to the logistical issue of working at multiple locations in the arctic. PDF Moore's PhD research was focused on Arctic charr in the Arctic, and has the experience and skill set to get this project started. A PhD will be recruited to work on this project with the PDF.

A total of $30,000 was moved from **Technician ($30,800)** to the **Postdoctoral** subsection. The rationale for the movement of these funds is given above.

Equipment and Facility

A minor amount of funds ($2,450) was moved from the Dissemination Costs to the Equipment and Facility sections, all of these funds were added to the **Purchase or rental** subsection. These funds were original going to be used to develop posters for Hunters and Trappers Associations but the number of communities we are working in now has been reduced and thus subsection is overfunded. The money will be used to purchase additional oceanographic equipment to support increased activities in Resolute. No changes to the **Operation and maintenance costs** subsection were made.

Materials and Supplies

A minor amount of funds ($1,000) was moved from the Dissemination Costs to the **Materials and Supplies** section. These funds were original going to be used to develop posters for Hunters and Trappers Associations but the number of communities we are working in now has been reduced and thus subsection is overfunded. The money will be used to purchase additional supplies to support increased activities in Resolute.

Dissemination Costs

The **other** subsection of **Dissemination costs** was reduced by $2,450. These funds were originally going to be used to develop posters for Hunters and Trappers Associations but the number of communities we are working in now has been reduced and thus subsection is overfunded.

Pacific Arena III.1-2

1. Project Number: Pacific Arena Projects III.1 and III.2

2. Project Title:

III.1 Characterizing oceanographic conditions for out-migrating juvenile and returning adult salmon
III.2 Biology, behaviour and physiology of migrating adult and juvenile Pacific salmon

3. Project Leader(s):

III.1 Rick Thomson (DFO, UBC), Scott Hinch (UBC), Steve Cooke (Carleton)
III.2 Scott Hinch (UBC), Steve Cooke (Carleton), Tony Farrell (UBC), Kristi Miller (DFO, UBC), Rick Thomson (DFO, UBC)

Collaborator(s):
III.1 Dave Patterson (DFO)
III.2 Dave Patterson (DFO), Merran Hague (DFO, PSC), Mike Lapointe (PSC), Dave Welch (Kintama), Brian Riddell (PSF), Karl English (LGL), Mark Shrimpton (UNBC)

4. Training of Highly Qualified Personnel:

a) List of the HQP and level of their salary support by SNG.

Personnel	*Title*	*%Time involved in project*	*% supported from SNG*	*Additional stipend support provided by*	*Dates*
Tim Clark	RA	100	100		1 Jan-30 Sep 2010
Erin Rechisky	PDF	10	0	Kintama Ltd.	1 Jan-30 Dec 2010
Eduardo Martins	PDF	10	0	CHIF/NSERC HydroNet	1 Jan-30 Dec 2010
Erika Eliason	PDF	100	100		1 Sep-30 Dec 2010
Matt Drenner	PhD	100	25	UBC PhD Recruitment Fellowship	1 Jan-30 Dec 2010
Graham Raby	PhD	100	0	NSERC PGSD	1 Jan-30 Dec 2010
Nolan Bett	PhD	100	0	NSERC PGSD	1 Aug-30 Oct 2010
Matt Casselman	MSc	5	5		1 May–30 Jun2010
Natalie Sopinka	PhD	5	0	NSERC PGSD	1 Sep-30 Sept 2010

Alison Collins	MSc	100	100		1 Jan–30 Dec 2010
Vivian Nguyen	MSc	100	0	OGS	1 Jan-30 Dec 2010
Kendra Robinson	MSc	100	0	NSERC PGSM	1 May-30 Dec 2010
Sam Wilson	MSc	100	10	NSERC PGSM	1 May-30 Dec 2010
Sarah LaRocque	MSc	10	0	OGS	1 Sep-15 Oct 2010
Charlotte Whitney	MSc	10	10		1 July-30 Sep 2010
Marika Gale	MSc	20	20		1 Nov-30 Dec 2010
Jeff Nitychoruk	undergrad	100	0	NSERC Hydronet / Ont. Summer Jobs Program	1 Jun-30 Aug 2010
Michael Lawrence	undergrad	100	50	NSERC USRA	1 May-30 Dec 2010
Sylvia Chow	undergrad	5	0	volunteer	1 Sep-30 Dec 2010
Andrew Lotto	technician	50	30	NSERC Strategic	1 Jan-30 Dec 2010
Darcy McKay	technician	25	0	NSERC Strategic	1 Jan-30 Sep 2010
Vanessa Ives	technician	25	0	NSERC Strategic	1 Jan-30 Mar 2010
Jessica Carter	technician	25	0	NSERC Strategic	1 Jan-30 Aug 2010
Taylor Nettles	technician	25	25	NSERC Strategic	1 Jan-30 Dec 2010

b) Explain the role, activities and opportunities for training of technical staff in your project.

Research on Pacific salmon requires significant interaction with stakeholders, use of specialized equipment, performing laboratory assays and analyses, and working in environments (e.g., on research vessels) that are inherently dangerous and require extensive training. As such, we have a team of technical staff that are essential to project success and play an important role in training of HQP. Our technical staff includes highly competent individuals who deal with aspects of site reconnaissance, biosecurity, field equipment maintenance and operation, vessel/vehicle fleet maintenance and operation, field camp logistics, technical operations of data collection, and most importantly mentoring of students in the field and lab. Our work requires extensive interaction with stakeholders (e.g. First Nations groups, fisher groups, ENGOs) which requires relationship building, consistency, and mutual respect. Relying solely on graduate students for stakeholder engagement is not consistent with the need to maintain long-term relationships. Moreover, technical staff plays critical roles in safety training and monitoring, ensuring that research activity is in compliance with university and government (provincial and federal) policies. Our technical staff serves a critical role as conduits of information from the public and other stakeholder groups to the investigators in our research program. Our technical staff is able to enhance their knowledge and further develop their abilities and skills through participating in workshops, local conferences, and meetings with partner and collaborator groups.

5. Progress towards Objectives/Milestones (1 Jan 2010 – 30 Sep 2010)

a) Please provide brief description of the overall objectives of this project (max ½ page).

Project III.1)

i) Characterize the upper ocean physical, chemical and biological environments encountered by juvenile and adult salmonids in coastal areas to order explore interannual variability in these environments, and obtain data for use in Project III.2 in order to relate ocean conditions to that of fish behavior, physiology, or survival.

Project III.2)

i) Examine how environmental and anthropogenic conditions experienced by migrating adult salmon *en route* to natal rivers during the coastal approach and estuarine transition zones varies among individuals depending on population of origin and physiological state.

ii) Examine how environmental, physiological and anthropogenic conditions influence adult salmon survival to the natal rivers and spawning grounds.

iii) Examine the effects of different types of acoustic transmitters and fish sizes on sustained swim speeds, metabolic rate, feeding, and survival in smolting sockeye salmon in both freshwater and saltwater.

iv) Examine speed of outmigration, and location and level of mortality in freshwater and coastal areas, for individual sockeye salmon smolts.

b) Describe progress towards meeting the project's objectives and specific milestones for the project.

Project III.1)

i) Rick Thomson (DFO) and his colleagues from the Institute of Ocean Sciences continue to conduct four oceanic surveys per year in the Salish Sea region from the entrance to Juan de Fuca Strait to the northern Strait of Georgia using the DFO vessel 'Vector'. These seasonal CTD/rosette surveys include profiles of salinity, temperature, chl a, light attenuation, density, and nutrients (P, Si, NO3). The four cruises are meant to define the seasonal cycle and long term trends. These long-term data will be used to link with multi-year tagging data we are now collecting on salmon smolt migration rates and survival through the Salish Sea (future graduate student). Thomson and colleagues continue to collect and process CTD profile data around 10 times per month in the Nanoose Torpedo Test range by the US and Canadian Navies. They continue to maintain current meter moorings to measure currents in the northern Strait of Georgia, including a long term current, water property and sediment flux measurements from site SOGN (approx. 10 nm south of Cape Mudge) and DPN (in Discovery Passage). Roy Hourston and Maxim Krassovski (DFO technicians with R. Thomson) have been developing models

using the hourly data from the northern current meters and from the met buoys in the Strait of Georgia to predict abundance and return timing of adult sockeye salmon.

Matt Drenner (PhD student) assisted by Charlotte Whitney and Sam Wilson (MSc students) collected CTD data from throughout the southern Strait of Georgia during August and September 2011 in conjunction with telemetry tracking of adult sockeye salmon. CTD casts were made in areas where sockeye were migrating and in areas they were not migrating to assess environmental characteristics preferred by salmon migrants. Sea surface temperature collected from meteorological buoys, sea surface salinity from coastal light-stations, tidal details, and daily volume discharge from the Fraser River will complement the CTD cast data. Additional temperature and salinity data are being provided by the VENUS observatory situated at the Fraser River mouth, and also Environment Canada buoys situated throughout the lower Fraser River.

Project III.2)

i) In August and September 2011, 64 adult Fraser River sockeye salmon were captured in coastal areas during their homeward migration and implanted gastrically with either radio transmitters (20) or depth/temperature sensing acoustic transmitters (40) (PhD Drenner, MSc Whitney, MSc Wilson, undergrad Lawrence; technicians Lotto, McKay, Thompson). Fish were tissue biopsied and plasma sampled prior to release for assessment of physiological condition. The acoustic transmitters were programmed for rapid (3 sec continuous) transmission for 4-8 hours so individual fish could be tracked by boat and their depth, temperature and salinity experience recorded based on tag and CTD information (from Project III.1). Sentinel acoustic receivers (operated by Kintama Ltd. and LGL Ltd) situated throughout the lower Fraser River were used to collect data on river entry timing, migration rates and lower river survival. Sentinel radio receivers (LGL Ltd) were also situated throughout the Fraser River watershed to assess speeds and fate of fish to certain spawning grounds for fish carrying radio transmitters. Field work has been completed. DNA analyses to assess stock composition and physiological analyses of tissues will be completed during winter 2012 (technicians Nettles, Hill, McKay, Thompson, Li). Downloading of the radio receivers is complete but downloading of the acoustic receivers will not occur until spring 2012 due to budget limitations of one of our partner groups (Kintama Ltd.) which owns and operates the lower Fraser acoustic line.

ii) In August 2011, radio tags were applied to 70 summer-run adult sockeye in the lower Fraser River estuary transition area (PhD Raby, MSc. Nguyen, undergraduate Nitychoruk, technicians Lotto, McKay, Hill, Thompson). Fish were captured by volunteer anglers and were either tagged and released immediately, tagged then air exposed for one minute prior to release, or tagged then air exposed for one minute then held in fast flowing water in an attempt to accelerate recovery prior to release. All fish had a DNA sample taken. Prior to release, all fish had a rapid reflex assessment made ('RAMP' method), an index of physiological impairment rather than taking a plasma sample. In September 2011,

radio tags were applied to 80 adult coho salmon in the lower Fraser River estuary transition area (PhD Raby, MSc Nguyen, MSc LaRocque, technician Lotto). Coho salmon were captured as by-catch in First Nations economic opportunity seine fisheries for pink salmon. Half of the tagged fish were immediately released and half were held in mesh flow through recovery bags for 30 minutes prior to release. RAMP was conducted on all tagged fish and 50 additional fish that were not tagged. DNA sample was taken on all fish. We attempted to capture and tag coho in the Strait of Georgia prior to them reaching the estuarine transition area via an angling charter vessel but were unsuccessful. In September 2011, radio tags were applied to 200 Late-run sockeye salmon in the Harrison River which is just upstream of the estuary transition area but still affected by the marine environment – there are large numbers of harbor seals that reside in the Harrison River and are the dominant predators on migrating salmon (MSc Robinson, MSc Wilson, PhD Bett, undergraduate Lawrence, technician Lotto). Fish were captured by First Nations beach seining (partner Chehalis First Nations) and then either immediately tagged and released, additionally stressed by swimming to exhaustion in a swim chamber and air exposed for one minute then tagged and released, or stressed as just described then held in fast flowing water in an attempt to accelerate recovery prior to release. Plasma samples were taken on all fish. The fate and survival of the tagged sockeye and coho in all studies to spawning areas was assessed with a telemetry array (set up in partnership with the Pacific Salmon Foundation and LGL Ltd). Field work is complete and telemetry data have been retrieved for all studies except the Harrison study which is still on-going. DNA and plasma analyses are all pending (technicians Nettles, Hill, McKay, Thompson, Li). The results of all these studies will help elucidate how different fishing handling and release strategies in environmental transition zones influence salmon behaviour and survival. In conjunction with the tagging studies, First Nations fishers (~ 100) were interviewed while they were fishing, using social science survey methods, to gain an understanding of how they view telemetry research, how they feel it should be used to help them manage their fisheries resource and the threats and opportunities they face in regards to their fisheries (MSc Nguyen, PhD Sopinka). All surveys have been completed.

We continue to collaborate with electronic engineers in utilizing a novel miniaturized data logger that records heart rate, swim speed, depth and temperature. Loggers are surgically implanted and must be recovered in order to access data (RA Clark, PhD Raby, Technician Lotto). In November 2011, we will implant 100 loggers into adult coho salmon that are being held at the DFO Cultus Lake Field Laboratory in the Fraser Valley. Fish with loggers will be exposed experimentally in large tanks to different techniques of beach seine capture (e.g. varying water depth of capture and time of capture in net) at different temperatures. The purpose is to better understand the physiological responses of salmon to capture technique and use that information to inform management on best fishing practices. Field work will be complete by the end of November.

In August 2011, we conducted a pilot study in the Strait of Georgia testing a newly designed VEMCO V9 accelerometer transmitter (n = 4) to determine if it were possible to individually track adult sockeye

salmon carrying these for significant periods of time (MSc Wilson; PhD Drenner; MSc Whitney). We were able to obtain some data on swim speeds and fish depth but signal strength was weak and we were not able to track fish for more than 1 hour. We have determined that a modified version of this tag (a V13 design) would be optimal for future work. We plan on conducting a large study next year in coastal and estuary transition areas individually tracking large numbers of adult salmon with V13 accelerometers in order to develop bioenergetics models of salmon migration. In preparation, calibrations need to be developed this year between accelerometry outputs (x, y, and z movement data from the transmitters) and swim speed and oxygen use. In October 2011, we captured and moved 40 adult sockeye to the DFO Cultus Lake Field Laboratory in the Fraser Valley. Individual fish are being gastrically implanted with accelerometer transmitters and put through standard respirometry trials which occur at different temperatures and involve cannulated plasma assessments of metabolites (PDF Eliason; MSc Wilson). Field work will be completed by November 2011.

iii) Given that tagging of animals is central to the OTN Canada program, there is clearly a need for both a synthesis of existing data as well as the generation of new data to ensure that the welfare status of tagged fish is maintained and that data from tagged fish are representative of untagged conspecifics. We continue to assess 'handling effects' to develop 'best practices' in terms of sizes of transmitters that can be used in field telemetry studies on juvenile salmon. Specifically, we need to know how to minimize effects of tag size on behaviour and survival, and in particular to assess new tag sizes recently brought onto the commercial market. Moreover, there are few tagging effects studies on sockeye salmon, our focal species, and none that assess tag burden influences on fish that are transitioned from freshwater to saltwater.

In 2011, we completed several relevant handling effects and review studies, one a global literature review examining how telemetry has been used to study marine migrating salmonids – this review has been accepted with revisions into PloS-1 (PhD Drenner, RA Clark, MSc Whitney, PDF Martins, Hinch and Cooke). Collins (MSc) completed a literature review as part of her thesis examining tag burden effects on juvenile salmonids. She also completed her thesis experiments wherein she assessed the effects of tag burden level and tag type (i.e. VEMCO V9, V7 and V6 designs) on swim performance, growth and survival of juvenile hatchery raised Cultus Lake sockeye salmon in freshwater and saltwater (manuscript submitted to TAFS), and effects of tag presence on standard metabolic rate. Tim Clark (RA) assessed effects of tag burden on survival of two-year old wild Chilko sockeye smolts, in 2010 and 2011, in field tanks, then transported them 650km to our lab and assessed survival after transitioning fish to saltwater tanks to represent fish entering ocean environments. All field and lab data have been collected and studies are either completed or being written up.

In November 2011, we will begin a tagging effects study in the lab using the new VEMCO V5 tag, their smallest, which enables for the first time 1 year old sockeye smolts to be tagged. As with studies using

the larger tags, we will assess the effects of specific tag burdens on individual growth, swim performance and survival (PDF Eliason, MSc Gale).

iv) In spring 2011, ~640 2-yr old juvenile sockeye salmon were captured as they initiated their smolt outmigration from Chilko Lake, a population situated 750 km inland from the ocean and is the highest elevation rearing lake for sockeye salmon in Canada.
Fish were surgically implanted with acoustic transmitters (RA Clark; PDF Rechisky; MSc Casselman, undergraduate Lawrence, technician Lotto). Sentinel acoustic receivers situated near the release site and in the lower Fraser River, and acoustic curtains associated with POST were used to determine travel rates, and locales and levels of mortality. Preliminary results indicate that smolts travelled at ~ 1-2 km/h during the initial sections of their migration through turbulent and clear water environments, and final sections, which were turbid and tidally influenced, of the freshwater migration. But they travelled ~ 5 km/h through the expansive fast flowing sections in between. Diel patterns were evident. Fish reached the ocean in 5-17 days. Survivorship from Chilko Lake to the Fraser River mouth of V7 lake released, V7 transport control, and V6 lake released smolts was similar (32%, 36%, 36%, respectively). Survivorship of V7 tagged smolts from release 80 km downstream of Chilko Lake (where the river becomes turbid) to the Fraser River mouth was higher than all other groups (55%) indicating that bypassing the first 80 km of the Chilko River boosted survival to the river mouth by ~70%. Subsequent marine survival through the Strait of Georgia to the northern end of Vancouver Island (to the Queen Charlotte Strait POST acoustic line) is estimated at 5-7% for the three release groups which is higher than in 2010 when survival was ~3%. Despite the transported smolts (those moved downstream of the clear water into the turbid areas) largely maintaining their initial freshwater survival advantage of 70%, ocean mortality wiped out the numerical benefit (4.7% vs. 6.7% of smolts survived to reach northern Vancouver Island, a 42% difference). Most smolts migrated north through the Strait of Georgia/Johnstone Strait route along the east coast of Vancouver Island. All data have been downloaded except those from the Northern Strait of Georgia Line (situated halfway between the mouth of the Fraser River and Queen Charlotte Strait line). This line belongs to POST and financial difficulties are preventing data downloads, and until data are in hand, we cannot fully assess marine survival or travel rates, nor can we complete the manuscript that summarizes two years of smolt telemetry. Potential solutions to this issue are discussed below.

c) Describe and justify any significant deviations from the original objectives or plans, including any revised goals, new projects, or deleted projects.

The original broad objectives, after being modified and approved last year, and described in the 2010 report, remain intact. We have expanded some of our current and planned telemetry projects on adult salmon to include assessing how different types of fishing practices influences survival and behaviour. This is a logical expansion given that assessing investigator 'handling' and 'tagging' effects is a large

component of all of our studies, and we acquire all of our fish to be telemetry tagged from various fisheries so having a more rigorous assessment of how these sampling platforms affects our telemetry results is important. Also, this expansion provides better linkages with DFO fisheries management, and with several stakeholder user groups (e.g. fishing and ENGO groups) who have partnered with us in these studies.

d) *Describe how the work of the project's co-investigators and collaborators was coordinated and integrated*.

Several face-to-face meetings, conference calls, Skype and email virtual meetings were held over the past year for purposes of integration, planning, logistics, and coordination among Pacific Arena researchers.

- Jan. 27, 2011 – meeting at UBC to review smolt tagging study results and plan for field season (Hinch, Clark, Collins, Welch)
- Feb. 9, 2011 – meeting at UBC to review adult salmon river tagging study results and plan for field season (Hinch, Cooke, Robinson)
- Feb 10, 2011 – OTNC Pacific Arena investigator and collaborator annual meeting (Hinch, Cooke, Farrell, Miller, Thomson, Patterson, Riddell, and several other collaborators, all OTNC Pacific graduate students, PDFS, technicians) – held in conjunction with 'Workshop on Salmon Migrations, Climate Change, and Capture/Release Fisheries', University of British Columbia, Vancouver, BC, Canada
- Apr. 13, 2011 – meeting at UBC to review adult salmon ocean tagging study results and plan for field season (Hinch, Farrell, Miller, Thomson, Drenner)
- May 10, 2011 – meeting at UBC to review adult salmon river tagging study results and plan for field season (Hinch, Farrell, Miller)
- June 1, 2011 – meeting in Halifax (in conjunction with 1st OTN Symposium) among OTNC Pacific investigators (Hinch, Cooke, Clark, Drenner, Collins, Wilson, Murchie)
- June 14, 2011 – meeting in Sapporo (in conjunction with 1st Intl. Fish. Tel. Conf.) among OTNC investigators and collaborators discussing issues involving field studies, receiver lines, budgets (Hinch, Cooke, Whoriskey, Welch, Murchie)
- June, 20, 2011 – meeting at UBC to discuss planning of adult salmon river tagging studies (Hinch, Cooke, Lotto, Robinson, Drenner)
- July 26, 2011 – meeting at UBC to discuss planning of adult salmon ocean tagging study (Hinch, Crossin, Lotto, Wilson, Drenner)
- Sept. 4, 2011 - meeting in Seattle (in conjunction with AFS) with OTNC Pacific investigators to discuss issues involving field studies, receiver lines, and budgets of adult salmon ocean tagging studies (Hinch, Cooke, Miller, Patterson, Welch)

- Monthly conference calls with project leaders and collaborators occurred (which included personnel from UBC, Carleton, the Pacific Salmon Foundation, the Pacific Salmon Commission, Fisheries and Oceans Canada (Nanaimo and Vancouver), Kintama Research, and LGL Ltd).
- Project leaders and collaborators were in frequent (weekly) contact on a multitude of issues via conference calls, email and Skype.

e) Describe the benefits of conducting this research as part of a network rather than as a separate project (e.g., scope of the research, cross disciplinary collaborations, new synergies and research opportunities, access to ship time, planning and coordination of research activities, exchange of information and data, benefits to students and technical staff).

The Pacific arena research program could not occur without a network of investigators which span several academic institutions (UBC, Carleton, and UNBC), government groups (Pacific Salmon Commission, DFO Science Branch), non-government environmental groups (Pacific Salmon Foundation, Canadian Wildlife Federation, and Vancouver Aquarium-POST) and private company partners (Kintama, LGL). OTNC funds facilitated and provided a level of funding that allowed these groups to come together to work on integrated applied fisheries science research with a large scope. Collaborations span several disciplines including: behavioural ecology, physiology, genomics, epidemiology, oceanography, electronic engineering, and fisheries harvest management – and such collaborations could not occur without the OTNC research funds and framework. Several new research opportunities have emerged using OTNC funds as leverage for example: studies examining smolt outmigration from Chilko Lake became possible when the Pacific Salmon Foundation and Kintama partnered with the Pacific OTNC investigators; the development and testing of inexpensive physiological biologgers became possible when the Canadian Wildlife Federation partnered with OTNC investigators; the assessment of fisheries handling impacts on adult salmon became possible when LGL, the Pacific Salmon Foundation, and DFO Fisheries Management partnered with OTNC investigators. Without our network, data and information exchange and research coordination would be nearly impossible. OTNC Pacific partners (i.e. POST, Kintama, and LGL) collate and coordinate much of the telemetry data that is collected and provide it in a timely and 'researcher friendly' means to OTNC investigators. LGL, Kintama and DFO Science Branch have taken lead roles in helping to coordinate some of the research activities and logistics that otherwise would overwhelm OTNC academic investigators. The benefits to students and technical staff cannot be understated – OTNC students and technicians are 'embedded' with partner groups in conducting research (e.g. our graduate students train in the field alongside LGL, Kintama and DFO investigators, and they write research papers with them, which facilitates training and has opened doors for subsequent employment). Lastly, without a network approach, the social science research we are conducting (fisher surveys) would be difficult to undertake and impossible for our results to be extended and widely disseminated to the appropriate stakeholder groups.

f) Describe the scientific and/or engineering significance of the results to date.

Results from the studies which correlate oceanographic conditions to adult salmon migration timing have found that river entry timing in Late-run Fraser sockeye is correlated with ocean wind stress and coastal salinity variables experienced by adult fish during their homeward migrations, though in a population-specific manner. Fisheries managers need to predict the likelihood and scale of pre-mature river entry migration by Late-run sockeye (a phenomenon persisting since 1996) because early migrants perish at high levels during the river migration including populations that are listed as endangered. With enough advance information, coastal and in-river harvest rates can be adjusted, 'in-season', to help compensate for potential high river mortality and thereby help DFO meet spawning ground escapement objectives. Thus, these oceanographic-salmon behaviour relationships have direct and important management applications.

Results from the coastal ocean tracking projects have yielded several novel findings to date. Adult sockeye that are milling in the Strait of Georgia spend most of their time in deeper cool water (~ 11-12 C) rather than the much warmer surface, nonetheless migrants occasionally are at surface where water approaches 20 C. Deeper areas are more saline and have low dissolved oxygen (4-5 mg/l) which can be stressful suggesting that physiological benefits of seeking cool water may trump physiological costs of oxygen stress. Moreover, we observed significant levels of seal predation which could also help explain why fish prefer deeper areas. We noted considerable inter-individual variability in thermal experience during the coastal migration and have found that individuals with relatively high variability in thermal experience (e.g. those that undertook high levels of vertical 'sounding' during their migration) had much higher plasma potassium at capture/release indicative of exercise stress.

We have been successful at capturing and tagging adult salmon in the ocean using troll, purse seine, and angling fisheries approaches which means it is possible to compare various marine fishing gear types and handling approaches - an area of research which we had proposed for future years and is in need of critical assessment. We also confirmed the feasibility of tracking adult salmon with accelerometer tags which will lead to a large project in 2012.

The tagging studies in the estuary transition areas have only began recently and early results indicate that adult salmon which are released after capture have reduced survival to reach spawning regions (or spawning times) when temperatures are warm and handling has been lengthy.

Results from the adult biologger studies have been groundbreaking in that they have demonstrated that: adult sockeye salmon receive a large energetic benefit from selecting thermal refugia during migration, their heart rates while stationary on spawning grounds are elevated to levels similar to that during migration through rapids (which may contribute to pre-spawning mortality), and, hearts actually

stop during the act of reproduction (the first time this has ever been observed in North American salmon). Overall, the biologgers have worked better than expected in our field trials and we are now using them to experimentally examine fishery handling effects in coho salmon.

We have begun to identify critical tag burdens (and size limits) that can start to inform 'best practice' procedures for tagging juvenile salmon, and we will incorporate these results into future juvenile tagging studies. It appears that 6-8% tag burden may represent an upper limit for juvenile sockeye salmon.

We have begun to identify key locales associated with juvenile salmon mortality during outmigration. Ours is the first telemetry study ever on wild juvenile sockeye. We recorded significant mortality of Chilko Lake sockeye smolts within the first 100 km (of their 600 km freshwater migration) likely as a result of predation. Tagged fish that we relocated from rearing areas past this section had a 70% higher survival to the ocean – fisheries managers could consider trapping, trucking and releasing smolts, as we did, as a simple means of increasing numbers of fish reaching the ocean. We also have identified areas along the coast where mortality was significant.

6. Difficulties encountered

a) Identify the main difficulties encountered in carrying out the research during the reporting period from the list below:

- ❑ Scientific problems/difficulties
- **X** Equipment and technology issues (e.g., delivery and malfunctioning of equipment)
- ❑ Personnel problems
- **X** Involvement of partners
- **X** Other (specify): ____direct collaboration with VENUS_____
- ❑ No problems occurred during this instalment of the grant

b) For each checked box, describe the difficulties identified above and the steps taken to resolve them.

i) *Equipment and technology issues:* We discovered a problem during our study this summer wherein individual adult salmon were tracked in coastal areas with V16-TP tags programmed for 3 second continuous transmissions for 4 hrs. It appears that the frequency and, most importantly, the rate of transmission we selected attracted harbor seals to our fish and several of our fish were predated upon shortly after they were tagged. We found that by tagging and releasing fish into a large school significantly reduced the likelihood of predation. Once this issue became apparent, we rapidly designed an experiment to confirm this predator-attraction hypothesis by releasing radio tagged fish and

acoustic tags with random and much longer transmission intervals at the same time as the rapid transmission tags and will compare relative survival rates to enter the river. Results of this are pending but this issue should serve as a wake-up call to researchers in all arenas to make sure their tagging technology is not affecting typical predator-prey interactions.

ii) Involvement of partners: One of our partners, Kintama Ltd, owns and maintains an array of VR2 receivers in the lower Fraser River - this 'Fraser River array' is a key array used by all OTNC Pacific investigators. As a result of a miscommunication, Kintama retrieved their receivers prematurely (so we could access the juvenile salmon data) however we needed those receivers in place for two more months in order to collect data on migrating returning adult salmon. They had no funds to re-deploy. OTNC Pacific investigators were able to find funds to rapidly redeploy the array but neither Kintama, other partners, or OTNC Pacific investigators have funds available to now retrieve the receivers, thus adult salmon data from that array are still not available. We are cautiously optimistic that other partners or OTNC investigators will find funds to assist in recovery by next spring.

We have another problem associated with funding and downloading of receiver lines. One of our partners POST (the Pacific Ocean Shelf Tracking project, administered through the Vancouver Aquarium) is experiencing significant financial problems. Until last year, their funding was largely from private endowments which had sunset clauses. For some time they have tried to negotiate with NOAA and DFO to assume financial leadership in maintaining the current infrastructure. Both agencies provided some funds to tide POST over through to the end of the current fiscal year (and hopefully beyond). Because of their age, all of the POST receivers needed to be retrieved this year for re-battering. Most POST lines have been retrieved, data downloaded, and receivers re-deployed. Batteries in these VR3 receivers should now last for 5 years. However due to additional costs with receiver retrievals, and their current poor budget situation they were not able to download the Northern Strait of Georgia (NSOG) acoustic line which contains critical data from our out-migrating smolts. The NSOG line is comprised of VR2s which were going to be replaced with VR3s. The earliest they may be able to retrieve and replace the line is early spring of next year although there are no funds available for that yet – though the 'hope' is that some funds can be found if DFO steps up to help with ongoing expenditures in next year fiscal. The executive director of the Vancouver Aquarium has recently discussed this issue with a DFO ADM.

Given that there are OTNC data on the NSOG line at present, that the batteries are near end of life, that there are no funds within POST to retrieve the receivers, and this line is of critical importance for OTNC long-term research, the Pacific OTNC investigators proposed a solution that has been favorably received by POST and approved by Fred Whoriskey (OTN CFI Director). OTNC will partner with POST to maintain the NSOG line. The Pacific Arena will donate VR4 receivers (~8, interspersed amongst 16 VR3s that POST owns and will deploy) to POST to create a newly refurbished NSOG line (to be renamed the

'Vancouver – Northern Strait of Georgia' (V-NSOG) line) that would replace the current line of 24 VR2s. OTN Pacific has a small receiver maintenance budget that will assist with deployment and annual data downloading of this refurbished 'partner' line. Thus, we should be able to shortly access the NSOG data and put in place the V-NSOG acoustic line that is more sustainable economically and more relevant for future OTNC research that will involve 180 KHz transmitters (which only VR4 receivers can detect).

iii) *Collaboration with VENUS:* The Victoria Experimental Network Under the Sea (VENUS) infrastructure is a coastal cabled seafloor observing system that collects and sends to shore data by fibre optic cable. The VENUS network is run by the University of Victoria in British Columbia, Canada as part of the Ocean Networks Canada Observatory. Two networks of instruments currently reside on the sea floor, one in Saanich Inlet on the western side of the Strait of Georgia (SOG) near Sydney, BC, the other is on the eastern side of the SOG near one section of the Fraser River mouth. The latter, called the SOG site, has two study 'nodes' that collect data within an area of 100-300m on the seabed, and they collect dissolved gas and current data at one site within the node at depths.

S. Hinch (Pacific arena co-leader) and M. Drenner (PhD student) discussed possible means of physical linkages between a VENUS SOG node and OTNC equipment with Richard Dewey (VENUS Associate Director, Research) and Paul Macoun (VENUS Phase II Project Manager). The eastern SOG nodes would be in most close proximity to where OTNC salmon migrate so only that site was considered. R. Dewey was primarily interested in some sort of physical linkage if there was an acoustic receiver array around the mouth of the Fraser River in the estuary - providing a logical location for a physical link between a receiver array and the SOG node. However, the Pacific Arena OTNC will not be deploying an array in the estuary because: there are not enough funds to purchase equipment for such a long array, receivers in that location of the estuary have in the past been damaged by fisheries, and there is currently an array in position that serves a similar purpose but which is not in immediate proximity to the VENUS SOG node. Specifically, the Fraser River array is a series of sentinel VR2s (12 VR2-90s, 12 VR2-160s) situated throughout the lower Fraser River just upstream of its mouth. We discussed the possibility of attaching a single VR4 or VR2 to the SOG VENUS pod but it was determined that any data on salmon migrations retrieved from such a receiver placement would be, at best, largely the same as what would be obtained from the Fraser River array and the detection efficiency of a single or a small set of receivers around the VENUS site would be low given there are 4 arms to the Fraser River mouth stretching a distance of ~35 km along the coast and salmon use all of them during their migrations. Given the current circumstances, we do not see a scientifically sound reason to invest significant infrastructure to physically link acoustic receivers from OTNC with VENUS equipment. Nonetheless, we continue to have access to VENUS oceanographic data and plan on using it (e.g. SST, salinity, other water quality measures) as one source of information to help us in linking salmon migration speeds and survival among days or years to environmental features.

7. Networking and outreach

Discuss the extent of networking and outreach by the project, both within the OTN Canada Network and with the broader community, by co-PIs, collaborators and HQP.

Intra-Network Collaboration and Partner Meetings

Oct 2010-Oct 2011 – The Pacific OTNC team has been engaged in several activities that involve interacting with researchers, partners and stakeholders within our arena and among arenas. One of the key among-arena activities that we led was the development of a paper to a high profile fisheries journal that summarizes the objectives and players in OTNC for an international fisheries audience. Co-leader for the Pacific Arena (S. Cooke) was lead on this paper. Cooke assembled a team of OTN coauthors from across the country and led the team in the development of an interdisciplinary perspective on OTN Canada - this paper represents one of a series examining networks of research within Canada. The introductory paper to this series which briefly overviews OTNC was just published and the one with a focus just on OTNC is in press:

Hasler, C.T., G.C., Christie, J. Imhof, M. Power, and S.J. Cooke. 2011. A network approach to addressing strategic fisheries, aquaculture, and aquatic sciences issues at a national scale: an introduction to a series of case studies from Canada. Fisheries 36:250-453.

Cooke, S.J., S. J. Iverson, M. J.W. Stokesbury, S. G. Hinch, A. T. Fisk, P. Smith, D. VanderZwaag, J. Brattey and F. Whoriskey. 2011 Ocean Tracking Network Canada: A network approach to addressing critical issues in fisheries and resource management with implications for ocean governance. Fisheries. In press.

Jan 2011 – Team members M. Donaldson (PhD student) and Tim Clark (RA) were invited to the Annual Meeting of the Pacific Salmon Commission's Fraser River Panel to provide an overview of OTN-related research and management implications. The panel is comprised of federal appointees from Canada and the US (40 panel members and managers in attendance). Two 45-minute presentations were delivered with following citations:

Donaldson, M., D.A. Patterson, J. Hills, J.O. Thomas, S.J. Cooke, S.G. Hinch, G. Raby, L.A. Thompson, K.M. Miller, D. Robichaud, K. English, and A.P. Farrell. The consequences of fisheries and holding-related stressors on adult Pacific salmon physiology, behaviour, and survival. Meeting of the Fraser River Panel of the Pacific Salmon Commission. Sheraton Wall Centre, Vancouver, January 11-13, 2011.

Clark, T.D., Hinch, S.G., Lotto, A., Jeffries, K., Welch, D., Rechisky, E., Riddell, B. Movement and survival of out-migrating Chilko Lake sockeye salmon smolts. Meeting of the Fraser River Panel of the Pacific Salmon Commission. Sheraton Wall Centre, Vancouver, January 11-13, 2011.

Feb 2011 – Annual OTNC Pacific Arena Investigator meeting was held in conjunction with a large research workshop (60 attendees) at UBC. Attendees included regional fisheries managers from DFO, several DFO scientists, fisheries managers from the Pacific Salmon Commission (PSC), the Chair of the Fraser Panel of the PSC, members of NGOs (including staff from the Suzuki Foundation and the Canadian Wildlife Federation), representatives from First Nations (Chehalis Band), industry representatives (LGL Ltd), and members of the recreational fishing community. Several HQP and PIs delivered presentations summarizing research from 2010 and obtained feedback on plans for 2011.

March 2011 - Dr. Tim Clark (Pacific Arena) provided acceleration data collected using biologgers on sockeye salmon to Ms. Fran Broell (Ph.D. student at Dalhousie in the Atlantic Arena) to facilitate the development of algorithms for measuring fish growth via acceleration data. Additional biologger data are currently being collected by Graham Raby (M.Sc. student, Pacific Arena) on coho salmon and that will also be shared with Ms. Broell. The students have been interacting via email and telephone and it is anticipated that there will be a lab exchange within the next year.

April 2011 – DFO Pacific Biological Station (Nanaimo BC) Workshop on Fraser sockeye decline for DFO management. Work from OTN Pacific investigators presented by DFO science partners (i.e., collaborator D. Patterson and co-investigator K. Miller) to DFO regional senior management. Material presented covered the smolt telemetry work and marine telemetry work.

April 2011 – OTNC collaborator (D. Patterson) was invited to the Fraser River Panel Meeting held in Kamloops (20 attendees) to provide an overview on the smolt telemetry research.

May 2011 - Dr. Steven Cooke hosted a M.Sc. student from the Atlantic Arena (from the Stokesbury Lab) to learn blood sampling of sturgeon and field physiology techniques. Cooke has also shared equipment with the student and is participating on the academic committee of the student.

June 2011 - OTNC Canada Workshop, Dalhousie University – Our team delivered five oral presentations and a poster. Dr. Cooke (along with Dr. Karen Murchie – PDF with Cooke at Carleton) delivered a workshop on fish surgery. The workshop was attended by 40+ OTNC researchers and provided them with an overview of key concepts and issues related to animal handling and surgery.

June 2011 - Alison Collins (M.Sc. student) discussed tagging effects and the importance of validating tagging techniques with several students from the Arctic and Atlantic arenas during the OTNC annual

meeting and symposium - most students in the other arenas have not assessed tagging effects for the species they are working with in the Atlantic.

June 2011 - S. Hinch and S. Cooke (Pacific Arena co-leaders) were invited to the Annual General Meeting of DFO (BC Interior Region; 100 attendees;Kamloops BC, June 17, 2011) to summarize OTNC and related research. The 90 minute presentation was entitled, "Fraser salmon migrations, climate change, and capture/release fisheries".

June 2011 – S. Hinch and S. Cooke had a one hour meeting with DFO Regional Director (Sue Farhlinger) to discuss ways to improve DFO-academia collaborative research.

June 2011 – S. Cooke worked with Dr. Aaron Fisk (from Arctic Arena) and S. Hinch Hinch to develop a presentation called "To tag or not to tag – ethical and stakeholder perspectives on animal tagging" given at the 1st International Conference on Fish Telemetry, Sapporo, Japan. We intend to develop the presentation into a paper for the SSHRC book being led by David VanderZwag and Richard Apostle (Dalhousie).

July 2011 - Matt Drenner (Ph.D. student) met with a number of different scientists from various agencies across multiple disciplines this month. He met with oceanographers (Dr. Rick Thomson and staff) from the Institute of Ocean Sciences (DFO, Sydney, BC) to discuss research development, protocols and data management. He also met with David Patterson and staff from DFO Environment Watch Program to coordinate research efforts, plans and develop sampling protocols. Meetings also took place at UBC with Dr. Kristi Miller from PBS to discuss research development and data collaboration. Matt also met with Andrew Taylor (Carleton graduate student) to discuss methodology for manual tracking to aid in the development of his research. Matt has also had numerous discussions with VEMCO concerning their tag technology application, development and use in the field.

Sept 2011 – Fraser River Panel members from the Pacific Salmon Commission (20 attendees) met with several OTNC Pacific investigators and HQP (tech Lotto, MSc Robinson, MSc Wilson, collaborator Patterson, PDF Eliason) in the field and were shown our research sites, explained how our research was conducted and then we held a Q/A period for the panel members.

Sept 2011 - Nguyen (MSc) was invited to a meeting of DFO's Lower Fraser Fisheries Area management team (Annacis Island office) to summarize OTNC research. Her seminar was divided into three parts with a discussion period following each session. Approximately 20 attendees were at this meeting, including the regional recreational fisheries manager, conservation officers, First Nation fisheries resource managers and the regional director.

Sept 2011 – R. Thomson (DFO co-investigator) met with the DFO assistant deputy minister to brief her on the Fraser River sockeye salmon river-entry timing research, sent her a copy of the related manuscript, and has on several other occasions during the year been called by her for consultations and briefing on fisheries and oceanographic matters.

Interaction/Outreach to Broader Community

Oct 2010-Oct 2011 - The OTNC Canada Pacific projects come at a time when management practices for salmon are being closely scrutinized and there is a general recognition that things have to change. The announcement in late 2009 by the Prime Minister of Canada of a Public Inquiry (Cohen Commission) relating to declines in sockeye salmon from the Fraser River has resulted in questions on why fisheries management has been unable to predict or explain variances in abundance over the past decade. OTNC research is well suited to address this question, and OTNC Pacific investigators are among a very small number of researchers actually looking at the condition of salmon and impacts of condition on survival. As such, we are playing key and critical roles in development of hypotheses to explain highly variable salmon returns.

The Cohen Commission is unprecedented in Canadian fisheries history in terms of its format (judicial format, subpoenaing witnesses, testimony presented under oath, 20+ intervening groups with as many lawyers conducting cross-examinations) and scope (to examine reasons for the decline and the long term prospects for Fraser River sockeye salmon stocks and to determine whether changes need to be made to fisheries management policies, practices and procedures). S. Hinch was a technical expert for the Commission and, along with E. Martins (PDF) produced a comprehensive review of potential climate change effects on survival of Fraser River sockeye salmon and an analysis of interannual trends in *en route* loss and pre-spawn mortality. S. Hinch and E. Martins were subpoenaed to testify under cross-examination over a two-day period, as were K. Miller (co-investigator), D. Patterson (collaborator), D. Welch (partner), and B. Riddell (partner), all on different days – in all cases OTNC research results were discussed as 'key evidence'. S. Cooke and T. Farrell (co-investigators) were brought in as technical experts to review scientific documents on behalf of the commission.

K. Miller presented genomic evidence of a powerful fate-associated signature associated with mortality at multiple life-history stages. She hypothesizes this signature is associated with a response to a novel viral pathogen which she recently identified in adults and juveniles. The media interest in this research and testimony was immense, with front page articles in all of the major Canadian newspapers. As a result of these findings, DFO initiated a broad-scale disease research program on migrating sockeye salmon. S. Hinch provided evidence that the unprecedented levels of mortality of adult salmon in the river are important in the context of the large-scale declines in abundance, and that both temperature and salmon condition play a role in these mortalities. He stressed the value of OTNC research and the

need for continued government funding of telemetry programs. S. Welch and B. Riddell both discussed, among other things, the high levels of juvenile mortality that OTNC researchers have uncovered during the outmigration of smolts. The evidence phase of the inquiry is complete and the judge is presently writing his report.

Oct/Nov 2010 - members of our research team, led by K. Miller, participated in a 5-day retreat at the 'Salute the Salmon Festival on the Adams River'. We had an outreach booth at the festival where our research team interacted with the public and provided information about our research program and observed the amazing return of >15 million sockeye to the Adams River. Over 200,000 people attended the 3 week festival, including public, salmon professionals, government and fisheries stakeholders and First Nations.

Jan 2011 - Presentation by S. Hinch on Pacific salmon research and conservation to 25 primary school children at Queen Elizabeth Elementary, Vancouver, BC

March 2011 – Team members had meetings with Ron Valeur (assistant manager of Chilliwack River Hatchery), Andrew Grant (DFO Stock Assessment Technician), Dan Selbie (Director of DFO Cultus Lake Lab), and Jeremy Hume (DFO Lake's Biologist) to explore the possibility of implanting VEMCO acoustic tags into a lower Fraser sockeye stock (specifically Chilliwack Lake). It was decided that 2011 was not a good year for tagging that stock due to expected abundances but that it could be feasible for 2012.

April 2011 and July/August 2011 – Team members met with Mark Sekela and Jennifer MacDonald of Environment Canada about developing and building a partnership in the Lower Fraser River for VR2 site locations. Environment Canada deployed two hydrographic weirs in the Lower Fraser River so we could attach VR2s for our Chilko smolt work in 2011. The plan is redeployed these buoys and receivers in 2012.

May 2011 - Mark Shrimpton (University of Northern BC) is collaborating with us through a MSc student who is working on the physiology of Chilko sockeye smolts; they used our field and capture sites to obtain samples and are coordinating their lab studies and findings with us (through D. Patterson). Although the student is not OTNC funded, she has been able to benefit from interacting with our team members that are tagging smolts.

June 2011 - OTNC Pacific team members (Robinson MSc, Donaldson PhD) were invited to make presentations on OTNC research to a meeting of the Lower Fraser Fisheries Alliance (50 attendees) on the topic of Salmon Migrations, Climate Change, and Capture/Release Fisheries: Research Overview and Future Directions. Lower Fraser Fisheries Alliance Forum, Shxway Village, Chilliwack, BC. June 17, 2011

June 2011 - At the First International Fish Telemetry Conference in Sapporo Japan, Alison Collins (MSc student) met with Carl Shreck (Oregon State University), John Eiler (National Marine Fisheries Service) and Amber Childs (South African Institute for Aquatic Biodiversity) to discuss the 2% tag burden rule and alternative metrics for assessing tagging effects.

Aug. 27. 2011 – Vancouver Sun article (Op-Ed written by OTNC investigator T. Farrell in regards to the inaccurate media coverage surrounding the debate over potential effects of aquaculture on declining trends in sockeye): "Agreeing to Disagree: a fish story by any other name".

Sept 2011 – Nguyen (MSc) was invited to the Totem Fly Fishers Club in Burnaby, BC to make a presentation on OTNC research (30 attendees). Presentation titled: Improving the post-release survival of incidentally caught salmon: integrating biology and social sciences.

Sept 2011 – OTNC Pacific had a major presence at the American Fisheries Society Conference in Seattle (over 4000 attendees) with six presentations, four of which were invited. S. Hinch was a Session Organizer and co-chair for the Symposium on Climate Change and Salmonids.

Sept. 2011 – While at the American Fisheries Society Conference, S. Hinch received the Society's 2011 'Excellence in Fisheries Education Award'.

Sept 2011 - At the American Fisheries Society Meeting, Alison Collins (MSc student) met with Alison Colotelo from the Pacific Northwest National Laboratories (WA, USA) to provide information on how that group can incorporate novel measures into assessing tagging effects e.g. studies of predation rates on tagged fish, suture material and incision placement used during surgery and tag insertion.

Sept 2011 – Invited presentation by E. Eliason (PDF) to Cafe Scientifique, Railway Club, Vancouver, on 'Pacific Salmon and Climate Change'.

Sept 28, 2011 - Nguyen (MSc) was an invited speaker to a research lab meeting with researchers Nick Dulvy and John Reynolds (and their graduate students) at Simon Fraser University to discuss social science survey methods for fishers, and share findings, and promote methodologies.

Oct 2011 – Presentation by V. Nguyen to the Board of Directors of the Canadian Fly Fishing Federation at the Fairmount Kenauk Resort, Montebello, QC.

Oct 2011 – Presentation by S. Cooke and V. Nguyen to the Board of Directors of the Canadian Wildlife Federation on OTNC Canada Research titled "Moving towards sustainable management of Pacific salmon." Ottawa, ON.

Oct 28, 2011 – Nguyen (MSc) has been invited to the Canadian Wildlife Federation Board Meeting to provide overview of her social science research findings.

8. Dissemination of information and results

List refereed journal articles (accepted/published, submitted) and conference presentations (invited, contributed). All other dissemination is included in section #9 (Other contributions and deliverables).

Refereed Journal Articles (15 total)- *Accepted/Published*

Drenner, S.M, Clark, T.D., Whitney, C.K., Martins, E.G., Cooke, S.J., and Hinch, S.G. 2011. A synthesis of tagging studies examining the behaviour and survival of anadromous salmonids in marine environments. PLoS ONE, accepted with revisions.

Raby, G.D., M.R. Donaldson, S.G. Hinch, D.A. Patterson, A.G. Lotto, D. Robichaud, K.K. English, W.G. Willmore, A.P. Farrell, M.W. Davis, and S.J. Cooke. 2011. Validation of reflex indicators for measuring vitality and predicting the delayed mortality of wild coho salmon bycatch released from fishing gears. Journal of Applied Ecology. In press.

Martins, E.G., S.G. Hinch, D.A. Patterson, M.J. Hague, S.J. Cooke, K.M. Miller, D. Robichaud, K.K. English, and A.P. Farrell. 2011. High river temperature reduces survival of sockeye salmon (*Oncorhynchus nerka*) approaching spawning grounds and exacerbates female mortality. Canadian Journal of Fisheries and Aquatic Sciences. In press.

Cooke, S.J., S. J. Iverson, M. J.W. Stokesbury, S. G. Hinch, A. T. Fisk, P. Smith, D. VanderZwaag, J. Brattey and F. Whoriskey. 2011 Ocean Tracking Network Canada: A network approach to addressing critical issues in fisheries and resource management with implications for ocean governance. Fisheries. In press.

Clark, TD, Donaldson, MR, Drenner, SM, Hinch, SG, Patterson, DA, Hills, J, Ives, V, Carter, JJ, Cooke, SJ and Farrell, AP. 2011. The efficacy of field techniques for obtaining and storing blood samples from fishes. Journal of Fish Biology, In press

Martins E.G., Hinch S.G., Patterson D.A., Hague M.J., Cooke S.J., Miller K.M., Lapointe M.F., English K.K. and Farrell A.P. 2011. Effects of river temperature and climate warming on stock-specific survival of adult migrating Fraser River sockeye salmon (*Oncorhynchus nerka*). Global Change Biology 17: 99-114

Eliason, E.J., Clark, T.D., Hague, M.J., Hanson, L.M., Gallagher Z.S., Jeffries, K.M., Gale, M.K., Patterson, D.A., Hinch, S.G. and Farrell, A.P. 2011. Differences in thermal tolerance among sockeye salmon populations. Science 332, 109-112.

Miller, K.M., Li, S., Kaukinen, K.H., Ginther, N., Hammill, E., Curtis, J.M.R., Patterson, D.A., Sierocinski, T., Donnison, L., Pavlidis, P., Hinch, S.G., Hruska, K.A., Cooke, S.J., English, K.K., and Farrell, A.P. 2011. Genomic signatures predict migration and spawning failure in wild Canadian salmon. Science 331: 214-217.

Cooke, S.J., G.N. Wagner, R.S. Brown and K.A. Deters. 2011. Training considerations for the intracoelomic implantation of electronic tags in fish with a summary of common surgical errors. Reviews in Fish Biology and Fisheries 21:11-24

Cooke, S.J., C. Woodley, M.B. Eppard, R.S. Brown and J.L. Nielsen. 2011. Advancing the surgical implantation of electronic tags in fish: a gap analysis and research agenda based on a review of trends in intracoelomic tagging effects studies. Reviews in Fish Biology and Fisheries 21:127-151

Thomson, R.E., and Roy A.S. Hourston. 2011. A matter of timing: The role of the ocean in the initiation of spawning migration by Late-run Fraser River sockeye salmon (*Oncorhychus nerka*). Fisheries Oceanography, 20:1, 47-65.

Donaldson, M.R., S.G. Hinch, D.A. Patterson, J. Hills, J.O. Thomas, S.J. Cooke, G.D. Raby, L.A. Thompson, D. Robichaud, K.K. English, and A.P. Farrell. 2011. The consequences of angling and beach seine capture on the physiology, post-release behaviour and survival of adult sockeye salmon during upriver migration. Fisheries Research 108:133-141.

Clark, TD, Jeffries, KM, Hinch, SG and Farrell, AP. 2011. Exceptional aerobic scope and cardiovascular performance of pink salmon (*Oncorhynchus gorbuscha*) may underlie resilience in a warming climate. The Journal of Experimental Biology, 214: 3071-3081.

Hasler, C.T., G.C. Christie, J. Imhof, M. Power, and S.J. Cooke. 2011. A network approach to addressing strategic fisheries, aquaculture and aquatic sciences issues at a national scale: an introduction to a series of case studies from Canada. Fisheries 36:450-453

Clark, T.D., E. Sandblom, S.G. Hinch, D.A. Patterson, P.B. Frappell, A.P. Farrell. 2010. Simultaneous biologging of heart rate and acceleration, and their relationships with energy expenditure in free-swimming sockeye salmon (*Oncorhynchus nerka*). Journal of Comparative Physiology B - Biochemical, Systemic, and Environmental Physiology. 180: 673-684.

Book Chapters

Payne, J.C., K. Andrews, C. Chittenden, G. Crossin, F. Goetz, S. Hinch, P. Levin, S. Lindley, S. McKinley, M. Melnychuk, T. Nelson, E. Rechisky, and D. Welch. 2010. *Tracking fish movements and survival on the Northeast Pacific Shelf*. Chapter 14 (pp. 267 – 290) in Life in the World's Oceans, Alasdair McIntyre, Ed. Wiley-Blackwell, Oxford, U.K.

Refereed Journal Articles (6 total)-*Submitted*

Hinch, S.G., S.J. Cooke, A.P. Farrell, K.M. Miller, M. Lapointe, and D.A. Patterson. Dead fish swimming: early migration and high premature mortality in adult Fraser River sockeye salmon. Submitted to Journal of Fish Biology.

Collins, Alison L, Hinch, Scott G., Welch, David, W., Cooke, Steven J., and Clark, Timothy D. Intracoelomic tagging of juvenile sockeye salmon: swimming performance, growth, survival, and post-surgical wound healing in freshwater and during a transition to seawater. Submitted to Transactions of the American Fisheries Society.

Nguyen, V.M., Rudd, M.A., Hinch, S.G. and Cooke, S.J. Pacific Salmon recreational anglers: attitudes and behaviors relevant for salmon conservation and management in British Columbia. Submitted to Animal Conservation.

Thomson, Richard E., Richard J. Beamish, Terry D. Beacham, Marc Trudel, Paul H. Whitfield, and Roy A.S. Hourston. Anomalous ocean conditions may explain the recent extreme variability in Fraser River sockeye salmon production. Submitted to Marine and Coastal Fisheries.

Nguyen, V.M., Rudd, M.A., Hinch, S.G. and Cooke, S.J. Differences in information use and preferences among recreational salmon anglers: implications for management initiatives to promote responsible fishing. Submitted to Human Dimensions of Wildlife.

Cooke, SJ, Hinch, SG, Donaldson, MR, Clark, TD, Eliason, EJ, Crossin, GT, Raby, G, Jeffries, KM, Lapointe, M, Miller, KM, Patterson, DA, and Farrell, AP. Conservation physiology in practice: has physiology improved our ability to sustainably manage Pacific salmon during upriver migration? Submitted to Philosophical Transactions of the Royal Society of London B – Biological Sciences.

Invited Conference Presentations (15 total)

Hinch, S.G., S. J. Cooke, A.P. Farrell, K.M. Miller, and D.A. Patterson. Physiological drivers of adult salmon migrations and consequences of different migration behaviour. Invited oral presentation at "Cognitive, sensory, and behavioural frontiers: Exploring fish movement and habitat use innovations in fish passage and protection" symposium at the American Fisheries Society Annual Meeting, 4-8 September 2011, Seattle, WA.

Eliason, E.,T.D. Clark, S.G. Hinch, and A.P. Farrell. Differences in cardiorespiratory performance and thermal tolerance among sockeye salmon populations: potential for adaptation to climate change? Invited speaker to symposium on 'Climate Change and Pacific Salmon'. 141st Annual Meeting of the American Fisheries Society. 4-8 September 2011, Seattle, WA.

Patterson, D.A., S.G. Hinch, J.M. Burt., C.K. Whitney. E. Martins, M. Hague, A.P. Farrell. From individual-based research on linking maternal experience to maternal condition to offspring performance/fitness to implications for cross-generational population dynamics Invited speaker to symposium on 'Climate Change and Pacific Salmon'.141st Annual Meeting of the American Fisheries Society. 4-8 September 2011, Seattle, WA.

Martins, E.G., S.G. Hinch, D.A. Patterson, M.J. Hague, S.J. Cooke, K.M. Miller, D. Robichaud, K.K. English, and A.P. Farrell. Effects of river temperature on stock- and sex-specific survival of adult migrating Fraser River sockeye salmon. Invited speaker to symposium on 'Climate Change and Pacific Salmon'. 141st Annual Meeting of the American Fisheries Society. 4-8 September 2011, Seattle, WA.

Drenner, S.M., L.A. Thompson, DA Patterson, J. Hills, D. Robichaud, R.E. Thomson, S.G. Hinch. 2011. Coastal thermal experience of adult sockeye salmon: links with physiology and environment. Invited speaker to symposium on 'Climate Change and Pacific Salmon'. 141st Annual Meeting of the American Fisheries Society, 4-8 September 2011, Seattle, WA.

Eliason, E. Sockeye salmon in hot water: population differences in cardiorespiratory performance and thermal tolerance. Invited speaker: Comparative Physiology Invited Speaker Seminar Series, Department of Zoology, UBC, Sept 19, 2011

Contributed Conference Presentations (22 total)

Robinson, K.A., S.G. Hinch, M.K. Gale, and S.J. Cooke. 2011. Facilitated recovery of sockeye salmon following capture. Pacific Ecology and Evolution Conference, Bamfield, BC. March 4-6, 2011.

Collins, A.L., Hinch, S.G, Welch, D.W, Cooke, S.J., and Clark, T.D. 2011. Acoustic tagging effects on juvenile sockeye survival, growth, and swimming performance. Pacific Ecology and Evolution Conference. 31 May 2011.

Raby, G.D., S. Wilson, M.R. Donaldson, D.A. Patterson, T.D. Clark, C.D. Suski, W.G. Willmore, A.P. Farrell, S.G. Hinch, S.J. Cooke. 2011. A comparison of holding environments for facilitating physiological recovery from capture stress in sockeye salmon. Canadian Society for Zoology Annual Meeting, Ottawa, May 2011.

Raby, G.D., M.R. Donaldson, V. Nguyen, D.A. Patterson, K.K. English, D. Robichaud, A.P. Farrell, M.W. Davis, S.G. Hinch, S.J. Cooke. 2011. Understanding delayed fisheries capture mortality with upriver migrating Pacific salmon. 1st International Conference on Fish Telemetry, Sapporo, Japan, June 14-18, 2011.

Collins, A.L., Hinch, S.G, Welch, D.W, Cooke, S.J., and Clark, T.D. 2011. Acoustic tagging effects on juvenile sockeye survival, growth, and swimming performance. First International Fish Telemetry Conference, Hokkaido University, Sapporo, Japan. 14 June 2011.

Clark, T.D., Collins, A.L., Hinch, S.G., Welch, D.W., Riddell, B. 2011. Acoustic tagging effects on juvenile sockeye survival, growth, and swimming performance. First International Fish Telemetry Conference, Hokkaido University, Sapporo, Japan. 14 June 2011.

Miller, K.M., T. Ming, K.H. Kaukinen, A. Schulze, P. Pavlidis, and D. A. Patterson. Genomic insights into the health and condition of out-migrating salmon smolts. 141st Annual Meeting of the American Fisheries Society. Seattle, WA, USA.

Robinson, KA, SG Hinch, SJ Cooke, MR Donaldson, MK Gale, DA Patterson. 2011. Effects of facilitated recovery and water temperature on capture-release survival of sockeye salmon. American Fisheries Society 141st Annual Meeting, Seattle, WA. September 4-8, 2011.

Collins, A.L., Hinch, S.G, Welch, D.W, Cooke, S.J., and Clark, T.D. 2011. Acoustic tagging effects on Juvenile sockeye survival, growth, and swimming performance. American Fisheries Society Conference, Seattle, USA. 8 Sept. 2011.

Nguyen, V.M., Rudd, M.A., Hinch, S.G. and Cooke, S.J. 2011. Latent-Class Cluster Analysis: Categorizing Recreational Salmon Anglers' Attitudes and Behaviours Relevant for Pacific Salmon Conservation and Management in British Columbia. American Fisheries Society 141st Annual Meeting, Seattle, WA. Sept. 2011.

Raby, G.D., S. Wilson, M.R. Donaldson, D.A. Patterson, C.D. Suski, W.G. Willmore, A.P. Farrell, S.G. Hinch, S.J. Cooke. 2011. Facilitating recovery from capture stress in sockeye salmon. American Fisheries Society 141st Annual Meeting, Seattle, WA. Sept. 2011.

Miller, K.M. Genomics insights into the health and condition of out-migrating salmon smolts. Salmon Ocean Ecology Meeting, March 23-24, 2011 Seattle Washington.

Ma, B, K.M. Miller, J.R. Curtis. A Bayesian network incorporating genomic information into in-season management of Fraser River sockeye salmon. Salmon Ocean Ecology Meeting, March 23-24, 2011 Seattle Washington

Raby, G.D., M.R. Donaldson, S.G. Hinch, D.A. Patterson, A.G. Lotto, D. Robichaud, K.K. English, W.G. Willmore, A.P. Farrell, M.W. Davis, and S.J. Cooke. 2011. Validation of reflex action mortality predictors for managing bycatch mortality: coho salmon bycatch in beach seines. Canadian Conference for Fisheries Researchers, Toronto, January 2011.

Nguyen, V.M., Raby, G.D., Donaldson, M.R., Lotto, A.G., Clark, T.D., Patterson, D.A., Robichaud, D., English, K.K, Farrell, A.P., Willmore, W.G., Rudd, M.A., Hinch, S.G. and Cooke, S.J. 2011. The relative roles of stress, injury, and recovery on the migratory behavior and success of caught and released sockeye. Canadian Conference for Fisheries Research 64th Annual Meeting, Toronto, Canada, January 2011

9. Other contributions and deliverables

Radio and Television Media Coverage

Oct. 19, 20, 21, 2011 - Discovery Network ('Daily Planet TV show') documentary on the Fraser sockeye situation with a focus on OTNC research (interviews with S. Hinch, A. Lotto, T. Clark, A. Collins)

Jan 14, 2011 - CBC National Radio program 'As it Happens' - feature interview with S. Hinch in regards to Science publication (Miller et al. 2011)

Feb 9, 2011 - CBC Radio news story on wild salmon and OTNC based research

Apr 2, 2011 - CBC National Radio program 'Quirks and Quarks' feature interview with Erika Eliason (PDF) in regards to Science publication (Eliason et al. 2011)

Printed Press and On-line Media Coverage

Jan 2011 - Based on our publication in Science (Miller et al. 2011), the following outlets published stories: Alberni Valley Times, AlphaTrade Finance, Angling BC, Bay Ledger News Zone, Calgary Herald, canada.com, CBC Thunder Bay, CBC.ca, CBC.ca News, Climate Spectator, Edmonton Journal, elEconomista.es, International Environmental Science, International Science, First Nations in BC, First Nations Fisheries Council, France 24, FoxNews.com, Global BC, Global News, Globe And Mail, Leader Post, KVAL.com, Live Science, Medical News Today, Montreal Gazette, Nanaimo Daily News, Nation Talk, OfficialWire, Osprey Steelhead News, Ottawa Citizen, Pacific Free Press, Physorg, Planet ARK, Reuters India, Reuters Science News, Reuters UK, Small Business News – Reuters, SOTT.Net Exchange Magazine, Stv.tv, Sync – Sympatico, Terra Daily, The Hook, The Post Chronicle, The Province, Times Colonist, UPI.com, Vancouver Sun, Windsor Star, Wired Science, Wired Blogs, Yahoo! News, Yahoo! News UK & Ireland, Time Magazine

Mar 2011 – Based on the government 'muzzling' of K. Miller in regards to the Science paper, several outlets published stories: World Press, Times Colonist, Globe and Mail, Vancouver Sun, Science magazine (Science Insider).

April 2011 - Based on our publication in Science (Eliason et al. 2011), the following outlets published stories: Agence France Presse, National Geographic, United Press International, CBC, Globe and Mail, Vancouver Sun, The Province, Dawson Creek Daily, The Daily News, Alberni Valley Times, Leader Post (Regina), Times Colonist (Victoria), Star-Phoenix (Saskatoon), Calgary Herald, Montreal Gazette, Science Daily

Aug 23, 2011 – Based on OTNC Pacific research, published in The Tyee Magazine. The Salmon Doctors: Condition Critical, First in a two-part series http://thetyee.ca/News/2011/08/23/What-Makes-Salmon-Resilient/

Aug 24, 2011 – Based on OTNC Pacific research, published in The Tyee Magazine *Sockeye Feel the Heat:* Global warming cranks up stress on salmon. Scientists are scrambling to identify what the heat's unleashed. Second in a two-part series. http://thetyee.ca/News/2011/08/24/Sockeye-Feel-Heat/

Aug 24, 2011 – Based on T. Clark's publication in the Journal of Experimental Biology, article published in 'Inside JEB' entitled, "Pink salmon better at braving the heat',

Sept 28, 2011 – T. Farrell interviewed by Nature News (journal NATURE) on declining salmon stocks http://www.nature.com/news/2011/110928/full/news.2011.563.html

Invited or contributed presentation/contribution at a workshop.

Martins, E.G., Hinch, S. G., Patterson, D. A., Hague, M. J., Cooke, J. Miller, K. M., Robichaud, D., English, K. K. & Farrell, A. P. 2011. Stock and gender mortality modelling using telemetry and river environmental data. Workshop on Salmon Migrations, Climate Change, and Capture/Release Fisheries, University of British Columbia, Vancouver, BC, Canada. Feb. 10, 2011

Drenner, M, S.G. Hinch, D.A. Patterson, A.P. Farrell, S. Cooke, and T. Clark. Ocean telemetry of sockeye salmon in 2010. 2011. Workshop on Salmon Migrations, Climate Change, and Capture/Release Fisheries, University of British Columbia, Vancouver, BC, Canada. Feb. 10, 2011

Donaldson, M., D.A. Patterson, J. Hills, J.O. Thomas, S.J. Cooke, S.G. Hinch, G. Raby, L.A. Thompson, K.M. Miller, D. Robichaud, K. English, and A.P. Farrell. 2011. The consequences of fisheries and holding-related stressors on adult Pacific salmon physiology, behaviour, and survival. Workshop on Salmon Migrations, Climate Change, and Capture/Release Fisheries, University of British Columbia, Vancouver, BC, Canada. Feb. 10, 2011

Clark, T, Hinch, S.G., Lotto, A., Jeffries, K., Welch, D., Rechisky, E., and Riddell, B. 2011. Movement and survival of out-migrating Chilko Lake sockeye salmon smolts. Workshop on Salmon Migrations, Climate Change, and Capture/Release Fisheries, University of British Columbia, Vancouver, BC, Canada. Feb. 10, 2011

Robinson, K, S.G. Hinch, D.A. Patterson, Gale, M.K., and S.J. Cooke. 2011. The effects of thermal and capture stress on migrating adult sockeye salmon (*Oncorhynchus nerka*). Workshop on Salmon Migrations, Climate Change, and Capture/Release Fisheries, University of British Columbia, Vancouver, BC, Canada. Feb. 10, 2011.

Raby, G.D., S. Wilson, M.R. Donaldson, D.A. Patterson, C.D. Suski, W.G. Willmore, A.P. Farrell, S.G. Hinch, S.J. Cooke. 2011. Facilitating recovery from capture stress in sockeye salmon. Workshop on Salmon Migrations, Climate Change, and Capture/Release Fisheries, University of British Columbia, Vancouver, BC, Canada. Feb. 10, 2011

Nguyen, V.M., Rudd, M.A., Hinch, S.G. and Cooke, S.J. 2011. Latent-Class Cluster Analysis: Categorizing Recreational Salmon Anglers' Attitudes and Behaviours Relevant for Pacific Salmon Conservation and Management in British Columbia. Workshop on Salmon Migrations, Climate Change, and Capture/Release Fisheries, University of British Columbia, Vancouver, BC, Canada. Feb. 10, 2011

Hinch, S.G. Linking behaviour, environment and physiology: tracking the movement and fate of fish in the OTNC Pacific Arena. 1st OTNC Canada Symposium, Dalhousie University, June 1–3, 2011 (invited).

Drenner, M., S.G. Hinch, and S.J. Cooke. Tracking the migration of adult sockeye salmon and relating migratory fate to physiological and oceanographic conditions. 1st OTNC Canada Symposium, Dalhousie University, June 1–3, 2011

Clark, T., S.G. Hinch, D. Welch, and E. Rechisky. Tracking the migration of wild juvenile sockeye salmon to the Pacific Ocean. 1st OTNC Canada Symposium, Dalhousie University, June 1–3, 2011

Collins, A., S.G. Hinch, S.J. Cooke, and D. Welch. Acoustic tagging effects on juvenile sockeye survival, growth, and swimming performance. 1st OTNC Canada Symposium, Dalhousie University, June 1–3, 2011

Wilson, S.M., Hinch, S.G., and S.J. Cooke. Evaluation of Electro-anaesthesia as an alternative to chemical anaesthesia in Pacific Salmon. Poster presentation. 1st OTNC Canada Symposium, Dalhousie University, June 1–3, 2011/

Invited or contributed presentation/contribution at a seminar series.

Hinch, S.G. Incorporating experimental biology into telemetry programs: lessons learned for science and management of Pacific salmon. Sept. 23, 2011, Fisheries Centre Seminar Series, UBC, Vancouver BC

Patterson D.D. Connecting science to fisheries management: recent examples from DFO Environmental Watch Program. Simon Fraser University Resources and Environmental Management Seminar Series. March 2011.

Cooke, S.J., G.D. Raby, and S. Larocque. Bycatch issues in inland waters – turtles and salmon. National Wildlife Research Centre's Seminar Series. March 2011.

Data reports, technical reports, manuscript reports, etc.

Hinch, S.G. and E.G. Martins. 2011. A review of potential climate change effects on survival of Fraser River sockeye salmon and an analysis of interannual trends in en route loss and pre-spawn mortality. Cohen Commission Tech. Rept. 9: 134p. Vancouver, B.C.

Clark, TD, Riddell, B, Farrell, AP, Welch, DW and Hinch, SG. 2011. Preliminary report on riverine and early marine survival of Chilko Lake sockeye smolts – October 12, 2011. Submitted to Pacific Salmon Foundation.

Clark, TD, Riddell, B, Farrell, AP, Welch, DW and Hinch, SG. 2011. Preliminary report on Chilko Lake sockeye smolt detections in the lower Fraser River – August 12, 2011. Submitted to Pacific Salmon Foundation.

Clark, TD, Riddell, B, Farrell, AP, Welch, DW and Hinch, SG. 2011. Assessing river and coastal ocean survival and movement rates of Chilko Lake sockeye salmon smolts using acoustic telemetry: A synthesis of findings from 2010. Submitted to Pacific Salmon Foundation, and Department of Fisheries and Oceans Canada.

Invited or contributed consultation with an agency; public or private

- See Section 7 above (e.g. Cohen Commission activities)

Leveraging your research/funds in order to make a new contribution to another initiative

- We are aware of several grants and funding requests that are either submitted or in development that leverage the OTNC NSERC or CFI grants, or their current infrastructure, including:

- Kristi Miller (DFO) was approached by funding managers from Bonneville Power (WA, USA) who fund $8-10 million worth of salmon research on the Columbia system annually, about doing genomic analyses on the Columbia River system salmon similar to what we are doing on the Fraser River. We are in initial stages of this collaboration, and if successful, it could broaden the depth of our applied management outcomes to salmon management in the US.

- Mark Shrimpton (UNBC) developing an NSERC grant that will rely on the OTNC as a platform for some smolt osmoregulatory work

- Kristi Miller (DFO) submitted a proposal to the Southern Endowment Fund of the Pacific Salmon Commission for smolt sampling and genomics work

- Timber Whitehouse (DFO) submitted a proposal to study downstream smolt behaviour to the Southern Endowment Fund of the Pacific Salmon Commission

- David Patterson (DFO) submitted a proposal to the Southern Endowment Fund of the Pacific Salmon Commission to improve models for predicting escapement adjustments which will incorporate OTNC based telemetry results on adult sockeye mortality estimates.

- Brian Riddell (Pacific Salmon Foundation) is approaching private donors to secure funds to help with OTNC tagging and tracking of sockeye smolts in 2012.

- David Welch (Kintama Ltd) has developed a large research proposal to study impacts of fish farms on wild Pacific salmon migrations and survival for consideration by DFO, industry and private foundations

A spin-off from the research that provided a new opportunity or new initiative

- OTNC Pacific is expanding some of its current and planned telemetry projects on adult salmon to include assessing how different types of fishing practices influences survival and behaviour. We have been able to do this as a result of keen partnerships with DFO management and their

provisions of logistic support and access to several fisheries. This is a logical expansion given that assessing investigator 'handling' and 'tagging' effects is a large component of all of our studies, and we acquire all of our fish to be telemetry tagged from various fisheries so having a more rigorous assessment of how these sampling platforms affects our telemetry results is important. Also, this expansion provides better linkages with DFO fisheries management, and with several stakeholder user groups (e.g. fishing and ENGO groups) who have partnered with us in these studies.

A new technology, method, protocol, measure, analytical technique, algorithm, operational or numerical model, or predictive tool. Include the validation of any of the former and their practical application.

- We have been collaborating with electronic engineers in field testing and ground truthing a novel miniaturized data logger that records heart rate, swim speed, depth and temperature

A proof of concept in relation to any of the above.

- See biologger example above

Baseline measures (e.g. reference for change), empirical relations (e.g. rates and states), or mapping products (e.g. range expansion or contraction) especially if of use to other scientists and the organizations listed above

- We generated the first ever baseline measures of wild sockeye smolt travel and survival rates which we provided to an ENGO partner (the Pacific Salmon Foundation) through technical reports (see Section 7 above) which has been used by them in their Cohen Commission submissions, and by other groups (i.e. DFO management).

Contribution as expert witness or expert panelist (COSEWIC, EIA)

- See Section 7 above (i.e. involvement by several people in Cohen Commission)

10. Collaborations with Industrial and Government Partners

a) Please describe which partners are actively involved in management, research, and knowledge transfer within the network and the specifics of their involvement.

Fisheries and Oceans Canada (DFO) are involved with the day to day management of the Pacific marine fisheries and several of their scientists, biologists and technicians are directly involved with us in conducting OTNC Canada Pacific research (e.g. Drs. K. Miller and R. Thomson and their lab groups; D. Patterson and the Fraser Environmental Watch Program). OTNC students have been training within the lab groups of these scientists. DFO genetic stock identification lab personnel (Pacific Biological Station) have been involved via processing samples for OTNC studies, and DFO Science Branch (Mark Saunders;

Dave Patterson) provided technical personnel to help in the field and lab, and have loaned equipment. DFO fisheries managers (e.g. Timber Whitehouse, Barry Rosenberger) have attended our planning meetings and extension workshops in order to be updated on the latest science so that they can incorporate relevant information into on-going management plans. These managers have also been instrumental in suggesting new research opportunities, getting First Nations groups involved with our work, and helping researchers get access to fishing vessels, fishing locales, stock assessment fences, etc. in order to obtain fish for tagging purposes.

The Pacific Salmon Commission (PSC) is a US/Canada joint commission involved with the management of Pacific salmon in the Fraser River. Their staff (Mike Lapointe, Steve Latham) have attended several of our recent planning meetings and OTNC Canada Pacific investigators have attended some of theirs. They have provided advice and staff time in the design of our tagging experiments and have helped with stock identification through rapid scale analyses. Managers have also been instrumental in suggesting new research opportunities and helping researchers get access to fishing vessels and fish. They have helped communicate our research results to fisheries managers via their bi-annual Fraser Panel Meetings.

The Pacific Salmon Foundation (PSF) is a federally incorporated non-profit charitable organization committed to the conservation and restoration of wild Pacific salmon and their natural habitats in British Columbia and the Yukon. Brian Riddell (President) provided OTNC Canada Pacific investigators with a large number of transmitters (purchased by the PSF) for our smolt studies. The PSF also provided funds to help with some field costs. The PSF has been instrumental in communication of OTNC results and findings to fisheries managers, the ENGO community, senior bureaucrats, politicians, and the public at large.

Environment Canada is a federal agency responsible for, among other things, water quality monitoring. The Water Quality Monitoring Program in the Pacific and Yukon Region consists of 49 long-term ambient water quality monitoring stations on rivers in British Columbia, and ten stations on rivers in the Yukon. These stations are primarily operated on rivers of federal interest (e.g. transboundary, national parks, major fisheries). Mark Sekela (Senior Environmental Quality Scientist) and Jennifer MacDonald from this group partnered with us and used their vessels to deploy OTNC acoustic receivers on hydrographic buoys in the lower Fraser River estuary transition area – they also deployed a new buoy for us. This enables us to obtain environmental data that are directly linked to fish passage.

The Canadian Wildlife Federation is a charitable environmental organization dedicated to protecting wild species and wild spaces and is a leader in conservation education, awareness and outreach. They helped purchase transmitters for us to use in adult salmon. They are also planning on writing an article for publication in one of their magazines and for their website overviewing our research program.

Kintama Research Corporation is involved in telemetry array design, development, installation, and maintenance, design and analysis of telemetry data, and surgical tagging and tag programming. They have collaborated with OTNC Pacific investigators since 2006. They are involved with downloading and maintenance of POST acoustic arrays and thus in providing to POST data for the Pacific OTNC studies. Kintama owns a series of receivers situated in the mouth of the Fraser River which collected important data from our juvenile and adult salmon studies in 2011. They have provided these data to us and are assisting in their analysis (PDF Erin Rechisky). They have also been instrumental in helping to train some of our students in surgical approaches and tagging, and in assisting in the design our juvenile salmon tagging project.

LGL Ltd Environmental Research Associates provides biological consulting services to public and private sectors. They are specialists in utilizing telemetry and have collaborated with OTNC Pacific investigators since 2002. They have been conducting adult salmon telemetry research over the past decade via contracts with DFO and PSC in order to assess run timing, stock sizes, and stock survival. Our students work alongside their staff on tagging crews, assisting with the biosampling, and receiver set-up and downloading. LGL provided receiver infrastructure and data management. Data will be shared amongst our two teams.

b) Cash in-kind contributions from partners for year 2.

Name of supporting organization: **DFO Pacific Region**	**Year 2** (1 Oct 2010 – 30 Sep 2011)
Cash contributions to direct costs of research	
In-kind contributions to direct costs of research	
61) Salaries for scientific and technical staff	64,900
62) Donation of equipment, software	34,800
63) Donation of material	8,000
64) Field work logistics	
65) Provision of services	
66) Other (specify): _____	
In-kind contributions to indirect costs of research	
31) Use of organization's facilities	
32) Salaries of managerial and administrative staff	
33) Other (specify): _____	
Total of all in-kind contributions	107,700

DFO details

Salaries

Thomson– 10% X $150000= $15,000

Miller– 10% X $140000 = $14,000

Patterson– 15% X $80000 = $12,000

Hague– 5% X 0.5 X $60000 = $1,500
Hill – 5% X $60000 = $3,000
Thompson – 5% X $60000 = $3,000
Ginther – 5% X $80000 = $4,000
Li – 5% X $60000 = $3,000
Whitehouse – 2% X 80000 = $1,600
Lindin – 2% X 40000 = $800
Hourston – 5% X $80000 = $4,000
Krassoffski - 5% X $60000 = $3,000
SubTotal = $64,900

Equipment
2 CTDs - $30,000 / yr = $30,000
Boat time in estuary/lower river – 6 days @ $800/d = $4,800
SubTotal = $34,800
Materials
Chemicals and lab supplies = **$8,000**

Name of supporting organization: **Pacific Salmon Commission**	**Year 2** (1 Oct 2010 – 30 Sep 2011)
Cash contributions to direct costs of research	
In-kind contributions to direct costs of research	
67) Salaries for scientific and technical staff	28,750
68) Donation of equipment, software	
69) Donation of material	
70) Field work logistics	
71) Provision of services	
72) Other (specify): _____	
In-kind contributions to indirect costs of research	
34) Use of organization's facilities	
35) Salaries of managerial and administrative staff	
36) Other (specify): _____	
Total of all in-kind contributions	28,750

PSC details
Salaries
Lapointe/Latham = $28,750

Name of supporting organization: **Pacific Salmon Foundation**	**Year 2** (1 Oct 2010 – 30 Sep 2011)
Cash contributions to direct costs of research	46,800
In-kind contributions to direct costs of research	
73) Salaries for scientific and technical staff	1,500
74) Donation of equipment, software	52,000
75) Donation of material	37,500
76) Field work logistics	
77) Provision of services	
78) Other (specify): _____	
In-kind contributions to indirect costs of research	
37) Use of organization's facilities	
38) Salaries of managerial and administrative staff	
39) Other (specify): _____	
Total of all in-kind contributions	137,800

Pacific Salmon Foundation

Salaries

Riddell – 1% X $150000 = **$1,500**

Equipment

Transmitters – (208 @ $250 ea.) **= $52,000**

Cash contribution for field research costs **- $46800**

Name of supporting organization: **Kintama Research Corporation**	**Year 2** (1 Oct 2010 – 30 Sep 2011)
Cash contributions to direct costs of research	
In-kind contributions to direct costs of research	
79) Salaries for scientific and technical staff	8,000
80) Donation of equipment, software	13,500
81) Donation of material	
82) Field work logistics	24,000
83) Provision of services	
84) Other (specify): _____	
In-kind contributions to indirect costs of research	
40) Use of organization's facilities	
41) Salaries of managerial and administrative staff	
42) Other (specify): _____	
Total of all in-kind contributions	45,500

Kintama Research Corporation

Salaries

Welch – 5% X $120000 = $6,000

Technical staff = $2,000

Sub-total $8,000

Equipment

Lease of dual frequency array sites in Fraser River **$13,500**

Logistics

Downloading of acoustic array in the Fraser River **$24,000**

Name of supporting organization: **LGL Ltd.**	**Year 2** (1 Oct 2010 – 30 Sep 2011)
Cash contributions to direct costs of research	
In-kind contributions to direct costs of research	
85) Salaries for scientific and technical staff	7,500
86) Donation of equipment, software	90,000
87) Donation of material	
88) Field work logistics	
89) Provision of services	
90) Other (specify): _____	
In-kind contributions to indirect costs of research	
43) Use of organization's facilities	
44) Salaries of managerial and administrative staff	
45) Other (specify): _____	
Total of all in-kind contributions	97,500

LGL Ltd

Salaries

Field technician - 10% X $50000 = $5,000

Office staff – 5% X 50000 = $2,500

Sub-total=$7,500

Equipment

Radio telemetry array deployment and maintenance = $**90,000**

Name of supporting organization: **Environment Canada**	**Year 3** (1 Oct 2010 – 30 Sep 2011)
Cash contributions to direct costs of research	
In-kind contributions to direct costs of research	
91) Salaries for scientific and technical staff	4,000
92) Donation of equipment, software	4,000
93) Donation of material	
94) Field work logistics	
95) Provision of services	
96) Other (specify): _____	
In-kind contributions to indirect costs of research	
46) Use of organization's facilities	
47) Salaries of managerial and administrative staff	
48) Other (specify): _____	
Total of all in-kind contributions	8,000

Environment Canada

Salaries

Field technicians (2) - 4 days ($250 per d) = **$4,000**

Equipment

Hydrographic buoy (2) placement and maintenance = $**4,000**

Name of supporting organization: **Canadian Wildlife Federation**	**Year 2** (1 Oct 2010 – 30 Sep 2011)
Cash contributions to direct costs of research	24,000
In-kind contributions to direct costs of research	
97) Salaries for scientific and technical staff	
98) Donation of equipment, software	
99) Donation of material	
100) Field work logistics	
101) Provision of services	
102) Other (specify): _____	
In-kind contributions to indirect costs of research	
49) Use of organization's facilities	
50) Salaries of managerial and administrative staff	
51) Other (specify): _____	
Total of all in-kind contributions	24,000

Canadian Wildlife Federation
Cash Contribution for transmitters **- $24,000**

11. Expenditures and Support

Year 2 (2011)

a) Indicate approved year 2 budget, actual expenditures from 1 January to 30 Sep 2011 and projected expenditures for the remainder of this installment (through to 31 December 2011).

Year 2 (2011)	Proposed	Actual Expenses 1 Jan-30 Sep 2011*	Total Balance 30 Sep 2011*	Projected Balance 31 Dec 2011**
1) Salaries and Benefits				
a) Students	47,000	19,466	**27,534**	**-3,021**
b) Postdoctoral Fellows	40,000	33,962	**6,038**	**6,038**
c) Technical/Professional Assistants	23,500	26,092	**-2,592**	**-2,592**
d) Other (specify)	0	0	**0**	**0**
2) Equipment or Facility				
a) Purchase or Rental	25,000	5,332	**19,668**	**1,115**
b) Operation and Maintenance Costs	0	0	**0**	**0**
c) User Fees	5,000	4,415	**585**	**585**
3) Material and Supplies	75,000	14,147	**60,853**	**607**
4) Travel				
a) Conferences	3,000	2,741	**259**	**259**
b) Field work	25,000	1,986	**23,014**	**-786**
c) Collaboration/ Consultation	3,000	1,506	**1,494**	**312**
5) Dissemination Costs				
a) Publication Costs	0	0	**0**	**0**
b) Other Activities	0	0	**0**	**0**
6) Other (specify)				
a)	0	0	**0**	**0**
b)	0	0	**0**	**0**
Total Expenditures	**246,500**	**109,648**	**136,852**	**2,516**

b) Below, explain any significant deviations from the proposed expenditures.

There are no significant deviations within the main categories.

Year 3 (2012)

a) Using the same excel form provided, indicate your approved year 3 budget (already entered for you) and any revisions to that original budget that you are proposing for year 3, noting that it must sum to ≤ the original total.

Year 3 (2012)	Original	Revised	Carry Over Requested
1) Salaries and Benefits			
a) Students	47,000	47,000	0
b) Postdoctoral Fellows	40,000	40,000	0
c) Technical/Professional Assistants	41,000	41,000	0
d) Other (specify)	0	0	0
2) Equipment or Facility			
a) Purchase or Rental	50,000	50,000	0
b) Operation and Maintenance Costs	0	0	0
c) User Fees	10,000	10,000	0
3) Material and Supplies	25,000	25,000	0
4) Travel			
a) Conferences	6,000	6,000	0
b) Field work	30,000	30,000	0
c) Collaboration/ Consultation	3,000	3,000	0
5) Dissemination Costs			
a) Publication Costs	1,000	1,000	0
b) Other Activities	0	0	0
6) Other (specify)			
a)	0	0	0
b)	0	0	0
Total	**253,000**	**253,000**	**0**

b) Provide a detailed justification for your year 3 budget. You may use your original justification (just as submitted in the proposal) and state that it remains on track if that is the case. For budget items that you are proposing to change, you must give a clear explanation/justification of why; these proposed changes must be approved by the SAC.

Budget Justification Year 3 (2012)

1) Salaries and benefits

a) Students

- on-going graduate student will be responsible for adult salmon telemetry and linking migration behaviour and fate to environmental factors - running from years 2 to 4 (@ $19,000/yr; year one salary is provided through another source)
- one on-going graduate student will be responsible for obtaining oceanographic information and empirical modelling efforts conducted in the coastal and estuarine areas linking with spatial/temporal tracking of salmon - running from years 1 to 4 (@ $19,000/yr)
- graduate student will be responsible for analyzing the gene array results and identifying genomic / physiological associations between salmon migration behaviour and fate (years 2 to 5; we will seek an individual holding a NSERC PGSD for years 2 and 3 and who would be a strong candidate for internal UBC fellowships in years 4 and 5, thus no funds are requested in this grant.
- on-going graduate student will conduct juvenile salmon telemetry. Will run from years 2 to 4. We will seek a student initially supported by NSERC PGSM.
- we will take on a USRA (NSERC undergraduate award student) each summer over the seven year program. [Hinch/Cooke/Farrell have been awarded these through their departments in each of the last 6 years]. We only request top-up support ($3,000). We will also take on an additional undergraduate assistant each year ($6,000). Each year, both students will assist with several of the projects.

b) Postdoctoral fellows

In addition to conducting specific studies, the PDFs will be responsible, each during their specific tenure, for helping the co-PIs and collaborators co-ordinate Pacific arena research, organize Pacific arena researcher meetings, assist with training of students, and writing grant proposals to seek funds for additional research projects that complement the OTNC program.

- one PDF in years 3 and 4 to conduct telemetry on salmon with link to environmental conditions (@ $40,000/yr)

c) Technical/professional assistants

- We will support 50% ($35,000) of the time of a technician (Andrew Lotto) who will be responsible for running and organizing all of the field sampling, experiment logistics and animal care including: fish capture, experimental apparatus set up and maintenance, lab water quality and temperature maintenance, lab on-site rearing of adults and juveniles, vehicle maintenance, safety training and planning, on-going animal care training of students. Mr. Lotto has worked in our group for the past 12 years, has a wealth of field and lab logistic and animal holding/experimentation experience. The remainder of his salary will be obtained through other on-going research programs.
- We will support 8% ($6,000) of the time of another technician to download data from receivers and from the towed CTD units, edit downloaded data, and provide to the graduate students and PDFs. The remainder of the salary will be obtained through other on-going research programs.

2) <u>Equipment or facility</u>

a) Purchase or rental

- Purchase: We do not need to purchase any large equipment in year 3
- Rental: Boat charters to deploy and retrieve data from sensors and receivers, capture juvenile and adult fish, and track fish ($50,000)

b) User fees

- Charges to use tanks and space at CAER and at UBC (which includes the time of an animal care technician) ($10,000)

3) <u>Materials and supplies</u>

- Oceanographic sensor supplies - re-outfit with new mooring hardware, acoustic release, instrument re-set up and calibration costs ($10,000)
- Stock ID: DNA analysis ($5,000)
- Physiological assay supplies: bioassays and reagent costs for analysis of stress hormones, indicators of oxidative stress and tissue damage, and all of the reproductive hormones ($5,000)
- Field supplies: batteries for three microwave energy meters, batteries for acoustic receivers, safety supplies, vials, coolers, dry ice, liquid nitrogen, rope, buoys and hardware, tools, tubing ($5,000)

4) Travel

a) Conferences

We will partially support graduate students and PDFs to attend conferences @ $1,500 / conference but expect students to also find support through internal university funds and through specific conference and society funds. Our group will have four conference attendees in year 3 ($6,000)

b) Field work

Lab and field sampling locations, in some cases, are considerable distances from each other and people, fish and samples need to be shuttled amongst them at different times of the year. Our adult salmon sampling locales are situated at two locales in the Salish Sea requiring a 2 hour drive and a 2 hour car ferry from UBC main campus. Our other adult sampling location in the Coastal Transition Zone near the Queen Charlotte Islands is 12 hour drive and 6 hour ferry from UBC main campus. The CAER is a 45 min drive from UBC main campus. Juvenile fish sampling locations are all within a 2 hour drive of CAER. Hinch's department owns and operates a 4X4 (Ford 350) pickup truck which can be used to transport fish in a large live box, and to move holding tanks. We also have access to a large Ford Econoline Van and small Mazda pickup truck. These vehicles will be largely available to us over the 7 year program for the transporting of fish from capture to the lab, and also to move people to the field capture sites.

- cost recovery of mileage on vehicles ($15,000)
- fuel ($5,000)
- accommodation (rent hotel rooms or houses each year, capture sites; $5,000)
- Food (will pay for food of our students while living at field sites; $5,000)

c) Collaboration/consultation

We have budgeted for costs of students to train and be mentored in the labs of our DFO co-PIs (Drs. Kristi Miller - Pacific Biological Station; Nanaimo BC) and Dr. Rick Thomson (Institute of Ocean Sciences, Sydney BC). Specifically, they will live in Nanaimo and Sydney BC for several days each year training with DFO technical staff and conducting lab and oceanographic data analyses. Collaboration also includes our annual Pacific Arena 1 day workshop where all investigators, collaborators, partners, and students come together in Vancouver to discuss current results, transfer our results and knowledge to our partners and other interested user groups, and plan next year's activities. Accommodation, food, airfare, ferries - $3,000

5) Dissemination costs

a) Publication costs

Many journals which we publish in now have no page charges and reprints can be obtained and distributed electronically at no cost. Based on our previous NSERC Strategic research experience, we estimate generating at least 30 publications in the scientific literature and technical fisheries management bulletins during the duration of this grant but have only budgeted $1,000 / yr

IV Networking and Ocean Governance Theme 5

1. Project Number: IV

2. Project Title: Integrating Research and Themes across Arenas and Implications for Ocean Governance: Theme 5

NOTE: the budgets for these two components (Networking and Ocean Governance) of the Network are combined both in the original SNG proposal and in annual reporting. This report focuses on Theme 5 activities, as networking and integration are already described elsewhere throughout the annual report.

3. Theme 5 Project Leader(s): Sara Iverson (Dalhousie), David Vanderzwaag* (Dalhousie), Richard Apostle* (Dalhousie)

*D. Vanderzwaag and R. Apostle do not receive direct funding from this proposal. However, they co-chair planned workshops from which matching or partial funding is being sought from SSHRC.

Theme 5 Collaborators:

OTN Canada and OTN Global PIs:

Robert Branton (OTN Global), Steve Cook (OTN Canada, Carleton), Julian Dodson (OTN Canada, Laval), Aaron Fisk (OTN Canada, Windsor), John Ford (OTN Canada Phase II, DFO-PBS, UBC), Scott Hinch (OTN Canada, UBC), Matthew Litvak (OTN Canada, Mount Allison), Mike Stokesbury (OTN Canada, Acadia), Chris Taggart (OTN Canada, Dalhousie), Frederick Whoriskey (OTN Global)

Natural Science (NS) and Social Science (SS) collaborators:

Nigel Banks (SS, U Calgary), Doug Clark (SS, U Saskatchewan), John Duff (SS, U Massachusetts, Boston), Shaun Fluker (SS, U Calgary), Jeff Hutchings (NS, Dalhousie), Charles Norchi (SS, U Maine), John Phyne (SS, St. Francis Xavier), Michael Robinson-Dorn (SS, U California Irvine), Phillip Saunders (SS, Dalhousie), Alan Springer (NS, U Alaska Fairbanks), Chris Tollefson (U Victoria), Boris Worm, (NS, Dalhousie), Nathan Young (SS, U Ottawa)

4. Training of Highly Qualified Personnel:

a) List of the HQP and level of their salary support by SNG.

Personnel	*Title*	*%Time involved in project*	*%supported from SNG*	*Dates*
Tsafrir Gazit*	PDF	100	0	1 Oct 2010 – 30 Sep 2011
María Cecilia Engler*	PDF	90	0	1 Oct 2010 – 30 Sep 2011

**Salary support provided by SSHRC.*

b) Explain the role, activities and opportunities for training of technical staff in your project.

No technical staff is supported by this project.

5. Progress towards Objectives/Milestones (1 Oct 2010 – 30 Sep 2011)

a) Please provide brief description of the overall objectives of this project (max ½ page).

Theme 5 objectives are to examine the adequacy of existing laws, management policies, socio-economic patterns, and harvesting practices for protecting marine species at risk in the three Arenas, and to suggest ways to weave a stronger protective net in light of increasing scientific information. This research component involves integrating OTN and associated data with both national and international interdisciplinary comparisons of how adequately marine species at risk are being protected, with a focus on the roles of science, socio-economics, ethics and political factors in designating species for legal protection, granting incidental take permits, identifying critical habitats and developing recovery plans. Under the national component, social and natural science researchers from each of the three Arenas are cooperating in gauging whether existing governance arrangements are adequate to protect key marine species at risk, and if not, to suggest governance improvements.

b) Describe progress towards meeting the project's objectives and specific milestones for the project.

Two workshops on Oceans Governance for the Natural and Social Sciences were held in Halifax (November 2010; June 2011), which brought together an initial core of natural and social science researchers to informally discuss possible ways forward in synergizing interdisciplinary collaborations under the OTN umbrella. The outcome of these discussions between the social and natural scientists was a list of case studies to be further developed.

The second workshop held in June 2011, in association with other OTN Canada meetings, brought together OTN co-PIs, collaborators, PDFs and potential collaborators from the social sciences to communicate the research progress in all Arenas to date.

The title and broad theme of this 2011 workshop was: "Protecting Marine Species at Risk: towards integrating natural and social science perspectives". The major themes which have been identified for discussions include: endangered species, the precautionary principle and its uses; the social and scientific meanings of uncertainty or risk, and their communication in scientific and policy fora; and the potential issues, uses and users of knowledge produced by OTN. Based on the outcomes of this workshop, we moved ahead with several key case studies, which interface with the natural and social sciences as follows:

- Sociology of knowledge (Richard Apostle, Tsafrir Gazit and Robert Branton).
- American eel (Richard Apostle, Phillip Saunders, Julian Dodson, John Duff*)
- Sturgeon (Richard Apostle, Mike Stokesbury, Matthew Litvak, David VanderZwaag)
- Bluefin tuna (John Phyne, Mike Stokesbury)
- Grey seals (Tsafrir Gazit, Sara Iverson)
- Pacific salmon (Nathan Young, Steve Cook, Scott Hinch)

- Atlantic cod (David VanderZwaag, Cecilia Engler, Jeff Hutchings, Charles Norchi*)
- Killer whale (Chris Tollefson, Michael Dorn Robinson, John Ford)
- Northern fur seal (Alan Springer, Sara Iverson, social scientist TBC)
  *TBC

c) Describe and justify any significant deviations from the original objectives or plans, including any revised goals, new projects, or deleted projects.

As had been intended from the beginning of the OTN program, a letter of intent was prepared and submitted to the SSHRC Partnerships Grants program in Jan 2011, entitled "Tracking and Protecting Marine Species at Risk: An Interdisciplinary and International Partnership". This proposal was aimed at funding the continuation, and in fact major proportion, of the Theme 5 plans. However, this was declined to go forward. Nevertheless, the commitment to Theme 5 remains a continuing goal of the OTN Canada Network. Since funding for Theme 5 workshops and collaboration was only budgeted for in Years 1 and 2 of the SNG proposal, S. Iverson attempted (successfully) to save funds wherever possible under the larger OTN Canada program (primarily under Administration and Networking budgets), so that this important part of OTN Canada could be continued. Due to the lack of SSHRC support of the international comparative work under OTN, and the current focus on it within the Network, the social sciences and legal components will now focus on comparative North American case studies of species at risk.

d) *Describe how the work of the project's co-investigators and collaborators was coordinated and integrated*.

S. Iverson, along with collaborating SSHRC investigators D. VanderZwaag (Canada Research Chair in Ocean Law & Governance, Marine & Environmental Law Institute, Dalhousie) and R. Apostle (McCulloch Chair of Sociology and Social Anthropology, Department of Sociology and Social Anthropology, Dalhousie), along with T. Gazit (HQP), met numerous times throughout the year to work out and plan the first two workshops, and develop further connections and cooperation strategies.

e) Describe the benefits of conducting this research as part of a network rather than as a separate project (e.g., scope of the research, cross disciplinary collaborations, new synergies and research opportunities, access to ship time, planning and coordination of research activities, exchange of information and data, benefits to students and technical staff).

Without the existing infrastructure, support and collaboration within the OTN Canada Network, this work could not have happened. The Network provided the natural science contacts, and the focus of the workshops and case studies identified. Working within the Network also provided the ability to piggyback social science workshops with those of the natural sciences and hence foster greater participation and cross-fostering of ideas than would otherwise be possible. Many natural science co-PIs and HQP attending the June Symposium, were able to sit in on discussions and contribute to or get involved as they wished. In turn, the social scientists attending the Theme 5 workshops had the chance to sit in on the natural science symposium to help them put their work in context. A joint poster

session and reception for both the natural and social scientists was held one evening and allowed interactions and new collaborations to be fostered.

f) Describe the scientific and/or engineering significance of the results to date.

Key research themes and species have been identified. Several case studies are already in progress and others are pending fieldwork budget.

Plans are well underway, together with the social and natural science teams identified, for producing an invited special issue of the Journal of International Wildlife Law & Policy. The editor has tentatively agreed to have OTN pull together this issue for early 2013, which will be entitled "Tracking and Protecting Marine Species at Risk: Scientific Advances, Sea of Governance Challenges". Professor Chris Tollefson, Director of the Environmental Law Centre at the University of Victoria, has offered to host (including providing accommodations for) a major workshop in the summer of 2012 off the coast of BC to help facilitate and complete manuscripts for this issue.

6. Difficulties encountered

a) Identify the main difficulties encountered in carrying out the research during the reporting period from the list below:

- ❑ Scientific problems/difficulties
- ❑ Equipment and technology issues (e.g. delivery and malfunctioning of equipment)
- ❑ Personnel problems
- ❑ Involvement of partners
- **X** Other (specify): Funding fieldwork
- ❑ No problems occurred during this instalment of the grant

b) For each checked box, describe the difficulties identified above and the steps taken to resolve them.

Lack of field work funds has caused delays of some current case studies and the development of others.

7. Networking and outreach

Discuss the extent of networking and outreach by the project, both within the OTN Canada Network and with the broader community, by co-PIs, collaborators and HQP. Describe how the project's research has been impacted by, and contributed to, the research carried out by other projects from across the Network.

Intra-Network Collaboration and Partner Meetings and Interaction/Outreach to Broader Community

The entire Theme 5 project is about networking and outreach, both within the Network and externally – which is the basis of accomplishing our work. This extensive networking and outreach, has already been described in the previous sections of this report, and thus need not be repeated here.

As an outcome of the two workshops held in November 2010 and June 2011, key research themes and species have been identified. Several case studies are already in progress and include joint teams across Canada and the United States, comprised of social, legal and natural scientists as well as with the OTN Data Center management team. Several teams are already lined up for further case studies. Work on these case studies is pending budget. The impacts of OTN Canada's Them 5 work will reach a very broad community indeed, through the publication of the special issue of the Journal of International Wildlife Law & Policy in early 2013.

8. Dissemination of information and results

List refereed journal articles accepted/published, submitted) and conference presentations (invited, contributed). All other dissemination is included in section #9 (Other contributions and deliverables)

Refereed Journal Articles (2 total) - *Accepted/Published*

Cooke, S.J., Iverson, S.J., Stokesbury, M.J.W, Hinch, S.G., Fisk, A.T., VanderZwaag, D.L., Apostle, R. and Whoriskey, F. (in press) Ocean Tracking Network Canada: A network approach to addressing critical issues in fisheries and resource management with implications for ocean governance. Fisheries.

VanderZwaag D., Engler Palma M., Hutchings J., 2011. "Canada's Species at Risk Act and Atlantic Salmon: Cascade of Promises, Trickles of Protection, Sea of Challenges". Journal of Environmental Law and Practice.

Submitted to Science and Society:

Gazitt, T., Apostle A., Branton B. "Deployment, Tracking and Data Management - Technology and Science for a Global Ocean Tracking Network"

9. Other contributions and deliverables

Invited or contributed presentation/contribution at a workshop.

- At the OTN Canada June Symposium, R. Apostle and D. VanderZwaag gave a combined plenary presentation on the social/legal projects being conducted. They then co-hosted the 2-day social science/natural science oceans governance workshop.

Data reports, technical reports, manuscript reports, advisory documents, briefing notes, handbook or guide, checklist, barcode, CTD casts, Glider runs, and/or data deposition to an agency/database (e.g., MEDS, GenBank, OBIS, etc.), as well as a contribution to a larger piece of work in any of the former.

- As described previously, we have a commitment from the Journal of International Wildlife Law & Policy for a special issue. We plan to have a set of case study articles ready by January 2013.

10. Collaborations with Industrial and Government Partners

a) Please describe which partners are actively involved in management, research, and knowledge transfer within the network and the specifics of their involvement.

N/A

b) Cash and in-kind contributions from partners for year 2.

Name of supporting organization:	**Year 2** 2011
Cash contributions to direct costs of research	
In-kind contributions to direct costs of research	
103) Salaries for scientific and technical staff	62,876*
104) Donation of equipment, software	
105) Donation of material	
106) Field work logistics	
107) Provision of services	
108) Other (specify): _____	
In-kind contributions to indirect costs of research	
52) Use of organization's facilities	31,944**
53) Salaries of managerial and administrative staff	
54) Other (specify): _____	
Total of all in-kind contributions	94,820

*SSHRC (PDFs: Tsafrir Gazit and María Cecilia Engler)

**Full and part time office use at Sociology & Social Anthropology and Marine & Environmental Law Institute, Dalhousie

11. Expenditures and Support

Year 2 (2011)

a) Indicate your approved year 2 budget, your actual expenditures from 1 January to 30 Sep 2011 and your projected expenditures for the remainder of this installment (through to 31 December 2011).

Year 2 (2011)	Proposed	Actual Expenses 1 Jan-30 Sep 2011*	Total Balance 30 Sep 2011*	Projected Balance 31 Dec 2011**
1) Salaries and benefits				
a) Students				
b) Postdoctoral fellows				
c) Technical/professional assistants				
d) other (specify)				
2) Equipment or Facility				
a) Purchase or rental				
b) Operation and maintenance costs				
c) User fees				
3) Material and supplies				
4) Travel				
a) Conferences	90,000	34,409	55,591	55,591
b) Field work				
c) Collaboration/consultation				
5) Dissemination costs				
a) Publication costs				
b) Other activities				
6) Other (specify)				
a)				
b)				
Total	**90,000**	**34,409**	**55,591**	**55,591**

The original year 2 budget listed in the table (revised from the original proposal based on the minor year 2 funding cut) encompasses the following:

Year 2: A total of **$90K** to support both Theme 5 and Networking:
The second of two targeted ocean governance workshops would be international and broaden the scope to global issues. The requested NSERC expenditures **($20 K**) are to fund a maximum of 10 key scientists to participate along with matching or great funds from SSHRC. Drs. VanderZwaag and Apostle will also arrange invitations for appropriate social scientists, lawyers and community/end users. This workshop would be piggy-backed on the first complete OTN Canada workshop **($70 K**), which would bring in all students and the eligible PIs to the extent possible, to present results, discuss current strategies, etc. This workshop would include an extra day to hold a training session on data management, which would be targeted at students but also PIs. DFO and industry would fund travel and participation for their researchers.

b) Below, explain any significant deviations from the proposed expenditures. (Note: Changes of >20% from budget categories require advance approval from the Reprofiling Committee and NSERC, and must come first to S. Iverson).

There were no deviations from the proposed expenditures, except that we were able to come in quite considerably under budget for both the social science workshop and the OTN Canada-wide June Symposium. This was done on purpose in order to find budgetary room for a full Network Symposium again in 2012 and for further social science work, given the lack of a full SSHRC grant.

Year 3 (2012)

a) Indicate your approved year 3 budget and any revisions to that original budget that you are proposing for year 3, noting that it must sum to ≤ the original total.

Year 3 (2012)	Original	Revised	Carry Over Requested
1) Salaries and benefits			
a) Students			
b) Postdoctoral fellows			
c) Technical/professional assistants			
d) other (specify)			
2) Equipment or Facility			
a) Purchase or rental			
b) Operation and maintenance costs			
c) User fees			
3) Material and supplies			
4) Travel			
a) Conferences	0	0	55,591*
b) Field work			
c) Collaboration/consultation			33,105*
5) Dissemination costs			
a) Publication costs			
b) Other activities			
6) Other (specify)			
a)			
b)			
Total	**0**	**0**	**88,696**

*We are proposing to use the $55,591 remaining in the Networking and Theme 5 budget from 2011, and at least some of the remaining $33,105 remaining in the Administration budget from 2011 to fund a full Network Symposium again in 2012 and to extend the social science work (see report).

b) Provide a detailed justification for your year 3 budget. You may use your original justification (just as submitted in the proposal) and state that it remains on track if that is the case. For budget items that you are proposing to change, you must give a clear explanation/justification of why; these proposed changes must be approved by the SAC.

The proposed changes to the budget are, with a total of **$88K** reserved from 2011, to fund:

1) the second complete OTN Canada workshop which will again bring in all HQP and PIs, to present results, discuss current research and integration strategies, and to further advance the impact and interactions of the Network (see Overall Network report). (This was a requirement of the peer review.)

and

2) to continue the social science work started in years 1 and 2 (see report text), as follows:

OTN Canada Theme 5

The OTN governance theme (OTN theme 5) objectives are to examine the adequacy of existing laws, management policies, socio-economic patterns, and harvesting practices for protecting marine species at risk in the world oceans, and to suggest ways to weave a stronger protective net in light of increasing scientific information.

Plans:

Workshops

Two workshops held in Halifax (November 2010; June 2011) to bring together an initial core of natural and social science researchers to informally discuss possible ways forward in synergizing interdisciplinary collaborations under the Ocean Tracking Network (OTN) umbrella. The outcome of these discussions between the social and natural scientists was a list of case studies to be developed.

Current Case Studies

The work on several case studies has already started. The next meeting of the social-legal group will engage the lawyers with the current case studies (including cross-boundary issues where applicable). Teams maybe expanded based on further expressions of interest.

Case studies to be included in the Journal of International Wildlife Law & Policy special issue:

- Sociology of knowledge (Richard Apostle and Tsafrir Gazit).
  First paper draft titled "*Deployment, Tracking and Data Management - Technology and Science for a Global Ocean Tracking Network*" (with Bob Branton) will be presented in one of the upcoming conferences.
- American eel (Richard Apostle, David VanderZwaag, Cecilia Engler-Palma, Julian Dodson, John Duff*)
- Bluefin tuna (John Phyne, Mike Stokesbury, phil****)
- Pacific salmon (Nathan Young, Steve Cook, Scott Hinch)
- Atlantic cod (David VanderZwaag, Cecilia Engler-Palma, Jeff Hutchings, Richard Apostle)
- Killer whale (Chris Tollefson, Michael Dorn Robinson, John Ford****)
- Northern fur seal (Alan Springer, Sara Iverson, Phillip Saunders*, Brenda Parlee*)
- Greenland shark (Boris Worm, Brendal Davis and Aurelie Cosandey-Godhi)
- Alewife (Charles Norchi*, Tsafrir Gazit, David VanderZwaag, Cecilia Engler-Palma)
- Right Whale (Chris Taggert, Tsafrir Gazit, Charles Norchi*)

On-going case studies:

- Grey seals (Tsafrir Gazit, Sara Iverson, Katie Sykes)
- Sturgeon (Richard Apostle, Mike Stokesbury, Matthew Litvak, David VanderZwaag, Cecilia Engler-Palma, Phillip Saunders)

*TBD

Possible future Case Studies

- Polar bear
- Leatherback turtles
- Humboldt squid

Future Case studies

- Canada - Australia
  David VanderZwaag will be in Australia in the next couple of months, and he will try to move forward with the Australia-Canada Oceans Research Network (ACORN) on Canadian – Australian comparative case studies.

Publications

We have a commitment from the Journal of International Wildlife Law & Policy for a special issue. We plan to have a set of case study articles ready by January 2013.

Funding

1) Workshops (SSHRC funds)

Two workshops planned to be held on the east coast (late spring, 2012) and the west coast (fall, 2012). Specific dates are yet to be determined. **Estimated costs below are expected to be covered by SSHRC funds being held (yet to release the funds).**

Workshops:	**Budget**
East coast	15,000
West coast	35,000
Total:	50,000

2) Field work (OTN Canada funds)

- Currently there is no funding for theme 5 fieldwork. For the current case studies we estimate the following costs (Travel, Research assistants):

Fieldwork Budget:

American eel	Travel	$1,680.00		Two trips to Quebec City
	Accommodation	$2,100.00		14 days
	Per Diem	$658.00		15 days
	RA	$1,200.00		HRAF analysis (80h)
	International Travel	$1,200.00		Washington (3 days) David VanderZwaag, Richard Apostle
	Accommodation	$900.00		3 Days
	Per Diem	$421.50		3 Days
		Sub Total:	$8,159.50	
Sturgeon	Travel	$420.00		Saint John River
	Accommodation	$175.00		Private - 7 days
	Per Diem	$329.00		7 days
		Sub Total:	$924.00	
Bluefin tuna	Travel	$1,260.00		3000 Km
	Per Diem*	$1,200.00		15 days x 2
	RA*	$3,600.00		20 hrs per week X 12 weeks (May to July)
		Sub Total:	$6,060.00	
Pacific Salmon	Travel	$3,010.00		Travel for fieldwork by the Principal Investigator and PhD (Two field research trips from Ottawa to Vancouver return, each trip lasting approximately 5 working days)
	Rental Car	$920.00		Travel for fieldwork by the Principal Investigator and PhD (Two field research trips from Ottawa to Vancouver return, each trip lasting approximately 5 working days)
	Accommodation	$1,050.00		
	Per Diem	$940.00		
	RA	$7,500.00		
		Sub Total:	$13,420.00	
Grey seals	Travel	$1,470.00		3500 Km (New Brunswick, Maine)
	Accommodation	$1,500.00		10 days
	Per Diem	$470.00		10 days
		Sub Total:	$3,440.00	
Alewife / Right whale	Travel	$840.00		2000 Km (New Brunswick, Maine)
	Accommodation	$900.00		6 days
	Per Diem	$282.00		6 days
		Sub Total:	$2,022.00	
		Total:	**$34,025.50**	

*STFX rate, **University of Ottawa rate

Budget Justification:

Personnel: Some of the above case studies will require a graduate level Research Assistant to aid in the research design, collection of data, and data analysis.

Travel: This research will require at least two round trips from Ottawa to Vancouver to conduct the necessary fieldwork. Travel is necessary to meet with colleagues working in the field, various stakeholders and to collect data.

Travel for the graduate student RA: The RA will also be involved in data collection and therefore will also make research trips to relevant locations.

Ocean Tracking Network Canada OTNC **NSERC**
Progress Report Year 2 Review: 1 October 2010 – 30 September 2011

Ocean Tracking Network Canada Secretariat

1. Project Number: V

2. Project Title: OTN Canada Secretariat

3. Project Leader(s): Sara Iverson (Scientific Director, Dalhousie), Daniela Turk (Network manager, Dalhousie)

4. Training of Highly Qualified Personnel:

a) List of the HQP and level of their salary support by SNG.

Personnel	*Title*	*%Time involved in project*	*%supported from SNG*	*Dates*
Sara Iverson	Scientific Director	75	0	1 Jan – 30 Sep 2011
Daniela Turk	Network Manager	100	100	1 Jan – 30 Sep 2011
Justin Frank	Administrative Asst.	100	100	1 April – 31 May 2011
Chelsea De Carufel	Administrative Asst.	100	100	1 Jun – 31 Sep 2011
Shauna Baillie	Administrative Asst.	100	100	1 Oct – present

Note: J. Frank and C. De Carufel were hired temporarily to provide administrative support until a permanent administrative assistant (S. Baillie) could be hired.

5. Progress towards Objectives/Milestones (1 Oct 2010 – 30 Sep 2011)

a) Please provide brief description of the overall objectives of this project (max ½ page).

The main objectives of the Secretariat in Y2 are listed bellow:

i) Office operation and HR.

- Participate in regular Network and OTN Global management meetings
- Conduct daily office duties and equip the office.
- Hire administrative assistant

ii) Finances and Budget re-allocation

- Oversee financial management of the Network
- Oversee reprofiling of projects and budgets as necessary
- Oversee and produce annual consolidated budget report to NSERC (NSERC Form 300 to be provided by Financial Services).

iii) Meetings/Symposium/Workshops and outreach

- Organize and host 1st OTN Canada Symposium.
- Organize Oceans Governance/Social Science Workshops.
- Organize Annual SAC and TLC meetings/conference calls.

- General outreach, communication and promotion of the Network

iv) Annual reports

- Produce consolidated annual progress report for projects active in 2011 and 2012.

v) Website and Newsletter

- Populate OTN Canada website
- Produce a Newsletter to be distributed to OTN, sponsors and related international community.

vi) Data management

- Meet with OTN global data management team to discuss data policy, requirements, metadata etc.

vii) Communication with OTN Global and funding partners.

b) Describe progress towards meeting the project objectives. How are the original milestones being met?

The Secretariat has followed up on all the main objectives and made good progress to meeting the milestones for the second year, as further described below.

i) Office operation and HR:

Sara Iverson is the Scientific Director for the OTN Canada Network and spearheaded the development of the SNG proposal, as well as oversees the execution of its research program and the Network as a whole. She oversees reports to both NSERC and the SAC, as well as the Executive Director of OTN and the Vice President Research Dalhousie. As Scientific Director, she serves on the following committees:

- the OTN Canada SAC, which meets twice yearly (once in person) and advises and reports on the planning and coordination among all projects undertaken under the OTN umbrella in Canada,
- the OTN Management Committee, which meets monthly, to ensure that the OTN (Global and Canada), and the projects undertaken within its umbrella, are managed responsibly, and in accordance with CFI and NSERC guidelines and Dalhousie University regulations and policy. S. Iverson submits a monthly written report to this committee updating on progress and issues within the OTN Canada Network.
- the Global Project Coordination Committee, which meets annually and advises and reports on the planning and coordination among all projects undertaken in countries around the world under the OTN umbrella, and
- the OTN Council, which meets twice yearly, and is the stewardship body for all of OTN (Global and Canada) on behalf of Dalhousie University and other stakeholders; the Council provides direction to the scientific and management affairs of the OTN that will ensure its development and enhance the value of its research leadership and assure its financial and scientific management.
- the Global Redeployment Committee, a committee of three people plus invited experts, which evaluates redeployment requests for OTN lines worldwide and makes recommendations to OTN Council.

Daniela Turk is the Network Manager. She assists the Scientific Director in overseeing the administrative management of the Network. She works closely with the Dalhousie/OTN Global communication officers on joint efforts with communications/dissemination of research results and

acts as liaison with Global management personnel on issues related to data management. She reports to the Scientific Director of OTN Canada and the Executive Director of OTN. As Network Manager, she serves on the following committees:

- the OTN Canada SAC
- the OTN Management Committee

Shauna Baillie was hired as an Administrative assistant in October 1st, 2011. She works closely with the Scientific Director and Network Manager on budget issues, meeting organization, annual report assembly and network communication.

*Note: In response to peer reviews of the original SNG proposal and several financial issues arising, S. Iverson attempted (successfully) to find budgetary room for several required components of the overall Network program that were not originally planned budgeted for (see ***c) Budget Deviation*** below). One of the means by which this was accomplished was to delay the hiring of a full-time permanent administrative assistant. This resulted in an excessive burden on the secretariat to accomplish its work in the first 1.5 years of the program, but has resulted in the ability successfully fund required components of the OTN Canada program (see budget proposals for year 3). The secretariat is now fully in place and will be able to function more effectively.

Office Set up: The OTN Canada Secretariat is currently located at Dalhousie University in the Life Sciences Centre. Scientific Director, S. Iverson has an office, as a professor within the Department of Biology. D. Turk, the Network Manager temporary shares the office with OTN Global personnel. Administrative Assistant S. Baillie is located within S. Iverson's offices in the Department of Biology. Dalhousie is planning for a new space to be made available for the Secretariat Office (D. Turk and S. Baillie) in the new Oceans Excellence Centre building upon completion (approx January 2013).

ii) Finances and Budget re-allocation

Reprofiling. This Sub-committee is comprised of a core of three members (currently A. Fisk (chair), J. Cullen, and S. Hinch) to be supplemented with additional specific expertise as needed. If one of the three members of this committee is the requester, NSERC has approved that S. Iverson serves as their replacement on the committee for that request. The committee would be called to meet only as issues and needs arise. The committee will review, make recommendations, and report to Sara Iverson, the OTN Canada Scientific Director, who will then report to the SAC and NSERC. In this manner due process should be carried out in fairly making any such decisions.

Two requests were received during the 2011 report year by I. Flemming and A. Fisk and were unanimously approved by the Sub-committee and the SAC. In submitting budgets and justifications for approval for yearly budgets during the time of annual reports, such requests will necessarily be a part of the SAC's review and approval of the projects' budgets. The most significant of these will be the reallocation resulting from T. Dick's resignation from OTN activities. A Fisk (U Windsor) has stepped in as replacement for T. Dick on OTN Council, and S. Vagle (U Victoria, DFO) has stepped in as 2nd Arctic theme leader and SAC member. All of the funds T. Dick has held at U Manitoba and proposed in the

future will be held and managed by A. Fisk at U Windsor (pending approval by the SAC), but with the planned Arctic program to essentially remain in place, and in fact should run more smoothly. All Arctic PIs are working very closely together to make this happen.

Other financial matters. Currently the SNG is held as one account at Dalhousie, with an agreement to subdivide this into 3 accounts: 1 for administration, 1 for all of Dalhousie oceanography (I.1) projects (3 separate projects), and 1 for everything else, including all institutional transfers, all other research projects held at Dalhousie, all networking budget items, and all Theme budget items. However, Dalhousie is producing a single Form 300 for submission to NSERC at the time of the annual report. This has proved to be extremely difficult to manage and report in a matching and transparent manner to NSERC and the SAC, both within and between these accounts, especially for the latter two accounts that combine a number of separate budgets. We expect this to be a discussion point for the SAC at the 2011 annual review, with a request to Dalhousie's finance head to allow for further separate accounts to be created and reported on through separate Form 300s.

iii) Meetings/Symposium/Workshops and outreach

The following describes meetings and workshops mostly within OTN Canada, those extending beyond the Network and other outreach and promotion of the Network are described in section **7**.

The Secretariat organized the 1st OTN Canada Symposium and associated workshops, two SAC meetings, several TLC conference calls, and assisted in organization of Arena meetings. Secretariat staff was responsible for producing the agenda, arranging presentations, extensive logistical arrangements, communicating the information regarding the meetings to the OTN Canada network, preparing the information to be listed on the web site, and producing minutes and summaries.

First Annual OTN Canada Symposium in Halifax

In June 1-3, 2011, we held the First Annual OTN Canada-wide Symposium in Halifax, NS. The purpose of this symposium was to bring together all students, PDFs, and PIs to present projects and results, discuss research strategies, and focus on integration of the OTN Canada Network and sharing of research tools and programs within and across Arenas. The first day of the Symposium featured keynote talks by Arena Leaders and the social science collaborators PIs, followed by presentations by HQP, the first meeting of the partnership of core social/legal researchers, and a late-afternoon/evening poster and wine and cheese reception for both the natural and social scientists. The second day of the symposium consisted of five workshops, and the third day of the symposium was devoted to a networking session. The symposium provided one of the first opportunities for many of the HQP to meet, as well as the first time for some of the PIs to meet each other. A lot of excitement and momentum was generated as a result. Full details are provided in the OTN Canada Network Overview at the beginning of this document.

OTN Workshop on Ocean Governance

The first OTN Workshop on Ocean Governance was held in Nov 2010 and the second, larger workshop was held on June 1-2, 2011 in conjunction with the First Annual OTN Canada Symposium The overall purpose of these workshops was to bring together an initial core of natural and social science

researchers to discuss possible ways forward in synergizing specific interdisciplinary collaborations under the Ocean Tracking Network (OTN) umbrella. The interfacing of natural and social sciences was strongly recommended in the respective NSERC and SSHRC funding programs. Full details of this project of the Network are provided in the Theme 5 report (IV) in this document.

SAC meetings

The OTN Canada Scientific Advisory Committee (SAC) held a working lunch meeting on Friday, 3 June 2011 in conjunction with 1st OTN Canada Symposium. This was not a complete SAC meeting but allowed those who were already present to have an interim discussion and address some current issues. The meeting focused on a briefing from the symposium, progress on networking and integration, reprofiling and technical issues, and format and revisions of annual scientific progress reports.

The 2nd annual face-to-face SAC Meeting is scheduled for 22-23 November 2011 in Halifax (also in association with the OTN Global Council meeting). The main objectives of this SAC are to review research progress of the Network, approve year 2 reports and budgets and review and approve proposed budgets for year 3, to ensure that milestones are on target, as well as to discuss any current or arising issues and planning for the Network.

TLC meetings

I. Jonsen stepped down from the TLC due to his changing research commitments and I. Flemming is appointed as "acting" member from the Atlantic arena**.**

The TLC held several conference calls during the year to discuss planning of the 1st OTN Canada Symposium, and had a face-to-face meeting during the Symposium The TLC communicates actively with Secretariat via email.

iv) Annual reports

An annual progress report template was modified to include the comments from the SAC meetings in both Nov 2010 and June 2011, as well as from comments made during the June Symposium. The template was distributed to PIs to be completed by October 15th. The Secretariat made extensive efforts to consolidate and format the reports submitted, seek corrections and additional information where insufficient, produce network summaries, and to correct and assemble complete budget reports. These are being to the SAC for final approval at the SAC Nov meeting. NSERC Form 300s from all institutions are being provided Financial Services.

v) Website and Newsletter

Jointly with OTN Global we are producing a bi-annual OTN Newsletter. The first addition was completed in June 2011 and distributed to OTN Canada researchers and a much wider audience at the 1st OTN Canada June Symposium, to our sponsors, relevant Dalhousie departments, to the OTN Global community and to all the events attended during the Dalhousie Oceans Week celebration in June. The

newsletter was very well received. Work on the 2nd combined newsletter for OTN Global and OTN Canada is underway with the plan for it to be issued with the holiday season in December.

The OTN Canada website (otncanada.org) has been a good source of information for OTN Canada researchers and the Global community. It continues to be populated and expanded. Plans are underway to significantly increase the input into this website with the assistance of the new administrative assistance and especially new student and HQP involvement.

vi) Data management

S. Iverson and D. Turk have met several times with the OTN Global Data management team (Bob Branton and Lenore Bajona) to discuss data flow. Discovery Metadata is now available on a web portal that is currently under review by the PIs. The OTN Canada metadata can be found online at http://members.oceantrack.org/data/discovery/new2/OTNCanada.htm. This metadata allows data to be discoverable via the internet and provides users with a contact point to learn more about the data. The metadata will also be used in things like the GoogleEarth application. Further information on OTN Data Policy is available online (http://www.marinebiodiversity.ca/OTN/policies/otn-data-policy-ver-11-oct-30).

vii) Communication with OTN Global and funding partners

The Secretariat has been communicating regularly with OTN Global personnel on joint efforts including data management, web pages, organization of meetings, establishing a plan of projects, technician requirements, etc. S. Iverson and D. Turk attend and contribute to monthly OTN Global Management Committee Meetings and S. Iverson presents the update on OTN Canada. She also attends OTN Council and Global Coordination meetings. S. Iverson has continued to be in contact with NSERC in terms of Network issues and deadlines, and with DFO in terms of partnering of funding.

c) Describe and justify any significant deviations from the original objectives or plans, including any revised goals, new projects, or deleted projects.

Budget Deviation:
In response to several financial issues arising, S. Iverson sought to find budgetary room for several required components of the overall Network program that were not originally budgeted for.
i) One of the concerns of reviewers was to ensure that there was significant interchange and integration within and across Arenas. In response to the peer reviews, we wrote: “after discussing the importance of these issues in response to reviewers’ comments, it is the consensus of the OTN Canada proposal steering committee that we make budgetary room for an additional full OTN Canada workshop in Year 3 [2012]. By adding this one workshop, this would ensure full co-PI/HQP workshops in Years 2, 3 and 4 consecutively, to ensure that integration and cross-Arena projects begin as soon as possible in the program and at the latest by the midway review.”
ii) A second budgetary concern arose from the decline of the pre-proposal for the SSHRC Partnership Grant in early 2011, which was intended to carry forward the plans for Theme 5 and issues for oceans governance (this was only budgeted for in years 1 and 2 of the SNG). This aspect of the OTN Canada

Network remains a high priority and commitment and thus funding is needed for additional workshops, field work and collaborative writing.

As described above, one way to find budgetary room for these needs was to delay the hiring of a full-time permanent administrative assistant. We did so until it was no longer possible with the workload encountered by the secretariat. Another means was that we were able to save on expected expenditures for the SAC meetings, the previous governance workshops, and the June Symposium through various cost-cutting measures. This has resulted in the ability to now successfully fund these required components of the OTN Canada program for year 3, 2012 (see budget details).

Change of SAC composition:
The SAC structure was altered to include two co-leaders for each Arena, instead of a single individual for each. SAC member Terry Dick (U Manitoba) has officially resigned from the OTN and is replaced by Svein Vagle (U Victoria, DFO-IOS). The current composition of SAC includes two members from each Arena representing 6 institutions: Atlantic: Ian Fleming (MUN) and Katja Fennel (Dal), Arctic: Aaron Fisk (U Windsor) and Svein Vagle (DFO-IOS, UVIC), Pacific: Scott Hinch (UBC) and Steve Cooke (Carleton U).

Change in TLC composition:
I. Jonsen stepped down from the TLC due to his current research commitments and I. Flemming has been appointed as acting member from the Atlantic arena.

d) *Describe how the work of the project's co-investigators and collaborators was coordinated and integrated*.

See overall network report.

e) Describe the benefits of conducting this research as part of a network rather than as a separate project (e.g., scope of the research, cross disciplinary collaborations, new synergies and research opportunities, access to ship time, planning and coordination of research activities, exchange of information and data, benefits to students and technical staff).

See overall network report.

f) Describe the scientific and/or engineering significance of the results to date.

N/A

6. Difficulties encountered

a) Identify the main difficulties encountered in carrying out the research during the reporting period from the list below:

√ Other (specify): _Annual report assembly_____

b) For each checked box, describe the difficulties identified above and the steps taken to resolve them.

The secretariat experiences difficulties with assembling the annual report due to late submissions and incomplete individual reports submitted by PIs. Hence, the effort of the secretariat required to put these together in a timely fashion for distribution to the SAC becomes compromised. This issue, along with the account separation issues (see **5** ii. *Other financial matters* above), will be discussed at the upcoming SAC meeting.

7. Networking and outreach

Discuss the extent of networking and outreach by the project, both within the OTN Canada Network and with the broader community, by co-PIs, collaborators and HQP. Describe how the project's research has been impacted by, and contributed to, the research carried out by other projects from across the Network.

The secretariat has continually provided ideas, extensive organizational support, and assistance in facilitation of networking, integration and outreach to the Network. Some of the examples are given bellow, while more details can be found in the Overall Network section of this report. The secretariat has also been very active in communicating and promoting aspects of the Network externally.

Intra-Network Collaboration and Partner Meetings

S. Iverson and D. Turk, together with collaborating social scientists D. Vanderzwaag and R. Apostle (and their students) and OTN Executive Director F. Whoriskey, conducted numerous meetings to discuss and plan for both the first (Nov 2010) second (June 2011) oceans governance workshops, which also included extending to the broader natural and social science community for input and invitations. S. Iverson continues to actively plan the future Theme 5 projects with D. Vanderzwaag and R. Apostle and meets with them on a monthly basis. S. Iverson worked with D. Vanderzwaag and R. Apostle on the initial pre-proposal to SSHRC, traveled with them to Ottawa to meet with SSHRC when it was declined as a fact finding mission, and is working with them again on a new pre-proposal for another attempt for a SSHRC grant.

S. Iverson and D. Turk meet regularly with TLC members and individual researchers and students to address Network and research issues and to help solve problems. S. Iverson worked extensively with Arctic researchers to resolve issues created by the resignation of T. Dick. Both S. Iverson and D. Turk attended and helped host the spring Atlantic Arena meeting, both attend monthly OTN Global-Canada Management meetings and the SAC, and S. Iverson sit on a number of other bodies which govern OTN as a whole (see 5a ii above).

S. Iverson and D. Turk hosted the 1st OTN Canada Symposium in June 2011 and S. Iverson led the networking session on the last day (see the OTN Canada Network Overview for full details).

Interaction/Outreach to Broader Community

S. Iverson attended the "Census of Marine Life and Beyond" workshop in Ottawa in Jan 2011 and presented both the concept of OTN Canada's research programs to other Canadian Networks and discussed potential collaborations and the future of some of the Networks. S. Iverson also attended the 1st Northwest Atlantic OTN Regional Meeting in Feb 2011 and discussed the research programs of OTN Canada and links with other agencies. S Iverson also attended the CHONe meetings in Montreal in April 2011 to help further establish contacts with other related NSERC Networks.

S. Iverson, together with representative members of OTN Canada - Steven Cooke (Pacific, lead author), Michael Stokesbury (Atlantic), Scott Hinch (Pacific), Aaron Fisk (Arctic), David Vanderzwaag (Theme 5), Richard Apostle (Theme 5), Fred Whoriskey (OTN Global) – submitted an invited paper in May 2011 to "Fisheries" (sponsored by the Canadian Aquatic Resources Section of the American Fisheries Society) entitled: "Ocean Tracking Network Canada: A network approach to addressing critical issues in fisheries and resource management with implications for ocean governance".

From Jan-June 2011, S. Iverson represented OTN Canada on the Oceans Week Planning Committee for planning and organizing the events of Dalhousie Oceans Week and attending the Launch of the Halifax Marine Research Institute. As part of these events, which the OTN Canada June Symposium kicked off, S. Iverson gave one of three widely advertised evening public lectures, in which she focused on both OTN Canada's research program and initial results.

A special session entitled "Integrating Oceanography and Animal Tracking- the Ocean Tracking Network" submitted by S. Iverson, D. Turk and several OTN Global members to be held at the 2012 Ocean Sciences meeting, 20-24 Feb, Salt Lake City was accepted by the organizers. We received 20 submitted abstracts (8 from OTN Canada researchers). The Ocean Sciences meeting is a large venue for scientific exchange across broad marine science disciplines, co-sponsored by AGU, ASLO, TOS and should be an exciting opportunity to introduce OTN to a very large group who may be largely unaware of OTN. S. Iverson and D. Turk are responsible for advertizing of the session to OTN Canada and international community, coordination with other sessions addressing similar topics and for presentation assignment.

During the report year, S. Iverson was extensively involved in the search and planning for the proposed NSERC Industrial Research Chairs program with Vemco. She served on the search and interview committee (Department of Biology) for two candidate positions (selected in April 2011), and subsequently was asked to take the lead on the development of both the pre-applications and subsequent full applications. S. Iverson organized a science planning and industry team, which met with the two candidates in September 2011 to begin development of the research programs, and has since continued to work with them closely on developing their proposals.

S. Iverson was asked to be part of the proposal team for application for a CFI Major Science Initiatives grant to further extend the operations and maintenance support for OTN Global, upon which OTN Canada relies very heavily for their continued functioning and success.

See overall network report for additional information.

8. Dissemination of information and results

List refereed journal articles accepted/published, submitted) and conference presentations (invited, contributed). All other dissemination is included in section #9 Deliverables)

Refereed Journal Articles (2 total) - *Accepted/Published*

Cooke, S.J., Iverson, S.J., Stokesbury, M.J.W, Hinch, S.G., Fisk, A.T., VanderZwaag, D.L., Apostle, R. and Whoriskey, F. (in press) Ocean Tracking Network Canada: A network approach to addressing critical issues in fisheries and resource management with implications for ocean governance. Fisheries.

9. Other contributions and deliverables

See the OTN Canada Network Overview for further details.

10. Collaborations with Industrial and Government Partners

a) Please describe which partners are actively involved in management, research, and knowledge transfer within the network and the specifics of their involvement.

b) Cash and in-kind contributions from partners for year 2

Name of supporting organization: **CFI**	**Year 1** (1 Jan – 30 Sep 2010)
Cash contributions to direct costs of research	
In-kind contributions to direct costs of research	
109) Salaries for scientific and technical staff	**
110) Provision of services	**

Indirect costs:

1) Salaries of managerial and administrative staff that assist the Secretariat:
   - Bob Branton, Director of Data Management
   - Susan Dufault, Data Manager
2) Provision of services through use of data management team and website assistance

Name of supporting organization: **Dalhousie University**	**Year 1** (1 Jan – 30 Sep 2010)
Cash contributions to direct costs of research	12,000
In-kind contributions to direct costs of research	
111) Salaries for scientific and technical staff	
112) Donation of equipment, software	
113) Donation of material	
114) Field work logistics	
115) Provision of services	
116) Other (specify): _____	
In-kind contributions to indirect costs of research	
55) Use of organization's facilities	1,311
56) Salaries of managerial and administrative staff	
57) Other (specify): _____	30,103
Total of all in-kind contributions	43,414

Direct costs:

1) Salaries for scientific and technical staff

- Salary support for teaching replacement (limited term appointments) for Scientific Director S. Iverson ($12,000).

Indirect costs:

1) Use of organization's facilities

- Annual rental of office space for OTN secretariat (Network manager D. Turk), 138 square feet at $9.50sq/ft $1,311;

2 and 3) Salaries of managerial and administrative staff and other:

- Dalhousie is contributing administrative, legal and other support services (basic administrative and infrastructure support, services of the research grants, and financial services offices, insurance, security, library access etc.). This support constitutes an additional in kind contribution of approximately $210,718 (for years 1 to 7).

11. Expenditures and Support

Year 2 (2011)

a) Indicate your approved year 2 budget, your actual expenditures from 1 January to 30 Sep 2011 and your projected expenditures for the remainder of this installment (through to 31 December 2011).

Year 2 (2011)	Proposed	Actual Expenses 1 Jan-30 Sep 2011*	Total Balance 30 Sep 2011*	Projected Balance 31 Dec 2011**
1) Salaries and benefits				
a) Students				
b) Postdoctoral fellows				
c) Technical/professional assistants				
d) Staff positions	131,881	71,756	60,125	29,925
2) Equipment or Facility				
a) Purchase or rental		1,358	-1,358	-1,358
b) Operation and maintenance costs				
c) User fees				
3) Material and supplies	8,950	1,276	7,674	4,674
4) Travel				
a) Conferences	15,450	6,568	8,882	-2,318
b) Field work				
c) Collaboration/consultation	5,150	3,634	1,516	1,516
5) Dissemination costs				
a) Publication costs	2,000	834	1,166	666
b) Other activities				
6) Other (specify)				
a)				
b)				
Total	**163,431**	**85,426**	**78,005**	**33,105***

* We request that the $33,105 balance be considered as carry over toward Theme 5: Networking and Ocean Governance. [Please see Admin Year 3 budget (below), as well as Networking and Ocean Governance Year 3 budget (above) tables].

The original year 2 budget listed in the table (revised from the original proposal based on the minor year 2 funding cut) encompasses the following:
1) Salaries:
d) Network Manager and Administrative Assistant

3) Materials and supplies: including office supplies, postage, courier charges, long distance telephone charges, printing and teleconference costs for the Scientific and Network Directors, Admin Assistant and the Scientific Advisory Committee

4) Travel
a) Conferences – the annual SAC meeting
c) Collaboration/consultation – travel for OTN Canada staff for communication and collaboration and outreach.

b) Below, explain any significant deviations from the proposed expenditures. (Note: Changes of >20% from budget categories require advance approval from the Reprofiling Committee and NSERC, and must come first to S. Iverson).

There was expenditure of equipment (computer for the Administrative Assistant), which was supposed to have been purchased in year 1 but delayed. There were no other deviations from the proposed expenditures, except that we were able to come in considerably under budget, especially by delaying the hiring of the Administrative Assistant. This was done on purpose in order to find budgetary room for a full Network Symposium again in 2012 and for further social science work (see report).

Year 3 (2012)

a) Using the same excel form provided, indicate your approved year 3 budget (already entered for you) and any revisions to that original budget that you are proposing for year 3, noting that it must sum to ≤ the original total.

Year 3 (2012)	Original	Revised	Carry Over Requested
1) Salaries and benefits			
a) Students			
b) Postdoctoral fellows			
c) Technical/professional assistants			
d) Staff positions	135,838	135,838	
2) Equipment or Facility			
a) Purchase or rental			
b) Operation and maintenance costs			
c) User fees			
3) Material and supplies	10,609	10,609	
4) Travel			
a) Conferences	15,914	15,914	
b) Field work			
c) Collaboration/consultation	5,305	5,305	33,105*
5) Dissemination costs			
a) Publication costs	5,305	5,305	
b) Other activities			
6) Other (specify)			
a)			
b)			
Total	**172,971**	**172,971**	**33,105***

*Carry over: We are proposing to use at least some of the remaining $33,000 in the Administration budget from 2011 (and the $55,591 remaining in the Networking and Theme 5 budget from 2011) to fund a full Network Symposium in 2012 and to extend the social science work (see overview report, and Networking and Theme 5 report). Also please see Networking and Ocean Governance Year 3 budget table (above). Note that this figure $33,105 is seen in Carry Over Requested toward Year 3 tables for both Projects IV and V. However, we are only asking for carry over of this figure just once, which originated as Balance in the Administration project Year 2 (see Year 2 Admin above) and we are requesting to be put toward Carry Over in Networking and Ocean Governance.

The Administrative budget remains unchanged from that in the accepted proposal.

b) Provide a detailed justification for your year 3 budget. You may use your original justification (just as submitted in the proposal) and state that it remains on track if that is the case. For budget items that you are proposing to change, you must give a clear explanation/justification of why; these proposed changes must be approved by the SAC.

Unchanged original year 3 budget:

1) Salaries:
d) Network Manager and Administrative Assistant

3) Materials and supplies: including office supplies, postage, courier charges, long distance telephone charges, printing and teleconference costs for the Scientific and Network Directors, Admin Assistant and the Scientific Advisory Committee

4) Travel
a) Conferences – the annual SAC meeting
c) Collaboration/consultation – travel for OTN Canada staff for communication and collaboration and outreach.

The proposed budget for carry over is to fund:

1) the second complete OTN Canada workshop which will again bring in all HQP and PIs, to present results, discuss current research and integration strategies, and to further advance the impact and interactions of the Network (see Overall Network report),

and

2) to continue the social science work started in years 1 and 2 (see report text).

Appendix A. Training of Highly Qualified Personnel (HQP)

Table 1. Summary of the number of Highly Qualified Personnel (HQP) trained within the scientific program of OTN Canada by Arena.

	Atlantic Arena		**Arctic Arena**		**Pacific Arena**	
HQP	**Total**	Supported completely by grant	**Total**	Supported completely by grant	**Total**	Supported completely by grant
Undergraduate	10	6	1	1	3	2
MSc	9	6	3	3	7	4
PhD	11	5	2	1	5	3
Post-Doctoral Fellows	6	3	4	1	3	1
Research Associates	3	2	-	-	1	1
Technicians	6	1	1	-	5	-
Total	**45**	**23**	**11**	**6**	**24**	**11**

I. Atlantic Arena

I.1 Integrated Interdisciplinary Observing and Modeling Platform
I.1.1 Observing Component

Matthew Beck	MSc, Dalhousie University
Franziska Bröll	PhD, Dalhousie University
Andre Benzanson	PhD, Dalhousie University
Mathieu Dever	PhD, Dalhousie University
Adam Comeau	Research Technician, Dalhousie University
Richard Davis	Research Technician, Dalhousie University
Jon Pye	Research Technician, Dalhousie University
Amy Ryan	Research Assistant, Dalhousie University

I.1.2 Integrated Physical and Biological Modeling Component

Karl Lagman	PhD, Dalhousie University
Paul Mattern	PhD, Dalhousie University
Shiliang Shan	PhD, Dalhousie University
Jorge Urrego-Blanco	PhD, Dalhousie University
Laura Bianucci	PDF, Dalhousie University
Daisuke Hasegawa	PDF. Dalhousie University
Kyoko Ohashi	PDF. Dalhousie University

I.1.3 Data Assimilation

Anna Katavouta	PhD, Dalhousie University
Vasily Korabel	Research Associate, Dalhousie University

I.2 Migratory Marine Living Resources and Trophic Interactions

I.2.1 Atlantic Salmon (*Salmo salar*): Migration, Distribution, and Oceanographic Features

Chris McQuaid	BSc, Cape Breton University
Stacey Pettipas	BSc. Cape Breton University
David Woodland	BSc. Cape Breton University
Edmund Halfyard	PhD, Dalhousie University
Connie Conway	Technician, Dalhousie University

I.2.2 Estuarine and Oceanic Migrations of the Juvenile and Reproductive Stages of the American Eel (*Anguilla rostrata*)

José Benchetrit	MSc, Laval University
Mélanie Béguer-Pon	PDF, Laval University
Simon Bernatchez	Research Assistant. Laval University

I.2.3 Atlantic Sturgeon on the East Coast of Canada: Migratory Behavior and Origin, and the Potential for Tidal Power Impacts

Christine Adams	BSc, Mount Allison University
Justin Barkhouse	BSc, Mount Allison University
Colin Burhiliwalla	BSc, Acadia University
Alicia Cassidy	BSc, Mount Allison University
William Roberts	BSc, Acadia University
Andrew Taylor	BSc, Mount Allison University
Jeffrey Beardsall	MSc, Acadia University
Jeremy Broome	MSc, Acadia University
Bridgitte Donovan	MSc, University of Prince Edward Island
Montana McLean	MSc. Acadia University
Andrew Taylor	MSc. Mount Allison University
Sierra Wehrell	MSc. Acadia University
Sima Usvyatsov	PhD, University of New Brunswick St John

I.2.4 Grey Seals (*Halichoreus grypus*) as Bioprobes: Spatial and Temporal Interactions with Prey and Physical Oceanography, *and*
I.2.5 Design Principles for OTN and Climate Change Impacts on Leatherback Turtle (*Dermochelys coriacea*) Foraging and Distribution.

Joey Hartling	BSc, Dalhousie University
Stuart Carson	MSc, Dalhousie University
Susan Heaslip	PhD, Dalhousie University
Ian Jonsen	Research Associate, Dalhousie University
Shelley Lang	PDF/Research Associate, Dalhousie University
Damian Lidgard	PDF/Research Associate, Dalhousie University

II. Arctic Arena

II.1 Ocean Physics, Migratory Marine Living Resources, and Trophic Interactions
II.1.1 Testing and Applying New Technology to the Arctic Marine Ecosystem;
II.1.2 Oceanography of the Arctic Arena;
II.1.3 Movement of Arctic char and Sculpin in Relation to Physical Variables in the Canadian Arctic: Frobisher Bay/Lancaster Sound;
II.1.4 Monitoring Bay- and Basin-Scale Movements of Arctic Cod (*Boregadus saida*) in Relation to Biotic and Abiotic Habitat Across Diverse Time Scales: Barrow Straight (Resolute); *and*
II.1.5 Trophic Interactions and Movements of Arctic Fish and Marine Mammals in a changing Cumberland Sound Ecosystem.

Eric Primeau	BSc, University of Windsor
Jordan Matley	MSc, University of Manitoba
Iva Peklova	MSc, University of Windsor
David Yurkowski	MSc, University of Windsor
Jeanette Bedard	PhD, University of Victoria
Cory Matthews	PhD, University of Manitoba
Bernard LeBlanc	Technician, University of Windsor

III. Pacific Arena

III.1 Ocean Physics, Migratory Marine Living Resources, and Trophic Interactions
III.1.1 Ocean Physics and Modeling, and Impact of Climate Variability
III.1.2 Biology and Behaviour of Migratory Marine Living Resources, and Impacts of Climate Variability

Sylvia Chow	BSc, University of British Columbia
Michael Lawrence	BSc, University of British Columbia
Jeff Nitychoruk	BSc, Carleton University
Alison Collins	MSc, University of British Columbia
Marika Gale	MSc, University of British Columbia

Sarah LaRocque	MSc, Carleton University
Vivian Nguyen	MSc, Carleton University
Kendra Robinson	MSc, University of British Columbia
Charlotte Whitney	MSc, University of British Columbia
Samantha Wilson	MSc, Carleton University
Nolan Bett	PhD, University of British Columbia
Matt Casselman	PhD, University of British Columbia
Matt Drenner	PhD, University of British Columbia
Graham Raby	PhD, Carleton University
Natalie Sopinka	PhD, University of British Columbia
Tim Clark	Research Associate, University of British Columbia
Erika Eliason	PDF, University of British Columbia
Eduardo Martins	PDF, Carleton University
Erin Rechisky	PDF, University of British Columbia
Andrew Lotto	Technician, University of British Columbia
Darcy McKay	Technician, University of British Columbia
Vanessa Ives	Technician, University of British Columbia
Jessica Carter	Technician. University of British Columbia
Taylor Nettles	Technician, University of British Columbia

Cross-Project, Cross-Arena, and Partner involvement in the training of HQP

The integration of research activities among projects within and across Arenas from University, and Government Agencies has proven to be invaluable in terms of allowing access to varied expertise across multiple fields of ocean sciences. The Networking Session of the OTN Canada June 2011 Annual Symposium also provided an impetus for future activities.

Examples of activities supporting cross-project, cross-Arena, and partner training of HQP:

Research Associates, Post-Doctoral Fellows, PhD Students, MSc Students, Undergraduate Students, and Research Assistants attended workshops offered at the OTN Canada June Symposium on Animal Handling, Technology, Data Management, and Data Visualization.

PhD student Franziska Bröll (project I.1.1, Dalhousie University) has begun work with Project Leader Matt Litvak (project I.2.3, Mount Allison University) on the testing of accelerometers to test the use of micro-accelerometers to investigate relations between acceleration and body size in fish (within species).

Post-Doctoral Fellow Mélanie Beguer-Pon (project I.2.2, Laval University) will visit Dalhousie University in November 2011 to work with project I.1 investigators learn how to use newly developed codes to calculate the probability density functions of animal position forward and backward in time, with and without animal behaviour.

HQP held a meeting at the OTN Canada June Symposium (participants represented all Arenas and Projects). During this lunch meeting, HQP discussed ways to facilitate communication among Projects and Institutions; potential collaborations among HQP, Projects, and Institutions; and desired topics for future training opportunities.

During the Networking Session of OTN Canada June Symposium, there was substantial discussion of HQP training. HQP presented the ideas from the above-mentioned HQP lunch meeting to PIs and other OTN Researchers. The outcome of the discussions were the following proposed activities for the following year:

- Plan an annual HQP meeting with the OTN Canada Symposium. Meeting activities could include training workshops for HQPs.

- Develop an on-line forum and e-mail list for HQPs improve communication among HQPs.

- Increase the presence of HQPs on the OTN Canada Website (e.g., individual profiles).

- Encourage inter-lab communication and training via workshops, HQP lab exchanges, Arena meetings, and Annual OTN Canada meetings.

- Create a process by which HQPs wishing to travel to other OTN Canada labs and meetings can apply for available funding from OTN Canada to foster inter-lab exchange.

- Encourage OTN HQP to promote research and education outside of OTN (e.g., to school and public groups).

- HQPs to prepare short communications highlighting their research activities for the website and Newsletter.