



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

**Annual Reports Year 7 (2016)**

**NSERC Research Network Grant: NETGP 375118 – 08**

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# Ocean Tracking Network (OTN) Canada Network Overview

## 1. Network Overview

### 1.1 OTN Canada Phase II framework

In 2014, OTN Canada entered its second funding phase (years 5-7; 2014-2016). The initial phase (2010 – 2013) of OTN Canada was centered around five key research themes. While these themes remain integral to the research program, Phase II builds on the work of Phase I while taking a more highly integrative approach to research. To achieve the evolved aims of OTN Canada, a conceptual framework of scientific questions was established to more strategically align the related research activities within that framework and to inform ocean governance. In Phase II, the research questions being addressed across OTN Canada (and international partners) are broadly structured around three major integrated “framework questions” (FQs), under which projects are organized (Table 1). Many activities will relate to more than one FQ. Additional scientific activities are structured under four major “cross-cutting activities” (CCAs; Table 1). CCAs are activities that cut across two or more FQs and/or projects and subprojects, which include methodologies and approaches that can inform the three FQs. This overall organization ensures a conceptual understanding of how projects are interrelated, illustrates how these can be most effectively integrated across the Network to best address OTN Canada’s mission, and allows rapid dissemination to interested parties of all individual research projects and programs. This approach also fosters a breadth of training opportunities and exposure for HQP.

Table 1. Framework Questions and Cross-Cutting Activities matrix used in Phase II.

| Cross-Cutting Activity (CCA)   | FRAMEWORK 1:<br>How do oceanographic & environmental features (both physical & biological) affect animal habitat use, movement & migrations? | FRAMEWORK 2:<br>How do aquatic species interactions & areas of ecological significance relate to habitat use, movement patterns, & biotic/abiotic features? | FRAMEWORK 3:<br>How do anthropogenic activities & development influence aquatic animal behaviour & ecology? |
|--|--|---|---|
| 1: Assimilating animal tracking data with coastal & offshore oceanographic models  |    |   |   |
| 2: Visualization & modeling of complex aquatic & marine observations   |    |   |   |
| 3: Advancing animal tracking technology & tagging techniques   |    |   |   |
| 4: Policy, stake holders & mechanisms for feeding into outreach & management; cooperation of natural & social scientists |    |   |   |

## 1.2 OTN Canada Phase II framework objectives

- FQ1: Understand valued or keystone species in marine ecosystems, and species at risk, and how their movements change in relation to oceanographic features and variability.
- FQ2: Expand knowledge of predator and prey distributions in time and space in relation to ocean characteristics and to test hypotheses concerning predator and other impacts on prey populations, including economically important commercial fish stocks.
- FQ3: Understand the direct and indirect effects of anthropogenic activities and infrastructure on animal populations and their movements, migrations and habitat use and survival, in the face of changing ocean environments.

## 2. Progress and Network Integration

OTN Canada continues to make great progress as demonstrated by the track record of first-rate science:

- OTN Canada researchers successfully developed an integrated Canada-wide research network with increasing international reach;
- engaged 25 principal investigators (PIs) who have collaborated with even more national and international researchers;
- several students and PIs received awards for their work and engagement in the telemetry community.

A key focus of the NSERC Network is the training of students and postdoctoral fellows, as well as technicians and research assistants. During this report year, OTN Canada was supporting, in whole or in part, the programs of 75 of these trainees (“HQP”). Integration of the Network within and across FQs and CCAs continues to increase and evolve through annual symposia (detailed in 4.17), directed workshops and meetings, the ideasOTN committee (detailed in 4.16), data exchange, joint publications and presentations, exchange of HQP, and integrated field exercises.

*Details of all the projects and Network integration are described in individual reports. Outreach, exchange and conference activities are further described in 4.16.*

## 2.1 Canadian Research Program

### 4.1 -- Coupled Physical-Biogeochemical Ocean Modeling and Assimilation (J. Sheng)

This team has developed new ocean circulation and ocean wave models. Collaborations with other OTN Canada researchers include analyzing observational data along the Halifax Line (4.2), examining the effect of physical conditions on American eel migration (4.5), determining winter aggregations sites of Bay of Fundy Atlantic sturgeon

(4.6), and determining physical conditions and swimming ability of post-smolt Atlantic salmon (4.4)

4.2 -- Ocean observation component: fixed and glider-based observations of physical, biological and chemical properties along the Halifax Line (HL) and in rich feeding habitats such as the Gully Marine Protected Area and the Roseway Basin Right Whale Critical Habitat (D. Hebert, T. Ross)

This component of Atlantic Arena studies is focused on analyzing and synthesizing data from Phase I and II of OTN, which has led to several publications. This project also supports several tagging studies as well as MEOPAR's Whale Habitat and Listening Experiment (WHaLE), which resulted in an education campaign led by the Canadian Wildlife Federation. The glider group at Dalhousie University, supported by OTN, has worked extensively with several local companies to facilitate integration of new sensors into autonomous vehicles. JASCO has built a new passive acoustic hydrophone that fits in the science bay of a Teledyne Webb slocum glider while both Ocean Sonics and GeoSpectrum Technologies Inc. have developed passive acoustic hydrophones for Liquid Robotics wave gliders. GeoSpectrum has purchased a new generation wave glider that will be operated by the glider group at Dalhousie University.

4.3 -- Accelerometry techniques and applications (C. Taggart)

Accelerometry research has led to the development of significantly enhanced accelerometer and inertial navigator tags. These tags are being used to investigate post-tagging effects in captive Atlantic cod, are describing the behaviour of wild shortnose sturgeon in relation to environmental variations, validating prey-capture events in grey seals, and establishing base-level behaviours in Pacific Halibut. Halibut accelerometer tagging has identified site fidelity and feeding activity masked in other studies. F. Broell was a Visiting Fellow at University of St Andrews (Scotland) and collaborated on a study of common skate within an expiring MPA in Scotland.

4.4 -- Overwinter biology, migrations, and carryover effects of Bras d'Or Atlantic salmon populations (G. Crossin, B. Hatcher)

This study examines post-spawning migration behaviour of wild Atlantic salmon tagged and released in Middle River and that of Middle River-caught salmon subsequently held and spawned in a near-by hatchery. Data from the Bras d'Or array is undergoing analysis, however physiological samples taken from both groups during tagging indicate that hatchery-spawned fish have higher baseline levels of stress than wild-spawned fish.

4.5 -- The biotic and abiotic control of the oceanic migrations of the threatened American eel (J. Dodson, M. Castonguay)

The migratory routes of eight pop-up satellite tagged eels were tracked beyond the Shelf, including four eels tracked over 2,700kms into the Sargasso Sea. This is the second year eels were observed reaching spawning grounds. Eels' trajectories and speeds were consistent with previous study years. However, vertical profiles were different. Another

study in collaboration with QC industry and government noted comparable migratory performance between stocked eels and wild eels.

#### 4.6 -- Movement and habitat use by sturgeon in Atlantic Canada and anthropogenic interactions (M. Stokesbury, M. Dadswell, M. Litvak)

Expanded tagging of sturgeon in the Suwannee River, FL, in collaboration with the USGS, will enable a comparative study of the marine phase of Atlantic and Gulf sturgeon. This project continues to inform tidal power developments in the Bay of Fundy/Minas Passage area. HQP C. Buhariwalla conducted range testing in the French Kerguelen Islands with French partners. This collaboration is set to recommence in 2017.

#### 4.7 -- Grey seals (*Halichoreus grypus*) as bioprobes: predicting impacts on their ecosystems (S. Iverson)

Almost 4,000 grey seal VMT detections have revealed 31% seal-seal encounters, 9% Atlantic cod-seal encounters, and the remaining 60% from OTN blue shark, OTN salmon, and Bluefin tuna. 58 cod were tagged on the Scotian Shelf. Collaborations with 4.8 are further modelling seals' tracks. This project has several outreach initiatives, including presentations to students of various ages, as well as contributing to the production of a film on the seals of Sables Island.

#### 4.8 -- Visualization and modelling of complex marine observations (J. Mills Flemming)

This group maintains and updates novel and robust models to help describe the spatial ecology of marine animals and how their distribution is affected by anthropogenic factors. It also ensures that observing technology (e.g., gliders) and accompanying modelling techniques are properly integrated. Five collaborations have been established outside of OTN, one of which is using modelling and visualization tools in mako shark research.

#### 4.9 -- Salmonids in the north – species transition zones and beyond, predicting impacts of climate change (I. Fleming, M. Power, R. Tallman, A. Fisk)

Tagging and isotope data from this study represent the first description of over-wintering activity in Northern (Labrador) Arctic charr. Archival geolocation tags and isotope sampling on 65 Atlantic salmon kelts is helping to identify life-stage foraging patterns. Kelt recapture is also quantifying treatment effects on survival and growth. Students are also engaged in work on the ecology of charr within the Nunavut Territory, specifically to understand factors affecting charr migration and productivity throughout their life cycle. In addition, acoustic telemetry studies are providing information on the migration and critical habitats of Inconnu (a species under special concern in the Northwest Territories) and for the management of the Great Slave Lake whitefish fishery.

#### 4.10 -- Fish and marine mammal interactions in the high Arctic (A. Fisk, S. Vagle, S. Ferguson)

Sampling of shorthorn sculpin and Arctic cod has revealed that cod feed pelagically and sculpin trophic ecology changed with size and food availability. Three different

movement patterns were discovered in sculpin and correlated to abundance of Arctic cod. Cod demonstrated displacement and a decrease in foraging movement in association with vessel traffic. Data from receivers stuck since 2011 revealed individual cod movements of up to 192km. Oceanographic data and PAM are revealing information on differing water properties in and outside Resolute Bay, and ambient noise, respectively.

4.11 -- Deep-water Arctic marine fishes: Developing commercial fisheries and interactions with marine mammals (A. Fisk, K. Hedges, S. Vagle)

This project was expanded to monitor oceanographic conditions and offshore movements of Greenland halibut in offshore Baffin Bay. 42 new moorings were equipped with temperature loggers and approximately 200 halibut were tagged to jumpstart offshore monitoring. Inshore studies have revealed a resident halibut population in Scott Inlet, that's migration timing to offshore corresponds with that of other regional populations of halibut. Hi-res accelerometer tags are assessing post-release behaviour and prey-capture of bycatch species (Arctic skate and Greenland shark).

4.12 – 4.15 -- Pacific salmon commercial and First Nations fisheries: delayed mortality, behaviour and physiology of released bycatch in coastal waters (S. Hinch); Tracking anadromous adult salmonids in Canada's three oceans to evaluate the sustainability of catch-and-release angling practices – behavioural and physiological perspectives on estuarine fisheries (S. Cooke); Seasonal movements and spawning migrations of White Sturgeon (G. Crossin); Survival and movement rates of out-migrating juvenile Pacific and Atlantic salmon (S. Hinch)

These projects cover several life stages of Pacific salmon and white sturgeon across large spatial scales. One study has revealed predation on sockeye salmon smolts by bull trout in the Chilko River. Adult salmon were tagged to understand the behaviour of different stocks during spawning migration. In tandem with this study, the effects of capture and release events were also studied to better inform fisheries, including a recommendation of “10 seconds tops” for fish to be safely released from an out of water state. Laboratory work is revealing mechanisms of stress and mortality including tagging burden. Collectively, Pacific Arena work represents a model for stakeholder engagement including extensive partnerships with First Nations, FGO, anglers and commercial fishers, and has provided data for informed fisheries management.

4.16 -- Networking, HQP Exchange and Social Science Components (S. Iverson, N. Young)

Just under 100 interviews with government and stakeholders of Fraser River Pacific salmon fisheries have been conducted on the perception of telemetry and its potential applications to fisheries policy. The research deals with processes of knowledge mobilization, knowledge exchange, and evidence-based resource management. Results and published papers have been disseminated directly to stakeholders and representatives of the Pacific Salmon Commission and the Department of Fisheries and Oceans (Pacific Region).



IdeasOTN continues progress on 22 projects focused on synthesizing data and information generated from OTN studies and generating output to inform policy. Membership of the committee is transitioning as some members have recently obtained faculty positions at various universities, and six new members have joined the committee.

### 3. Training of Highly Qualified Personnel (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 HQP access to varied expertise across multiple fields of ocean sciences. Descriptions of HQP involvement are contained in the individual project reports. The following table summarizes the HQP who have been supported by the Network during 2016.

Table 2. Summary of the number of Highly Qualified Personnel (HQP) trained within the scientific program of OTN Canada by Project. Brackets represent the number of HQP receiving 100% support from OTN Canada in Year 7.

| <b>HQP</b><br>Total (Receiving<br>100% support<br>from OTNC) | BSc students | MSc<br>students | PhD students | Post<br>Doctoral<br>Fellows | Research<br>Associates | Research<br>Assistants | <b>Total<br/>(100%<br/>support<br/>from OTNC)</b> |
|--|--------------|-----------------|--------------|-----------------------------|------------------------|------------------------|---|
| 4.1  | -            | -               | 3            | -                           | 1                      | -                      | <b>4</b>  |
| 4.2  | 2            | 2               | 2 (1)        | -                           |                        | 1                      | <b>7 (1)</b>                                      |
| 4.3  | -            | -               | -            | 1                           | -                      | -                      | <b>1</b>  |
| 4.4  | 1            | -               | 1 (1)        | -                           | 1                      | 3                      | <b>6 (1)</b>                                      |
| 4.5  | -            | -               | -            | -                           | 1 (1)                  | -                      | <b>1 (1)</b>                                      |
| 4.6  | 1            | 4 (3)           | -            | -                           | -                      | -                      | <b>5 (3)</b>                                      |
| 4.7  | 1            | 1 (1)           | -            | -                           | 1                      | -                      | <b>3 (1)</b>                                      |
| 4.8  | -            | 1               | 2 (1)        | -                           | 1 (1)                  | -                      | <b>4 (2)</b>                                      |
| 4.9  | 2            | 3               | 2 (2)        | 1 (1)                       | -                      | 1                      | <b>9 (3)</b>                                      |
| 4.10   | -            | 3 (2)           | -            | -                           | 1 (1)                  | -                      | <b>4 (3)</b>                                      |
| 4.11   | -            | 2 (2)           | 2 (1)        | -                           | 1                      | -                      | <b>5 (3)</b>                                      |
| 4.12-4.15  | 1            | 7               | 11           | 3                           | 3                      | -                      | <b>25</b>   |
| 4.16   | -            | -               | -            | -                           | 1                      | -                      | <b>1</b>  |
| <b>Total (receiving<br/>100% support<br/>from OTNC)</b>      | <b>8</b>     | <b>23</b>       | <b>23</b>    | <b>5</b>                    | <b>11</b>              | <b>5</b>               | <b>75 (18)</b>                                    |

## 4. Dissemination and Other Contributions

### 4.1 Publications and presentations

OTN Canada research is making impacts locally, regionally, nationally and abroad. Important scientific discoveries are being made by OTN Canada researchers and published in high impact scientific journals. Formal presentations at workshops and seminars are helping forge and solidify relationships with collaborators and stakeholders and augment visibility in the broader science community, and to the general public. Additionally, consultations with local community members help inform tracking study design and are an important part of planning and implementation, and relationship building with communities on which the research has direct implications. The OTN Canada Network continues to share research insights and results with stakeholders including grade-school groups, local communities, academic and industry partners, and government officials through such communications channels as personal websites; workshops and lectures (outside the Network); public presentations; newspaper, television and radio interviews; documentary filming; and through affiliated organizations' newsletters and other media. There have also been many outputs of technical reports, invited conference 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. However, a summary of accepted/published journal articles, conference presentations, and other forms of dissemination by OTN Canada PIs and HQP is presented below and detailed in the individual reports that follow.

Table 3. Summary of accepted or published refereed journal articles and conference presentations (invited and contributed) by HQP and PIs by project in Year 7.

| Project  | 4.1 | 4.2 | 4.3 | 4.4 | 4.5 | 4.6 | 4.7 | 4.8 | 4.9 | 4.10 | 4.11 | 4.12-4.15 | 4.16 | Total      |
|--|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|-----------|------|------------|
| Accepted/published refereed journal articles                           | 6   | 1   | 2   | 1   | 2   | 3   | 1   | 2   | -   | 6    | 12   | 32        | -    | <b>68</b>  |
| Conference presentations (invited and contributed)                     | 12  | 9   | 3   | 5   | 2   | 6   | 2   | 10  | 7   | 3    | 6    | 31        | 5    | <b>101</b> |
| Books, data/technical reports, any other relevant output/contributions | 2   | -   | 2   | 1   | -   | 3   | -   | 5   | -   | -    | -    | 8         | -    | <b>21</b>  |

Table 4. Summary of dissemination (partner meetings, public outreach of other deliverables) and awards received by HQP and PIs by project in Year 7.

| Project   | 4.1 | 4.2 | 4.3 | 4.4 | 4.5 | 4.6 | 4.7 | 4.8 | 4.9 | 4.10 | 4.11 | 4.12-4.15 | 4.17 | Total     |
|---|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|-----------|------|-----------|
| Formal meetings, workshops or seminars as part of collaborations with non-OTN members | -   | -   | -   | 1   | -   | 5   | 1   | -   | -   | -    | -    | 14        | 1    | <b>22</b> |
| Public dissemination (e.g., interview, community or school presentation)              | -   | 8   | 1   | 1   | 6   | 1   | 6   | 1   | 1   | -    | 3    | 27        | 5    | <b>60</b> |
| Awards Received   | -   | -   | 2   | -   | -   | -   | -   | -   | -   | -    | -    | -         | 3    | <b>5</b>  |
| Other (e.g. facility tour, meeting with government official)                          | -   | 9   | -   | -   | -   | -   | 1   | 1   | -   | 2    | -    | 2         | 2    | <b>17</b> |

**Ocean Tracking Network Canada****NSERC****Progress Report Year 7 Review: 1 October 2015 – 30 September 2016****1. Project Number:** 4.1**2. Project Title:** Coupled Physical-Biogeochemical Ocean Modeling and Assimilation**3. Project Leaders:** Jinyu Sheng (Dalhousie U)

**Other OTN Canada participants:** T. Ross, D. Hebert, J. Dodson, M. Castonguay, S. Iverson, D. Bowen, J. Mills-Flemming, G. Crossin, M. Litvak, M. Stokesbury, I. Fleming

**Collaborators:** Katja Fennel (Dalhousie U), Keith Thompson (Dalhousie U), Blair Greenan (DFO-Bedford Inst, Dalhousie U)

**4. Training of Highly Qualified Personnel (and level of support)**

| Name  | Title* | % Time in project | % Support from OTNC | Start Date (actual date HQP started with OTN) | End Date (actual or anticipated) |
|---|--------|-------------------|---------------------|---|----------------------------------|
| Kyoko Ohashi  | RA     | 80                | 60                  | 2 Oct 2010                                    | 1 May 2016                       |
| Research Topic/current employment (if no longer OTNC HQP): individual-based model (IBM) in the study of Atlantic salmon post-smolt movement in the Gulf of St. Lawrence |        |                   |                     |   |                                  |
| Shiliang Shan   | PhD    | 50                | 10                  | 1 Oct 2010                                    | 1 Aug 2016                       |
| Research Topic/current employment (if no longer OTNC HQP): Development of a multi-nested model to study coastal upwelling on the inner Scotian Shelf                    |        |                   |                     |   |                                  |
| Yi Sui  | PhD    | 20                | 5                   | 1 Sept 2014                                   | 31 Dec 2016                      |
| Research Topic/current employment (if no longer OTNC HQP): dispersion and hydrodynamic connectivity of surface waters on the Scotian Shelf using a numerical model      |        |                   |                     |   |                                  |
| Pengcheng Wang  | PhD    | 20                | 5                   | 1 Jan 2016                                    | 31 Dec 2016                      |

**5. Public summary of report**

Only the physical modelling component was funded by the OTN-Canada during this report period. Major progress has been made by this component in two areas: (1) applications of the newly-developed ocean circulation model and ocean wave model to simulate ocean currents, hydrography and surface gravity waves over the Scotian Shelf and Gulf of St. Lawrence; and (2) synthesis activities by working closely with other OTN researchers in examining the effect of physical conditions on the migration of American eels and Atlantic salmon post-smolt movement in the study region.

**6. Networking, outreach, and synthesis**

*a) Interaction/Outreach to Broader Community/Public (including radio or television interviews or contribution to a programme/documentary, stakeholder workshops, etc.)*

We published our research results in 12 refereed scientific journals and gave 12 presentations in the various national and international conferences and institutions.

*b) Synthesis activities*

We worked very closely with the ocean observation team led by Dave Hebert and Tetjana Ross (project 4.2) in analyzing observational data along the Halifax line and also using the observational data for assessing the model performance. We also worked very closely with the team for project 4.5 led by Julian Dodson, Martin Castonguay and Melanie Beguer (post-doctoral fellow) in examining the effect of physical conditions on the migration of American eels. We helped the research team (project 4.6) led by Mike Stokesbury, Michael Dadswell, and Matthew Litvak in determining the winter aggregation area of adult Atlantic Sturgeon in the Bay of Fundy. Dr. Kyoko Ohashi (Research Associate) also collaborated with other OTN researchers in determining the physical conditions and swimming ability of Atlantic salmon post-smolt movement over the northern Gulf St. Lawrence.

**7. Dissemination of information and results***a) Refereed journal articles (6\*\* total) – accepted/published*

\*\*Note: In order to avoid double-listing of dissemination/publications given the extensive cross-collaboration with Project 4.2, 4.5, and 4.6, one publication is listed under Project 4.2's and one under Project 4.5's reports.

6. Wang, P., and J. Sheng, 2016. A comparative study of wave-current interactions over the eastern Canadian shelf under severe weather conditions. *Journal of Geophysical Research-Oceans*, 121, 5252-5281, doi: 10.1002/ 2016JC01175.
5. Taylor, A., K. Ohashi, J. Sheng, and M. Litvak, 2016. Oceanic distribution, behaviour, and a winter aggregation area of adult Atlantic sturgeon, *Acipenser oxyrinchus oxyrinchus*, in the Bay of Fundy, Canada. *PloS One*. doi: 10.1371/journal.pone.0152470.
4. Shan, S., J. Sheng, O.K. Ohashi, and M. Dever, 2016. Assessing the performance of a multi-nested ocean circulation model using satellite remote sensing and in-situ observations. *Satellite Oceanography and Meteorology*, 1, 39-59. doi: 10.18063/SOM.2016.01.004..
3. Chang, Y-L, J. Sheng, K. Ohashi, M. Béguer-Pon, Y. Miyazawa, 2016. Impacts of interannual ocean circulation variability on Japanese eel larval migration in the western North Pacific Ocean. *Public Library of Science (PLOS)*. doi:10.1371/journal.pone.0144423.
2. Urrego-Blanco, J., J. Sheng, Fred Dupont, 2016. Assessing the performance of one-way and two-way nesting techniques for the shelf circulation modelling system of the eastern Canadian shelf. *Atmosphere-Ocean*, 54, 75-92, doi:10.1080/07055900.2015.1130122..
1. Ohashi, K., and J. Sheng, 2016. Investigating the effect of the physical environment and swimming behaviours on the movement of particles in the Gulf of St. Lawrence using an individual-based numerical model. *Atmosphere-Ocean*, 54, 278-298, doi: 10.1080/07055900.2015.1090390.

*b) Refereed journal articles (1 total) – submitted*

1. Ohashi, K., and J. Sheng, 2016. Simulation of Atlantic salmon post-smolt movement along the north shore of the Gulf of St. Lawrence using an individual-based model. *Journal of Marine Systems* (in prep).

c) Conference/workshop/seminar presentations (12 total) – invited or contributed

12. Sheng, J. and K. Ohashi, Simulation of Atlantic salmon post-smolt movement along the north shore of the Gulf of St. Lawrence, 14th International Conference on Estuarine and Coastal Modeling, Rhode Island, USA, June 2016.
11. Sheng, J., and Y. Wang, Hydrodynamic connection between the Gulf of the St. Lawrence and adjacent coastal and shelf waters of the northwest Atlantic Ocean, 8th International Workshop on Modeling the Ocean, Bologna, Italy, June, 2016.
10. Sheng, J., and L. Guo, Impacts of climate change on the ocean waves over the eastern Canadian shelf, 8th International Workshop on Modeling the Ocean, Bologna, Italy, June, 2016.
9. Sheng, J., “Study of Circulation and Hydrography over the Eastern Canadian Shelf using a Coupled Circulation-Ice Model”, Norwegian Meteorological Institute, Oslo, May, 2016.
8. Wang, P., and J. Sheng, Examination of wave-current interactions over the eastern Canadian shelf under severe weather conditions using a coupled circulation-wave model, 50th Annual CMOS Congress, Fredericton, Canada, May, 2016.
7. Shan S., J. Sheng, K. Ohashi, and M. Dever, Simulating three-dimensional circulation and hydrography over the central Scotian Shelf using a multi-nested ocean circulation model, 50th Annual CMOS Congress, Fredericton, Canada, May, 2016.
6. Wang, Y., and J. Sheng, Hydrodynamic connection between the Gulf of St. Lawrence and shelf waters of the Northwest Atlantic Ocean, 50th Annual CMOS Congress, Fredericton, Canada, May, 2016.
5. Ohashi, K., and J. Sheng, Simulation of Atlantic salmon post-smolt movement along the north shore of the Gulf of St. Lawrence, 50th Annual CMOS Congress, Fredericton, Canada, May, 2016.
4. Wang, P., and J. Sheng, Examination of wave-current interactions over the eastern Canadian shelf under severe weather conditions using a coupled circulation-wave model, JONSMOD 2016, Oslo, Norway, May, 2016.
3. Sheng, J., and S. Shan, Numerical study of circulation and hydrography over the Scotian Shelf using a multi-nested ocean circulation model, JONSMOD 2016, Oslo, Norway, May, 2016.
2. Sheng, J., “Application of the complex Empirical Orthogonal Function in the study of interannual variability of circulation over the eastern Canadian shelf”, Hohai University, Nanjing, March, 2016.
1. Sheng, J., “Wave-current interactions over the eastern Canadian shelf under severe weather conditions, a numerical study using a coupled wave-circulation model”, Hohai University, Nanjing, October, 2015.

*d) Books, data/technical reports, or any other relevant output/contributions not included above*

2. Sheng, J., and D. Lefairvre, 2016. Introduction to the special issue on dynamics of the Gulf of St. Lawrence system and its influence on the ecosystem: past, present and future. *Atmosphere-Ocean*, 54, 193-198, doi: 10.1080/07055900.2016.1189397.
1. Sheng, J., C. Wilson, and X. Zhai, 2015. Editorial. *Ocean Dynamics*, 65, 1583-1584, doi: 10.1007/s10236-015-0890-2.

**Ocean Tracking Network Canada****NSERC****Progress Report Year 7 Review: 1 October 2015 – 30 September 2016****1. Project Number:** 4.2

**2. Project Title:** Ocean observation component: fixed and glider-based observations of physical, biological and chemical properties along the Halifax Line (HL) and in rich feeding habitats such as the Gully Marine Protected Area and the Roseway Basin Right Whale Critical Habitat

**3. Project Leaders:** Dave Hebert (DFO-Bedford Inst, Dalhousie U), Tetjana Ross (Dalhousie U)

**Other OTN Canada participants:** K. Fennel, J. Sheng, S. Iverson, D. Bowen

**Collaborators:** Peter Smith (DFO-Bedford Inst, Dalhousie U), Blair Greenan (DFO-Bedford Inst, Dalhousie U), John Kocik (NOAA, USA)

**4. Training of Highly Qualified Personnel (and level of support)**

| Name   | Title*      | % Time in project | % Support from OTNC | Start Date (actual date HQP started with OTN) | End Date (actual or anticipated) |
|--|-------------|-------------------|---------------------|---|----------------------------------|
| Mathieu Dever  | PhD         | 100               | 100                 | Jan 2011                                      | Dec 2016                         |
| Research Topic: Dynamics of the Nova Scotia Current and its Relationship with Atlantic Salmon Migration Patterns over the Inner Scotian Shelf.     |             |                   |                     |   |                                  |
| Gennavieve Ruckdeschel   | MSc         | 30                | 0                   | Jun 2014                                      | Mar 2017                         |
| Research Topic/current employment (if no longer OTNC HQP): Right whale habitat: distribution and dynamics of zooplankton species in Roseway Basin. |             |                   |                     |   |                                  |
| Matt Beck  | MSc         | 100               | 0                   | Sep 2010                                      | Dec 2015                         |
| Research Topic/current employment (if no longer OTNC HQP): A multiparameter approach for estimating chlorophyll a from ocean gliders.              |             |                   |                     |   |                                  |
| Hansen Jonson  | PhD         | 25                | 0                   | Jan 2015                                      | Jan 2020                         |
| Research Topic/current employment (if no longer OTNC HQP): Passive acoustics from gliders – real-time detection of baleen whales.                  |             |                   |                     |   |                                  |
| Ryan Gosse   | Co-op       | 25                | 0                   | Jan 2016                                      | Dec 2016                         |
| Research Topic/current employment (if no longer OTNC HQP): Glider data processing and visualization  |             |                   |                     |   |                                  |
| Mimi Cahill  | Co-op       | 50                | 0                   | Jan 2016                                      | Apr 2016                         |
| Research Topic/current employment (if no longer OTNC HQP): Procedures for Ocean Gliders Canada   |             |                   |                     |   |                                  |
| Jude van der Meer  | research as | 50                | 0                   | Oct 2016                                      | Dec 2016                         |
| Research Topic/current employment (if no longer OTNC HQP): Glider logistics support  |             |                   |                     |   |                                  |

**5. Public summary of report**

In this synthesis year, work in the OTN Observing Component focussed on analyzing, synthesizing and communicating the wide array of physical, biological and chemical observations collected during Phases I and II of OTN. These data were primarily collected along the Halifax Line (HL), which serves as the test bed for OTN research in the Atlantic Arena. Analysis of physical data from several bottom moorings containing acoustic Doppler current profilers (ADCPs) that provide measurements of the currents throughout the water column and conductivity-temperature-depth (CTD) sensors near the HL



dating back to April 2008 as well as ocean glider data dating back to 2011 continued, resulting in one HQP publication accepted and several conference and workshop presentations. Analysis of the optical data led to the completion of one thesis (Matt Beck) and the synthesis of these optical data with the physical data led to one submitted publication. Close collaboration with the OTN Modelling Component (Catherine Brennan and Shilang Shan; one publication), researchers tagging Atlantic salmon (John Kocik and Carrie Byron; several presentations) and the researchers in the MEOPAR Whales Habitat and Listening Experiment (Chris Taggart, Kim Davies and Mark Baumgartner; several presentations, many newspaper articles), who are using OTN ocean glider data to assess endangered North Atlantic right whale habitat, continued. Dalhousie's Marine Observations Support Team (MOST) maintained the gliders in a state of research readiness and continued to develop their skills by supporting some glider deployments funded by MEOPAR. The data from these deployments joins the OTN archive, available for synthesis activities.

## 6. Networking, outreach, and synthesis

### *a) Interaction/Outreach to Broader Community/Public (including radio or television interviews or contribution to a programme/documentary, stakeholder workshops, etc.)*

OTN's ocean observation component, and particular the glider group, have have much media coverage in 2016; including a number of news articles (CBC, GlobalNews, Globe and Mail, Ottawa Citizen, Times Colonist) focussing on the whale observations added to the program through partnership with the MEOPAR-WHaLE project and a Daily Planet Documentary (July 2016). The glider-whale project also led to a educational campaign led by the Canadian Wildlife Federation, which showcased near real-time glider based whale detection on CWF's website (<http://apps.cwf-fcf.org/whales/>). We were also involved in teaching children about our science/technology through SuperNOVA camps (Jul 2016). The glider group also played host for a number of visits of both national and international figures; including the Minister of Innovation, Science and Economic Development (Feb 2016), Minister of Science (April 2016), Colombian Tall Ship (July 2016), MP Bernadette Jordan (July 2016), MP Geoff Regan (Aug 2016), Xie Janing (Aug 2016), Issam Al Zahid (Aug 2016), Former Parliamentarians (Sep 2016), Ambassadors from UAE, Saudi Arabia, Qatar and Kuwait accompanied by three Nova Scotia MPs (Bill Casey, Darren Fisher and Shaun Fisher, Oct 2016), and the Offshore Energy Research Association (Oct 2016).

### *b) Synthesis activities*

PhD student Mathieu Dever has led this component's synthesis activities, with work on linkages between ocean conditions and migration patterns of Atlantic salmon smolts (Dever, Kocik, et al, in prep) and the integration of glider data into OTN modelling exercises (Shan et al, 2016). Equally important, though less productive in terms of dissemination, the technology group, led by Adam Comeau, has ensured glider data are available and interpretable, have maintained the glider fleet and supported glider missions funded through other projects (e.g. the MEOPAR-WHaLE supported whale listening missions that have garnered much attention).

## 7. Dissemination of information and results

### *a) Refereed journal articles (1\*\* total) – accepted/published*

**\*\*Note:** In order to avoid double-listing of dissemination/publications given the extensive cross-collaboration with Project 4.1, one publication is listed there.

Dever M., Hebert D., Greenan B.J., Sheng J. and Smith P.C. (2016) Hydrography and coastal circulation along the Halifax Line and the connections with the Gulf of St Lawrence. *Atmosphere-Ocean*. DOI: 10.1080/07055900.2016.1189397

*b) Refereed journal articles (4 total) – submitted*

Ross T., Craig S., Dever M., Beck M., Comeau A. and Davis R. Blooms and subsurface phytoplankton layers on the Scotian Shelf: Insights from profiling gliders. Submitted to *Journal of Marine Systems*

*c) Conference/workshop/seminar presentations (9 total) – invited or contributed*

Hebert, D. and Dever, M. (2016, Sep) Glider observations as part of the Canadian Department of Fisheries and Oceans' Atlantic Zone Monitoring Program on the Scotian Shelf. EGO meeting, Southampton, UK.

Davis, R., Baumgartner, M., Comeau, A., Cunningham, D., Davies, K., Furlong, A., Johnson, H., L'Orsa, S., Ross, T., Taggart, C., Whoriskey, F. (2016, Sep). Tracking whales on the Scotian Shelf using passive acoustic monitoring on ocean gliders. OCEANS '16 MTS/IEEE Monterey, CA, USA.

Davis, R., Baumgartner, M., Comeau, A., Covey, B., Davies, K., Dever, M., Fupsova, K., Hebert, D., L'Orsa, S., Ross, T., Whoriskey, F. (2016, Sep). Ocean observations on the Scotian Shelf using autonomous vehicles. 7th EGO Conference on Autonomous Ocean Gliders and Their Applications, Southampton, UK

Dever M., Hebert D., Greenan B. and Sheng J. (2016, April). Getting to the bottom of surface currents: Investigating the dynamics of a coastally-trapped, buoyancy-driven current. Invited speaker at the at the National Oceanography Centre in Southampton, Southampton, UK.

Dever M., Hebert D., Greenan B. and Sheng J. (2016, February). Characterization of the Nova Scotia coastally-trapped Current and monitoring of the associated density front using underwater gliders. Presented at the Ocean Sciences meeting, New Orleans, LA, U.S.A.

Dever M., Kocik J., Hebert D., Zydlewski J., Hawkes J., Stich D. and Greenan B. (2016, February). Linkage Between Coastal Conditions, Detection Patterns and Migratory Behavior of Atlantic Salmon Smolts (*Salmo salar*) Along the Halifax Line. Poster presented at the Ocean Sciences meeting, New Orleans, LA, U.S.A.

Ross T., Craig S., Dever M., Beck M., Comeau A. and Davis R. (2016, February). The physical context of seasonal and inter-annual variability in phytoplankton across the Scotian Shelf: Insights from profiling gliders. Poster presented at the Ocean Sciences meeting, New Orleans, LA, U.S.A.

Ruckdeschel, G., Ross, T., Davies, K. (2016, February). How Do Density Fronts Interact with Zooplankton Distributions to Create Baleen Whale Prey-Fields in Roseway Basin? Poster presented at the Ocean Sciences meeting, New Orleans, LA, U.S.A.

Dever M., Kocik J., Hebert D., Zydlewski J., Hawkes J., Stich D. and Greenan B. (2015, December, January and February). Linkage Between Coastal Conditions, Detection Patterns and Migratory Behavior of Atlantic Salmon Smolts (*Salmo salar*) Along the Halifax Line. Invited speaker at the University of Maine (Orono, ME, U.S.A.), at the Bedford Institute of Oceanography (Dartmouth, NS, Canada) and in the biology Department at Dalhousie University (Halifax, NS, Canada).

## 8. Contributions from industrial and government partners

| Name of supporting organization:<br><b>DFO</b>                      | <b>Year 7<br/>(2016)</b> |
|---|--------------------------|
| <b>Cash contributions to direct costs of research</b>               |                          |
| <b>In-kind contributions to direct costs of research</b>            |                          |
| 1) Salaries for scientific and technical staff                      |                          |
| 2) Donation of equipment, software                                  |                          |
| 3) Donation of material   |                          |
| 4) Field work logistics   |                          |
| 5) Provision of services  | 1,000                    |
| 6) Other (specify):   |                          |
| <b>In-kind contributions to indirect costs of research</b>          |                          |
| 1) Use of organization's facilities                                 | 15,600                   |
| 2) Salaries of managerial and administrative staff                  |                          |
| 3) Other (specify):   |                          |
| <b>Total of all in-kind contributions</b>                           | 16,600                   |
| <b>Is this new funding (acquired during this reporting period)?</b> | no                       |

## 9. Notes

The glider group at Dalhousie University, supported by OTN, has worked extensively with several local companies to facilitate integration of new sensors into autonomous vehicles. JASCO has built a new passive acoustic hydrophone that fits in the science bay of a Teledyne Webb slocum glider while both Ocean Sonics and GeoSpectrum Technologies Inc. have developed passive acoustic hydrophones for Liquid Robotics wave gliders. GeoSpectrum has purchased a new generation wave glider that will be operated by the glider group at Dalhousie University.

**Ocean Tracking Network Canada****NSERC****Progress Report Year 7 Review: 1 October 2015 – 30 September 2016****1. Project Number:** 4.3**2. Project Title:** Accelerometry techniques and applications**3. Project Leaders:** Christopher Taggart (Dalhousie U)

**Other OTN Canada participants:** K. Fennel, J. Sheng, M. Litvak, M. Stokesbury, S. Iverson, D. Bowen, G. Crossin, I. Fleming, A. Fisk, S. Hinch, S. Ferguson

**Collaborators:** Dale Webber (Vemco)

**4. Training of Highly Qualified Personnel (and level of support)**

| Name   | Title* | % Time in project | % Support from OTNC | Start Date (actual date HQP started with OTN) | End Date (actual or anticipated) |
|--|--------|-------------------|---------------------|---|----------------------------------|
| Franziska Broell   | PhD    | 100               | 80                  | May 2010                                      | February 2016                    |
| Research Topic/current employment (if no longer OTNC HQP): Accelerometry, the key to measuring size-at-age and activity in fish / currently OTN PDF (& Maritime bioLoggers CEO)  |        |                   |                     |   |                                  |
| Dr Franziska Broell  | PDF    | 100               | 80                  | Mar 2016 (LOA) Oct 2016                       | May 2016 (LOA) Dec 2016          |
| Research Topic/current employment (if no longer OTNC HQP): Accelerometry in halibut and seals (& Maritime bioLoggers) OTN PDF Mar-May 2016, St. Andrews Visiting Fellow June-Dec 2016, OTN PDF Jan-Mar 2017 (See 9. NOTES below for explanation) |        |                   |                     |   |                                  |

**5. Public summary of report**

The accelerometry research has led to a significantly enhanced accelerometer and inertial navigator tags. After developing a market-ready inertial tag, commercialized through Broell's spin-off company Maritime bioLoggers, various grants (NRC-CNRC ARP, Innovacorp Early Adopter Program) were secured. The tags have also been used to investigate how shortnose sturgeon change their behavioural and activity patterns in relation to environmental variation (temperature, depth, ambient light, tidal velocity) in the wild. Post-tagging effects on behaviour and energy expenditure were also addressed using captive Atlantic cod and in the wild using sturgeon by measuring frequency and intensity of aberrant behaviour related to various tag loads. In collaboration with the International Pacific Halibut commission, high-resolution activity tags were deployed on 14 Pacific Halibut in Alaska to determine base levels of movement and behaviour during the summer of 2015. Data (undergoing analyses) indicate high site fidelity and identifiable feeding activity previously masked in other studies, as only high-resolution accelerometry in this species is able to determine energy budgets and activity. In collaboration with the OTN Atlantic Arena, inertial and accelerometer tags were deployed on seals to measure activity and prey-capture events in conjunction with video analysis. The accelerometry data from the deployments in 2015 are being used in collaboration within the Atlantic Arena as a validation tool for behavioural estimators from state-space modelling. Two manuscripts were published in 2016 and one is nearing completion for submission in late 2016. FB has further enhanced the tagging technology as a Visiting Fellow at St Andrews University in Scotland. Archival and VEMCO acoustic tags were deployed to determine behaviour and movement in an endangered species (common skate)

within a marine protected area. Data from deployments will inform Scottish government (Scottish Natural Heritage) on the status of the species within the MPA and will be critical in delivering a scientific basis for renewal of the MPA in 2017.

## 6. Networking, outreach, and synthesis

### *a) Interaction/Outreach to Broader Community/Public (including radio or television interviews or contribution to a programme/documentary, stakeholder workshops, etc.)*

FB received a MASTS PECRE Visiting Fellowship with St. Andrews University (Scotland) to further develop Maritime bioLoggers technology and conduct research on an endangered species (common skate) in the Firth of Lorn (Scotland). This collaboration also makes use of the acoustic array in the Firth of Lorn that consists of receivers that are on loan from OTN. The project received substantial in-kind contribution of tagging technology from Maritime bioLoggers, field logistical support from Scottish Natural Heritage and in kind contribution from research staff at Marine Scotland (see 8). The telemetry and archival data collected during the Visiting Fellowship will provide direct input to the Scottish government (Scottish Natural Heritage, Dr. Jane Dodd) on the status of the species within the MPA and is critical in delivering a scientific basis for the renewal of the MPA in 2017. FB is also collaborating with Marine Scotland (Dr. Bee Berx, Dr. James Thorburn), the Scottish Association of Marine Science (Dr. Dimitry Aleynik), the University of Aberdeen (Dr. Beth Scott, Marianna Chimienti), and Ifremer (Dr. Cecilia Pinto) on this project. FB has also been awarded the Sally Connally Hardie Visiting Researcher Bursary to continue her work on this project.

Maritime bioLoggers (MBL) under FB is involved as industry partner for a Collaborative Research and Development (CRD) grant aimed at investigating stock structure and spawning movement in Atlantic halibut (HaliBT). This proposal will bring together industry (MBL, Atlantic Halibut Commission), government (DFO) and academia (Dalhousie University, Memorial University) aimed at research on Atlantic halibut movement and connectivity in the North Atlantic. Maritime bioLoggers has been awarded the Early Adopter Program (20K) from Innovacorp in 2016 to develop species-specific tagging technology for the HaliBT project and will serve as industry partner on the HaliBT project.

FB and Maritime bioLoggers have been featured in the 20th anniversary of CFI celebrations. The company profile and technology have been highlighted on the CFI website, in an anniversary brochure and FB will be participating a celebration and outreach event in Ottawa in 2017 showcasing the achievements of the company and the involvement of CFI and OTN.

### *b) Synthesis activities*

A synthesis study on opportunities and advances in remote bioenergetics measurements in wild fish has been published through the ideasOTN initiative (see below).

## 7. Dissemination of information and results

### *a) Refereed journal articles (2\*\* total) – accepted/published*

\*\*Note: In order to avoid double-listing of dissemination/publications given the extensive cross-collaboration with other projects, one publication is listed under the Pacific Arena report.

Broell F., Taylor, A.D., Litvak, M.K., Taggart, CT. (2016) Post-tagging behaviour and habituse in shortnose sturgeon measured with high-frequency accelerometer and PSATs Anim Biotelemetry 4:11 DOI 10.1186/s40317-016-0103-x.  
[http://www.phys.ocean.dal.ca/~taggart/Publications/broell\\_etal\\_2016\\_AnimBiotel.pdf](http://www.phys.ocean.dal.ca/~taggart/Publications/broell_etal_2016_AnimBiotel.pdf)

Broell, F., Burnelll, C., Taggart CT. (2016). Measuring abnormal movements in free-swimming fish with accelerometers: implications for quantifying tag and parasite load. J. Exp. Biol. 291, 695-705. [http://www.phys.ocean.dal.ca/~taggart/Publications/Broell\\_etal\\_2016\\_JEB.pdf](http://www.phys.ocean.dal.ca/~taggart/Publications/Broell_etal_2016_JEB.pdf)

*b) Refereed journal articles (1 total) – submitted*

Broell, F, McCain, J.S.P., Taggart, C.T. Thermal time explains size-at-age and -stage variation in molluscs. Submitted to MEPS, 03 Nov 2016

*c) Conference/workshop/seminar presentations (3 total) – invited or contributed*

Broell, F., James, M, Thorburn J, Nielsen J., Taggart CT. 2016. Characterizing and quantifying activity patterns of fish with accelerometer archival tags. Marine Alliance for Science and Technology for Scotland Conference. Scotland (contributed)

Broell, F. 2016. Challenges of activity recognition in fish using accelerometer sensors. Scottish Ocean Institute Seminar, St Andrews University, Scotland (invited)

Broell, F. 2016 Challenges of activity recognition in fish using accelerometer sensors. Marine Alliance for Science and Technology for Scotland Webinar, Scotland (invited)

*d) Books, data/technical reports, or any other relevant output/contributions not included above*

CFI - Innovation Brochure - showcases the OTN facilitated development of new tagging technology.

Some of the most important findings in Broell and Taggart (PLoS ONE, 2015) have been incorporated in The Physics of Living Systems (Fabrizio Cleri, Springer Publishing), an undergraduate text book: p. 469 - 470, Chapter 10: Of Limbs, Wings and Fins

## 8. Contributions from industrial and government partners

|   |               |
|---|---------------|
| Name of supporting organization:                                    | <b>Year 7</b> |
| <b>Maritime bioLoggers, Scottish Natural Heritage</b>               | <b>(2016)</b> |
| <b>Cash contributions to direct costs of research</b>               |               |
| <b>In-kind contributions to direct costs of research</b>            |               |
| 1) Salaries for scientific and technical staff                      | 3,000         |
| 2) Donation of equipment, software                                  | 7,000         |
| 3) Donation of material   |               |
| 4) Field work logistics   | 6,000         |
| 5) Provision of services  |               |
| 6) Other (specify):   |               |
| <b>In-kind contributions to indirect costs of research</b>          |               |
| 1) Use of organization's facilities                                 |               |
| 2) Salaries of managerial and administrative staff                  |               |
| 3) Other (specify):   |               |
| <b>Total of all in-kind contributions</b>                           | <b>16,000</b> |
| <b>Is this new funding (acquired during this reporting period)?</b> | <b>yes</b>    |

## 9. Notes

FB was on PhD stipend for January and February 2016 and completed her PhD in February 2016. We had hoped she would be finished by end December 2015 and budgeted accordingly. FB then carried on as a PDF starting March 2016, later than we indicated in our 2015 report. She was on PDF stipend for March through May, then took a leave of absence when she started an externally funded Visiting Fellowship from June to December at St Andrews University in Scotland. We therefore request to carry over our remaining funds to Jan-Mar 2017 so that she can complete the OTN seal analyses and the Alaska halibut analyses.

**Ocean Tracking Network Canada****NSERC****Progress Report Year 7 Review: 1 October 2015 – 30 September 2016****1. Project Number: 4.4****2. Project Title:** Overwinter biology, migrations, and carryover effects of Bras d'Or Atlantic salmon populations**3. Project Leaders:** Glenn Crossin (Dalhousie U), Bruce Hatcher (Cape Breton U)**Other OTN Canada participants:** S. Cooke, S. Hinch, I. Fleming, C. Taggart**Collaborators:** Gary Bugden (DFO-BIO), Dave Patterson (DFO – Pacific), Brian Petrie (DFO-BIO), Dale Webber (Vemco), Fred Whoriskey (OTN), Jinyu Sheng (Dalhousie U)**4. Training of Highly Qualified Personnel (and level of support)**

| Name  | Title*             | % Time in project | % Support from OTNC | Start Date (actual date HQP started with OTN) | End Date (actual or anticipated) |
|---|--------------------|-------------------|---------------------|---|----------------------------------|
| Xavier Bordeleau  | PhD                | 100               | 80                  | 1 Sept 2014                                   | 31 Dec 2018                      |
| Research Topic/current employment (if no longer OTNC HQP): Physiological and environmental correlates of habitat use by adult Atlantic salmon in the Bras d'Or Lakes, Nova Scotia |                    |                   |                     |   |                                  |
| Leah Strople  | BSc (Hons)         | 15                | NA                  | Oct 2015                                      | May 2017                         |
| Danny Farrar  | research assistant | 5                 | 100                 | Jan 2016                                      | Feb 2016                         |
| Michael Orr   | RA                 | 10                | NA                  | Oct 2013                                      | Nov 2015                         |
| Research Topic/current employment (if no longer OTNC HQP): Fish physiology, smolt tagging & tracking  |                    |                   |                     |   |                                  |
| Joel Hayes  | research assistant | 5                 | NA                  | Oct 2015                                      | June 2016                        |
| Research Topic/current employment (if no longer OTNC HQP): Environmental technology, receiver array service   |                    |                   |                     |   |                                  |
| Ilyia Kierkosz  | research assistant | 5                 | NA                  | May 2016                                      | May 2017                         |
| Research Topic/current employment (if no longer OTNC HQP): Limnology, receiver array service  |                    |                   |                     |   |                                  |

**5. Public summary of report**

We used acoustic telemetry and physiological sampling techniques to examine the post-spawning behaviour of adult Atlantic salmon in the Bras d'Or Lakes, Cape Breton, Nova Scotia. The capture and tagging of wild salmon on the Middle River occurred from December 2015 to January 2016. Led by the project's PhD student Xavier Bordeleau, fish were captured via angling, with assistance from CBU staff & students, local angler groups, conservation societies, and citizen scientists. In parallel, wild Middle River salmon held and spawned at the Margaree Hatchery as part of a provincial broodstock program were also tagged, so that we can compare the post-reproductive migration behaviour of wild-spawned and hatchery-spawned fish. 25 wild salmon were tagged on the Middle River, and another 15 were tagged at the Margaree Hatchery and released back into the Middle River. Detection data from the acoustic receiver array in the Bras d'Or Lakes have been downloaded, and are now being analyzed. Physiological samples from the fish at time of tagging and release show that the hatchery-spawned fish have higher baseline measures of stress (plasma glucose and cortisol) than wild-spawned fish. Whether these influence subsequent behaviour and survival are yet to be determined.



## 6. Networking, outreach, and synthesis

### *a) Interaction/Outreach to Broader Community/Public (including radio or television interviews or contribution to a programme/documentary, stakeholder workshops, etc.)*

B. Hatcher presented an update of the research to the Cape Breton Salmon Initiative in Wagmatcook (December 8, 2015)

X. Bordeleau attended a scale reading workshop given by Fred Whoriskey at Dalhousie University (May 6, 2016).

CBC News – Nova Scotia, August 1, 2016.

### *b) Synthesis activities*

X. Bordeleau lead a journal publication coordinated via the ideasOTN committee (refer to section 4.16 and see submitted publication below).

## 7. Dissemination of information and results

### *a) Refereed journal articles (1 total) – accepted/published*

Crossin GT, Hatcher BG, Denny S, Whoriskey K, Orr M, Penny A, Whoriskey FG (2016) Condition dependent migration behaviour of endangered Atlantic salmon smolts in an inland sea. Conservation Physiology 4(1). DOI 10.1093/conphys/cow018

### *b) Refereed journal articles (1 total) – submitted*

Bordeleau X, Zhang R, Hutchings JA, Whoriskey FG, Fennel K, Crossin GT (2016) The importance of iteroparity to the population dynamics of Atlantic salmon (*Salmo salar*). Canadian Journal of Fisheries and Aquatic Sciences.

### *c) Conference/workshop/seminar presentations (5 total) – invited or contributed*

Hatcher BG, Crossin G, Orr M, Penney A. (2015) Migration decisions by Atlantic Salmon smolts in a complex estuary: Should they stay or should they go? Oral presentation. Atlantic Society of Fish and Wildlife Biologists Symposium in St. Ann's, Nova Scotia, October 2015.

Bordeleau X, Denny S, Whoriskey F, Hatcher BG, Orr M, Sheng J, Crossin GT (2016) Migration strategies and survival of post-spawning Atlantic salmon of the Bras d'Or Lakes. Oral presentation. 6th annual Ocean Tracking Network Symposium. Halifax, Nova Scotia, June 2016.

Bordeleau X, Denny S, Whoriskey F, Hatcher BG, Orr M, Sheng J, Crossin GT (2016) Individual's post-spawning condition: implications for migration timing and survival of Atlantic salmon on their journey back to sea. Oral presentation. 9th Annual Dr. Patrick Lett Symposium. Halifax, Nova Scotia, February 2016.

Bordeleau X, Denny S, Whoriskey F, Hatcher BG, Orr M, Sheng J, Crossin GT (2016) Postspawning condition and implications for migratory decisions of Atlantic salmon. Oral presentation. 69th Canadian Conference for Fisheries Research. St. John's, Newfoundland and Labrador, January 2016.

Crossin GT, Whoriskey K, Orr M, Penny A, Denney S, Whoriskey F, Hatcher BG (2016) Behaviour of Atlantic salmon smolts through a unique inland sea: influence of water temperature and body condition. Canadian Conference for Fisheries Research. St. John's, Newfoundland and Labrador, January 2016.

*d) Books, data/technical reports, or any other relevant output/contributions not included above*

Bordeleau X (2016) A New Chapter in the Story of Salmon Research in the Bras d'Or Lakes. The Blue Heron, Bras d'Or Stewardship Society, March, 2016.

## 8. Contributions from industrial and government partners

|   |                         |
|---|-------------------------|
| Name of supporting organization:<br><b>Bras d'Or Institute for Ecosystem Research</b> | <b>Year 7</b><br>(2016) |
| <b>Cash contributions to direct costs of research</b>                                 |                         |
| <b>In-kind contributions to direct costs of research</b>                              |                         |
| 1) Salaries for scientific and technical staff  | 9755                    |
| 2) Donation of equipment, software  |                         |
| 3) Donation of material   |                         |
| 4) Field work logistics   | 4500                    |
| 5) Provision of services  |                         |
| 6) Other (specify):   |                         |
| <b>In-kind contributions to indirect costs of research</b>                            |                         |
| 1) Use of organization's facilities   | 10000                   |
| 2) Salaries of managerial and administrative staff                                    | 1200                    |
| 3) Other (specify):   |                         |
| <b>Total of all in-kind contributions</b>   |                         |
| <b>Is this new funding (acquired during this reporting period)?</b>                   | yes                     |

**Ocean Tracking Network Canada****NSERC****Progress Report Year 7 Review: 1 October 2015 – 30 September 2016****1. Project Number:** 4.5**2. Project Title:** The biotic and abiotic control of the oceanic migrations of the threatened American eel**3. Project Leaders:** Julian Dodson (U Laval), Martin Castonguay (DFO-Institut Maurice-Lamontagne, U Laval)**Other OTN Canada participants:** R. Apostle, K. Fennel, J. Sheng, K. Thompson, D. VanderZwaag**Collaborators:** Guy Verreault (Ministère des Forêts, de la Faune et des Parcs (MFFP), Québec) and David Stanley (Ontario Power Generation, OPG)**4. Training of Highly Qualified Personnel (and level of support)**

| Name   | Title* | % Time in project | % Support from OTNC | Start Date (actual date HQP started with OTN) | End Date (actual or anticipated) |
|--|--------|-------------------|---------------------|---|----------------------------------|
| Mélanie Béguer-Pon   | RA     | 100               | 100                 | 17 Sept 2010                                  | 30 Dec 2016                      |
| Research Topic/current employment (if no longer OTNC HQP): Migratory behaviour of silver American eels |        |                   |                     |   |                                  |

**5. Public summary of report**

A satellite tracking experiment on adult American eels was conducted in October 2015. Fourteen large adult eels from the St. Lawrence River were equipped with pop-up satellite archival tags and released at the Cabot Strait (over the Laurentien Channel) in an attempt to track them during their oceanic spawning migration. The migratory routes of 10 eels that kept their tags attached for 25 to 58 days were reconstructed using the method we previously developed. Eight eels were tracked beyond the continental shelf, including 4 eels that crossed the Gulf Stream and were tracked into the Sargasso Sea. These four eels migrated for about 2,270 to 2,750 km, providing new data on the behaviour during the migration from the Canadian coasts to and into the Sargasso Sea. Even if the eels tracked in 2015 did not go as far as the one tracked in 2014 (that reached the northern limit of the spawning area), the global success of our field experiment conducted in 2015 significantly improved with a total cumulated tracking distance and tracking length that both increased by 56% compared to the year 2014 (19,940 km vs and 8,400 km and 396 days vs 172 days, respectively). This improvement might be due to the release site that was located directly over the Laurentian Channel, at the Cabot Strait (i.e. at great depth and where the exiting current could have favored a quick departure from coastal waters). The observed trajectories and speeds were similar to those of eels tracked in 2014, reinforcing our observations previously published. Like previous years, a high rate of suspected predation events by coastal pelagic fish was highlighted. Eels also exhibited marked vertical migration related to daylight periods. However, eels tracked at sea in 2015 did not reach the surface at night as did the eels tracked in 2014. The physical factors we tested (temperature, salinity, moon cycle) did not seem to explain the differences in vertical profiles between years. The role of diel vertical migration is still not understood but it does not seem to affect the overall migratory horizontal trajectories. The comparison between the two year's results illustrates the importance of observing a greater number of eels and the necessity of repeating the experiments over several years. Results from this year's experiment and the previous one are reported in a publication currently in preparation and that should be submitted by the end of 2016. Results from our previous

satellite tagging experiments that were published in Nature Communications in October 2015 experienced widespread media coverage with many articles published in a variety of media (Newspaper such as the New York Times, or magazines such as National Geographic). We were contacted by many journalists to provide interviews. In October 2015, a documentary that relates our field tracking experiment was filmed in Nova Scotia and has been released on the OTN website for public use.

A review of 81 studies published between 1974 and 2016 that used telemetry to assess the movements of eels in a variety of habitats was conducted. The review, submitted in August 2016, provides a global overview of the various telemetry tools employed over time and the species, life-history stages and habitats and summarizes the main findings. This work discusses some limitations of telemetry technology and identifies new questions and avenues of research that would not be evident without the review article (for instance the geographical setting of the studies that is restricted relative to the distribution of each species, males rarely tracked, etc.).

The acoustic receivers deployed at Cabot Strait and downloaded during spring 2016 provided additional data on eels tagged and detected in late 2014. These eels were tagged by our collaborators from the Ministère des Forêts, de la Faune et des Parcs (MFFP) and Ontario Power Generation (OPG). The goal, oriented toward management purposes, was to monitor the escapement rate at the Cabot Strait Line and to compare the migratory performance between stocked, trapped and transported, and wild eels. Results indicate that stocked eels can find their way out of the Gulf of St. Lawrence (thus can reach the marine waters) and exhibit migratory performance similar to that of wild eels. Two cases of predation by homeotherm fishes were also highlighted. A paper reporting these original and significant results is currently being prepared and should be submitted by the end of 2016.

Our study about the simulation of the migration of eels in Gulf of St. Lawrence was accepted after minor modifications in the journal Marine Ecology Progress Series in March 2016. The work, conducted in collaboration with physical oceanographers from the OTN team of Theme I.1, served as a basis for producing another study that simulated the oceanic migration of silver adults Japanese eels. That study was led by a researcher from Taiwan and was published in 2016. Another study that simulated the dispersal of Japanese eel larvae has been conducted and was submitted to a journal during summer 2016.

## 6. Networking, outreach, and synthesis

### *a) Interaction/Outreach to Broader Community/Public (including radio or television interviews or contribution to a programme/documentary, stakeholder workshops, etc.)*

Mélanie Bégue-Pon, actively participated in two papers led by Dr Yu-Lin Chang, a physical oceanographer from the Institute of Marine Environmental Sciences and Technology in Taiwan and who visited Dalhousie University on several occasions in 2015. These papers are about the simulation of the migration of the Japanese eel and are based on the modeling work we previously conducted on the American eel during our OTN research project.

Results from our satellite tagging experiments published in the high-ranking journal Nature Communications in October 2015 had large media coverage. They were disseminated to the public through a variety of media: newspaper (e.g. New York Times, Le Monde), magazines (e.g. National Geographic) and web media (e.g. the conversation.com, news.sciencemag.org). We have been contacted by many journalists to provide interviews that were included in the released articles.

A 13-min documentary, “Eeltrack”, was filmed in Nova Scotia in October 2015 during our last field tracking experiment. The film presents an opportunity for everyone to have a look into the work we have carried out. The movie has been released on the OTN website for public use (<http://oceantrackingnetwork.org/eeltrack-film-documents-migration-of-american-eels-from-nova-scotia-to-the-sargasso-sea/>).

### *b) Synthesis activities*

As a member of the ideasOTN committee, Mélanie has been actively involved in synthesis activities. M. Béguer-Pon, participated in most of the monthly phone meeting conducted in 2016. She participated in the preparation of a poster and an oral communication presented during the last OTN annual meeting. The poster provided a dynamic schematic view of ideasOTN synthesis activities while the oral communication presented three regional case studies (including one on the eels) that demonstrate the utility of aquatic telemetry technology as a powerful tool to guide management and conservation of species.

M. Béguer-Pon, has also been involved in a review of crustacean movements studies that is led by the master student Emilie Simard from UQAR. The paper is currently in progress. We wrote a paper that reviews 81 studies published between 1974 and early 2016 that use telemetry to study the movements of eels in a variety of habitats. The paper involved co-authors who have a strong background in telemetry studies associated with eel species in various areas of the world and who are OTN members (K. Aarestrup) or not (D. Jellyman and K. Tsukamoto). The paper was submitted in August 2016 in the journal “Reviews in Fish Biology and Fisheries”.

## **7. Dissemination of information and results**

### *a) Refereed journal articles (2 total) – accepted/published*

Béguer-Pon, M., Ohashi, K., Sheng, J., Castonguay, M., Dodson, J.D. (2016) Modeling the migration of the American eel in the Gulf of St. Lawrence. *Marine Ecology Progress Series* 549, 183-198.

Chang, Y.-L., Miyazawa, Y., Béguer-Pon, M. (2016) Simulating the Oceanic Migration of Silver Japanese Eels. *PLoS ONE* 11, e0150187.

### *b) Refereed journal articles (2 total) – submitted*

Béguer-Pon, M., Dodson, J., Castonguay, M., Jellyman, D., Aarestrup, K., Tsukamoto, K. (Submitted in August 2016) Tracking anguillid eels: five decades of telemetry-based research. *Reviews in Fish Biology and Fisheries*.

Chang, Y.-L., Miyazawa, Y., Béguer-Pon, M. (Submitted in July 2016) The dynamical impact of mesoscale eddies on dispersal of Japanese eel larvae. *Scientific Reports*.

### *c) Conference/workshop/seminar presentations (2 total) – invited or contributed*

Béguer-Pon, M., Castonguay, M. and Dodson, J.J., Sheng, J., and Thompson, K. 2016. Overview of OTN project 4.5: Project 4.5: Oceanic migration of the threatened American eel to spawning

grounds in the Sargasso Sea. Oral communication at the OTN Annual Meeting, June 2-3, Halifax, NS, Canada.

Béguer-Pon, M, Castonguay, M. and Dodson, JJ. Tracking eels with PSAT. Oral communication during a meeting with researchers from Ifremer (France), 19-22 July 2016.

## 8. Contributions from industrial and government partners

|   |                 |
|---|-----------------|
| Name of supporting organization:                                    | <b>Year 7</b>   |
| <b>Department of Fisheries and Oceans</b>                           | <b>(2016)</b>   |
| <b>Cash contributions to direct costs of research</b>               | <b>\$4,600</b>  |
| <b>In-kind contributions to direct costs of research</b>            |                 |
| 1) Salaries for scientific and technical staff                      | \$17,000        |
| 2) Donation of equipment, software                                  |                 |
| 3) Donation of material   |                 |
| 4) Field work logistics   | \$2,000         |
| 5) Provision of services  |                 |
| 6) Other (specify):   |                 |
| <b>In-kind contributions to indirect costs of research</b>          |                 |
| 1) Use of organization's facilities                                 |                 |
| 2) Salaries of managerial and administrative staff                  |                 |
| 3) Other (specify):   |                 |
| <b>Total of all in-kind contributions</b>                           | <b>\$19,000</b> |
| <b>Is this new funding (acquired during this reporting period)?</b> | yes             |

## 9. Notes

Papers that are in preparation and expected to be submitted by the end of the year:

Béguer-Pon, M., Shan, S., Dodson, J.J., Castonguay, M. (In prep) Tentative title: Behavioral plasticity in the vertical and horizontal oceanic migrations of mature American eel. *Limnology & Oceanography*.

Béguer-Pon, M., Stanley, D., Threader, R., Verreault, G., Castonguay, M., Dodson, J. (In prep) Leaving the St. Lawrence system: can stocked and transported silver eels make it? *North American Journal of Fisheries Management*.

**Ocean Tracking Network Canada****NSERC****Progress Report Year 7 Review: 1 October 2015 – 30 September 2016****1. Project Number:** 4.6**2. Project Title:** Movement and habitat use by sturgeon in Atlantic Canada and anthropogenic interactions**3. Project Leaders:** Mike Stokesbury (Acadia U), Michael Dadswell (Acadia U), Matthew Litvak (Mount Alison U)**Other OTN Canada participants:** R. Apostle, S. Cooke, C. Taggart, J. Sheng, D. Vanderzwaag, G. Crossin**Collaborators:** Colin Simpfendorfer and Michelle Hueple (James Cook University, Australia), Kevin Stokesbury (U. Mass, USA), Matt Balazak (Virginia Commonwealth U., USA), Ike Wirgin (NYU Langone Medical School, NY, USA), Cornel Ceapa (Acadian Sturgeon and Caviar), Rod Bradford, (BIO, DFO, NS, Canada), K. Sulak and M. Randal, (USGS, Gainesville, Florida, US)**4. Training of Highly Qualified Personnel (and level of support)**

| Name   | Title*    | % Time in project | % Support from OTNC | Start Date (actual date HQP started with OTN) | End Date (actual or anticipated) |
|--|-----------|-------------------|---------------------|---|----------------------------------|
| Laura Logan-Chesney  | MSc       | 100               | 100                 | 1 Sept 2012                                   | 1 Jan 2017                       |
| Research Topic: Breaching behaviour and Population specific movements of Atlantic Sturgeon in Minas Basin  |           |                   |                     |   |                                  |
| Colin Buhariwalla  | MSc       | 100               | 60                  | 1 Sept 2012                                   | 1 April 2017                     |
| Research Topic: Striped Bass biology and movements in the Mira Estuary   |           |                   |                     |   |                                  |
| Seth Newell  | BSc (Hon) | 50                | 0                   | 1 May 2015                                    | 1 Sept 2016                      |
| Research Topic: Spawning periodicity of Atlantic sturgeon in the Saint John River  |           |                   |                     |   |                                  |
| Margaret Whitmore  | MSc       | 100               | 100                 | 11 July 2015                                  | 1 Sept 2017                      |
| Research Topic: Seasonal distribution, movement patterns, and habitat use of juvenile Atlantic sturgeon from the Saint John River, New Brunswick, Canada |           |                   |                     |   |                                  |
| Matthew Brown  | MSc       | 100               | 100                 | 1 May 2014                                    | 31 Dec 2017                      |
| Research Topic: Seasonal distribution, movement patterns, and habitat use of Atlantic sturgeon from the Saint John River, New Brunswick, Canada          |           |                   |                     |   |                                  |

**5. Public summary of report**

This year saw more limited tagging activities occurring in Minas Basin, while sturgeon tagging was geographically expanded to include deployment of five miniPAT tags on Gulf Sturgeon in the Suwannee River, FL, US in collaboration with the USGS. Laura Logan-Chesney finished up her two research chapters on sturgeon distribution and movement behaviour in Minas Passage and is scheduled to defend her thesis in early December 2016. Colin Buhariwalla is working on his residency chapter for the striped bass tagging project in the Mira (connection to sturgeon tagging detailed in past reports). Colin's thesis work was interrupted as he took a four month hiatus to work with French OTN partners in the Kerguelen Islands, in the Antarctic Ocean, providing international knowledge and technology transfer, between groups. Colin is finishing up his second research chapter and is due to graduate in Spring 2017. Suwannee River tagging will enable comparative study of the marine phase of the closely related

Atlantic and Gulf sturgeon. This Gulf sturgeon population is recovering from a very low level of abundance and is expanding its distribution in the river and in the Gulf of Mexico. A strong collaboration has formed between the Coastal Ecology Lab at Acadia University and the USGS office in Gainesville, where Stokesbury is a visiting researcher from November 2016 through March 2017.

2016 saw the publishing of several papers important for sturgeon management. One in particular (Stokesbury 2016) detailed the spatial and temporal distribution of Atlantic sturgeon when moving through Minas Passage, an area where a tidal turbine was deployed on 7 November 2016. This is a first of several test turbines to determine if it is financially and environmentally viable to harvest green energy from tides in the Bay of Fundy.

## 6. Networking, outreach, and synthesis

### *a) Interaction/Outreach to Broader Community/Public (including radio or television interviews or contribution to a programme/documentary, stakeholder workshops, etc.*

- Stokesbury – Interview CBC Halifax Mainstreet – 21 June 2016 – Tidal Turbines in the Bay of Fundy
- Dadswell - Meeting with Big Moon Tidal Power concerning deployment of their ‘kinetic keel’ in the inner Bay of Fundy
- Dadswell - Three fisher sponsored meetings in Gaspereau and Wolfville with FORCE and Cape Sharp Tidal Venture (CSTV) concerning deployment of OPEN HYDRO axial-flow, hydraulic lift turbine in Minas Passage.
- Dadswell - Expert witness for Fundy Inshore Fishers Association at ‘stay’ hearing for CSTV turbine deployment (October 26, 2016).
- Dadswell - Publication of three ‘OPINION’ pieces in Chronicle Herald (Halifax) concerning deployment CSTV turbine in Minas Passage. {July (2), October (1)}.

### *b) Synthesis*

A synthesis paper detailing much of the valuable work that OTN has supported on Atlantic sturgeon in Minas Basin and Passage was published in the Journal of Fish Biology (Dadswell et al. 2016 The annual feeding aggregation of Atlantic sturgeon *Acipenser oxyrinchus* in the inner Bay of Fundy: population characteristics and movements). Over the course of our research program we have answered, in a systematic, intuitive process, many important questions about Atlantic sturgeon biology. These include population structure, spatial and temporal movement patterns, overwintering areas, growth, diet, fine-scale feeding behaviour, post-bycatch survival, and abundance. Our trainees have gone on to higher education, work both with the provincial and federal governments, and to industry. We thank OTN and the OTN headquarters group for their incredible support for this program.



## 7. Dissemination of information and results

### a) Refereed journal articles (3 total) – accepted/published

- Stokesbury, MJW, M. McLean, A. Redden, J. Beardsall, J. Broome, D. Bates and M.J. Dadswell. 2016. Atlantic sturgeon spatial and temporal distribution in Minas Passage, Nova Scotia, a region of future tidal power extraction. Plos One 11:e0155387. DOI:10.1371/journal.pone.0158387.
- Dadswell, MJ, SA Wehrell, AD Spares, MFMcLean, JW Beardsall, LM Logan-Chesney, G. Nau, C. Ceapa, AM Redden, and MJW Stokesbury. 2016. The annual feeding aggregation of Atlantic sturgeon *Acipenser oxyrinchus* in the inner Bay of Fundy: population characteristics and movements. Journal of Fish Biology 89: 2107-2132. DOI:10.1111/jfb.13120
- Beardsall J, MJW Stokesbury and MJ Dadswell. 2016. Adult Atlantic sturgeon, *Acipenser oxyrinchus*, coastal overwintering behaviour in the Bay of Fundy: depth and temperature distributions. Journal of Applied Ichthyology DOI:10.1111/jai.13175.

### b) Refereed journal articles (2 total) – submitted

- Stewart, ND, L. LoganChesney, G. Gibson, I. Wirgin, MJ Dadswell, MJW Stokesbury. Natural stranding of Atlantic sturgeon *Acipenser oxyrinchus oxyrinchus* in the Bay of Fundy, Nova Scotia, from populations of concern in USA and Canada. Journal of Applied Ichthyology (in revision).
- Dadswell, MJ. AD Spares, ND Stewart, C Ceapa, A Curry, R Bradford, and MJW Stokesbury. Population characteristics of adult Atlantic sturgeon captured in the fishery in the Saint John River estuary, New Brunswick, Canada. Transactions of the American Fisheries Society (in revision).

### c) Conference/workshop/seminar presentations (6 total) – invited or contributed

- Stokesbury, MJW, Logan-Chesney, L, Buhariwalla, C and B Sanderson. 2016. Predicting and quantifying interactions between in-stream tidal power turbines and migrating Atlantic sturgeon. Seminar Series, School for Marine Science and Technology, University of Massachusetts, Dartmouth, 21 Sept. 2016, New Bedford, Massachusetts, U.S.A.
- Stokesbury, MJW. 2016. The Global Ocean Tracking Network. Shark Class invited lecture, 30 August, 2016, Dalhousie University, Halifax, N.S.
- Stokesbury, MJW. 2016. Predicting interactions between Atlantic sturgeon and tidal power turbines. Gulf of Maine Institution, Teacher Professional Development Initiative. 25 August, 2016, Acadia University, Wolfville, N.S.
- Stokesbury, MJW, Logan-Chesney, L, Stewart, N, McLean, MF, Beardsall, JW and MJ Dadswell. 2016. Predicting the effects of in-stream tidal power turbines on migrating Atlantic sturgeon. Canadian Society of Zoologists, Annual General Meeting, 10 May 2016. London, Ontario, Canada (**Keynote**)

Wirgin, I, Fox, D, Savoy, T and MJW. Stokesbury. 2016. Use of Individual Based Assignment Tests in the Coastwide Management of Atlantic Sturgeon. Atlantic and shortnose sturgeon workshop. NOAA 16-18 May 2016, Shepardstown, West Virginia, USA.

Logan-Chesney, LM, Stokesbury, MJW, and RH Karsten. 2016. Atlantic sturgeon breaching behaviour in Minas Basin, inner Bay of Fundy, Canada. Acadia Grad Student Association (AGSA) Conference, Wolfville, Nova Scotia. February 26-27, 2016. Oral presentation.

## 8. Contributions from industrial and government partners

|   |               |
|---|---------------|
| Name of supporting organization:                                    | <b>Year 7</b> |
| <b>Acadia University (through internal funds to MJWS CRC)</b>       | <b>(2016)</b> |
| <b>Cash contributions to direct costs of research</b>               | <b>4,800</b>  |
| <b>In-kind contributions to direct costs of research</b>            |               |
| 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): Travel costs for UMass talk                     |               |
| <b>In-kind contributions to indirect costs of research</b>          |               |
| 1) Use of organization's facilities                                 |               |
| 2) Salaries of managerial and administrative staff                  |               |
| 3) Other (specify):   |               |
| <b>Total of all in-kind contributions</b>                           |               |
| <b>Is this new funding (acquired during this reporting period)?</b> | <b>no</b>     |

**Ocean Tracking Network Canada****NSERC****Progress Report Year 7 Review: 1 October 2015 – 30 September 2016****1. Project Number:** 4.7**2. Project Title:** Grey seals (*Halichoreus grypus*) as bioprobes: predicting impacts on their ecosystems**3. Project Leaders:** Sara Iverson (Dalhousie U), Don Bowen (DFO-Bedford Inst, Dalhousie U), Joanna Mills Flemming (Dalhousie U)**Other OTN Canada participants:** K. Fennel, J. Sheng, T. Ross, I. Fleming**Collaborators:** Mike Hammill (DFO-Gulf region), Luke Comeau (DFO-NB), Doug Swain (DFO-Gulf region), Fred Whoriskey (OTN), D. Webber (Vemco), B. McConnell (Sea Mammal Research Unit)**4. Training of Highly Qualified Personnel (and level of support)**

| Name  | Title* | % Time in project | % Support from OTNC | Start Date (actual date HQP started with OTN) | End Date (actual or anticipated) |
|---|--------|-------------------|---------------------|---|----------------------------------|
| Damian Lidgard  | RA     | 80                | 80                  | 1 Jan 2010                                    | 31 Dec 2016                      |
| Research Topic: Encounters between grey seals and their prey and at-sea social interactions amongst grey seals  |        |                   |                     |   |                                  |
| Benia Nowak   | MSc    | 100               | 100                 | 4 May 2015                                    | 6 April 2017                     |
| Research Topic: Examining the influence of oceanographic features on the movement and habitat use of grey seals |        |                   |                     |   |                                  |
| Lindsay Randell   | BSc    | 40                | 0                   | 1 April 2015                                  | 08 Oct 2015                      |
| Research Topic: Using acoustic telemetry to examine movement patterns of cod                                    |        |                   |                     |   |                                  |

**5. Public summary of report**

On 28 October 2015 at Sable Island two female grey seals were deployed with a VMT, satellite transmitter, head- and back-mounted accelerometers and a back-mounted camera. The accelerometers were designed and built by the local company Maritime Biologgers (a company created by Fran Broell, OTN HQP, 4.3). The camera was custom-built by CATS (Australia) for use on grey seals. The aim of this deployment was to collect data on fine head and body movements using the accelerometers to determine behaviours during encounters with tagged fish, and to use video footage from the camera to associate behaviours with the accelerometer data. Between December 2015 and January 2016, instruments were recovered from both of these seals in addition to 12 of the 15 VMT and satellite transmitters deployed on grey seals on Sable Island in June 2015. Preliminary examination of the accelerometer data clearly suggests that foraging and resting bouts, amongst other behaviours, can be discerned and that previous assumptions of sea behaviour inferred from dive data alone can be misleading. Unfortunately, although video footage was collected from the two cameras, the failure of the infra-red lights to turn on resulted in no usable footage to examine behaviours. Both cameras were examined and tested by the manufacturer and one of these, along with a VMT, satellite transmitter and accelerometer, was re-deployed opportunistically on a pregnant female seal on Sable Island in September 2016. Data from this seal will be recovered in January 2017 (fieldwork expenses covered by DFO). Of the 3908 detections collected by the VMTs 31% were due to seals detecting each other and 9% from detecting 24 Atlantic cod, 19 of which were detected by one seal. The remaining detections were from three OTN tagged marine species (Atlantic salmon, blue shark and Atlantic bluefin tuna). With

assistance from DFO and local fishermen in June 58 cod were tagged on the Scotian Shelf. The grey seal work was presented by Damian Lidgard to students from SHAD and the Marine Mammal and Biologging classes at Dalhousie University, as well as to children at the Bedford Academy and the local independent organisation, Thrive Education. Sea-sea productions are working with the grey seal bioprobe team to produce a film on the seals of Sable Island, the research of the grey seal bio-probe project with particular emphasis on the use of cameras to study seal behaviour, and linking both with the photography of Damian Lidgard to bridge science with art. Lindsay Randell, a Dalhousie Experiential student, joined the grey seal bio-probe project to examine seal- and receiver-detections of cod. Damian Lidgard is a member of IdeasOTN and is working on several review papers with other OTN members. Seal GPS data were used in a collaborative study to look at the occurrence of viral influenza in grey seals and this was recently published in the journal *Emerging Microbes and Infections*. Benia Nowak has modeled grey seal tracks using “swim” in collaboration with Kim Whoriskey (4.8) and foraging patch analysis of grey seal tracks. She is a Nova Scotia Graduate Scholarship (NSGS) recipient. Benia also spent four weeks during the winter on Sable Island learning and engaged in fieldwork activities.

## 6. Networking, outreach, and synthesis

### *a) Interaction/Outreach to Broader Community/Public (including radio or television interviews or contribution to a programme/documentary, stakeholder workshops, etc.)*

The lead PIs and key HQP of Projects 4.7 and 4.8, and more recently 4.3 (S Iverson, D Bowen, D Lidgard, B Nowak, S Lang, J Mills Fleming, M Auger-Methe, S Carson, K Whoriskey, F Broell) meet once monthly to review the past month's activities and progress, address any concerns or questions, and to discuss planned activities and progress for the next month. This group also works together on many joint publications and presentations (see 4.8 report).

D Lidgard gave presentations to students at local schools, organisations and Dalhousie University on the grey seal research on Sable Island and OTN

D Bowen and D Lidgard completed a collaboration with Wendy Puryear (Biological Engineering, MIT) on the ecology of influenza in Western Atlantic grey seals (published in the journal *Emerging Microbes and Infections*)

In collaboration with Jarrett Corke (WWF), D Lidgard created a video to highlight the use of bluetooth technology to remotely collect data on encounters between grey seals and fish

D Lidgard is collaborating with Sea-Sea Productions to produce a pilot film on the grey seals on Sable Island and the research of the grey seal bio-probe project. CBC Nature of Things have shown interest in this pilot.

D Lidgard is the co-chair of the Scientific Committee for the Marine Mammal conference (Halifax, October 2017). As a result of his involvement, OTN will be featured as one of the four plenaries at the conference

B Nowak coordinated graduate student presentations for OTN's visit of former parliamentarians

B Nowak was a Guest Lecture for Biologging in Ecology class

B Nowak was involved in First Year Interest Groups “Science Speed Dating”

B Nowak attended 'Women in STEM' discussion

B Nowak has modeled grey seal tracks using “swim” in collaboration with Kim Whoriskey

### *b) Synthesis activities*

D Bowen and D Lidgard are collaborating on a paper examining the role of marine mammals in the marine ecosystem; D Bowen, S Lang and D Lidgard are collaborating on a paper that will link the diets of grey seals, based on stable isotopes, with foraging style; the collaboration between M Auger-Méthé, D Lidgard, D Bowen, I Jonsen and J Mills-Flemming on the use of the Template Model Builder to model the movement of grey seals at sea is under review by the journal Marine Ecology Progress Series; D Lidgard is a member of ideasOTN and is involved in three research papers: 'Using bioprobes to examine predator-prey interactions in a marine system' (with D Bowen, S Iverson, Ian Jonsen), 'Animal movement and space-use in terrestrial and marine ecosystems' (with Marie Auger-Methe) and 'Review of animal accelerometry (with F Broell, Chris Taggart)'.

## 7. Dissemination of information and results

### *a) Refereed journal articles (1\*\* total) – accepted/published*

\*\*Note: In order to avoid double-listing of dissemination/publications given the extensive cross-collaboration with Project 4.8, all but one of 4.7 publications are listed under Project 4.8 report. The publication listed here used only 4.7's seal GPS tracking data so did not involve 4.8.

Puryear WB, Keogh M, Hill N, Moxley J, Josephson E, Davis KR, Bandoro C, Lidgard D, Bogomolni A, Levin M, Lang S, Hammill M, Bowen D, Johnston DW, Romano T, Waring G, Runstadler J (2016) Prevalence of influenza A virus in live-captured North Atlantic gray seals: a possible wild reservoir. *Emerg Microbes Infect* 5:e81

### *c) Conference/workshop/seminar presentations (2 total) – invited or contributed*

B Nowak and D Lidgard attended and presented work at OTN Symposium 2016 for Project 4.7

D Lidgard presented synthesis projects through ideasOTN at OTN Symposium 2016

## 8. Contributions from industrial and government partners

| Name of supporting organization:<br><b>CFI</b>             | <b>Year 7<br/>(2016)</b> |
|--|--------------------------|
| <b>Cash contributions to direct costs of research</b>      |                          |
| <b>In-kind contributions to direct costs of research</b>   |                          |
| 1) Salaries for scientific and technical staff             |                          |
| 2) Donation of equipment, software                         |                          |
| 3) Donation of material                                    | 2400                     |
| 4) Field work logistics                                    |                          |
| 5) Provision of services                                   |                          |
| 6) Other (specify):  |                          |
| <b>In-kind contributions to indirect costs of research</b> |                          |

|   |    |
|---|----|
| 1) Use of organization's facilities                                 |    |
| 2) Salaries of managerial and administrative staff                  |    |
| 3) Other (specify):   |    |
| <b>Total of all in-kind contributions</b>                           |    |
| <b>Is this new funding (acquired during this reporting period)?</b> | no |

**Ocean Tracking Network Canada****NSERC****Progress Report Year 7 Review: 1 October 2015 – 30 September 2016****1. Project Number:** 4.8**2. Project Title:** Visualization and modelling of complex marine observations**3. Project Leaders:** Joanna Mills Flemming (Dalhousie U)

**Other OTN Canada participants:** D. Bowen, S. Iverson, C. Taggart, G. Crossin, I. Fleming, J. Dodson, S. Cooke, A. Fisk

**Collaborators:** Simon Bonner (Western University), Chris Field (Dalhousie U), Aaron McNeil (Australian Institute of Marine Science), Wayne Olford (U Waterloo), Tim Stone (Vemco), Dale Webber (Vemco), Ian Jonsen (Macquarie University), Duncan Murdoch (Western University), Anders Neilsen and Christoffer Moesgaard Albertsen (both from the Technical University of Denmark)

**4. Training of Highly Qualified Personnel (and level of support)**

| Name  | Title* | % Time in project | % Support from OTNC | Start Date (actual date HQP started with OTN) | End Date (actual or anticipated) |
|---|--------|-------------------|---------------------|---|----------------------------------|
| Stuart Carson   | PhD    | 100               | 85                  | 1 Jan 2012                                    | 1 Feb 2017                       |
| Research Topic/current employment (if no longer OTNC HQP): Getting off the track: spatio-temporal statistical methods for evaluating at sea acoustic tag data |        |                   |                     |   |                                  |
| Marie Auger-Méthé   | PDF    | 100               | 100                 | 1 Aug 2014                                    | 31 Jul 2016                      |
| Research Topic: Efficient and Robust State-Space Models for Animal Movement Data  |        |                   |                     |   |                                  |
| Kim Whoriskey   | PhD    | 100               | 100                 | 1 Sep 2014                                    | 1 Apr 2019                       |
| Research Topic: Statistical Advances for Understanding Animal Behaviour in Aquatic Environments   |        |                   |                     |   |                                  |
| Marie Auger-Méthé   | RA     | 100               | 100                 | 1 Aug 2016                                    | 31 Dec 2016                      |
| Research Topic/current employment (if no longer OTNC HQP): Efficient and Robust State-Space Models for Animal Movement Data                                   |        |                   |                     |   |                                  |

**5. Public summary of report**

In order to answer scientific questions of relevance to OTN, we must have both effective visualization tools and reasonable models. Only then can we gain the scientific knowledge critical to understanding both the continental shelf and open ocean ecosystems. This cross-cutting activity is seeing the development of novel statistical techniques using cutting edge software so that complex models can be fitted to data in a fraction of the time that has typically been required. These models are both accurate and robust. With what we have achieved to date we are beginning to understand the spatial ecology of marine animals and predicting how their distribution will be affected by anthropogenic factors (e.g. climate change, fishing). To help disseminate the use of the tools that we are developing we continue to update and maintain the OTN GitLab statistical modeling group account (<https://gitlab.oceantrack.org/groups/otn-statistical-modelling-group>).

Our team has seen much activity over the last year. Many new collaborations have ensued including those with Matthew Ogburn (Smithsonian Environmental Research Center), Leigh Torres (Oregon State University), Bradley Wetherbee (University of Rhode Island), Nancy Shackell (Department of Fisheries and Oceans Canada) and Tom Binder (Hammond Bay Biological Station). Various other researchers

(both OTN Canada participants and others) have solicited input from our team members but some of these have been delayed/declined due to a lack of HQP. Notwithstanding this limitation Joanna Mills Flemming (JMF) and Kim Whoriskey (KW) have agreed to offer a workshop for the University of Miami (Neil Hammerschlag) in Spring 2017. In addition, a new MSc student Ethan Lawler (funded by the Division of Statistics at Dalhousie U) has recently joining us and is rapidly learning our modelling and visualization tools with the goal of refining them for the simultaneous analysis of mako (and potentially also tiger) shark tracks collected at the Guy Harvey Research Institute.

PhD Christoffer Albertsen (CA) from the Danish Technical University visited Dalhousie U from February 29 to March 4 to collaborate with JMF, KW and Marie Auger-Méthé (MAM). They critically assessed using CA's covafill R Package to incorporate environmental variables into their animal movement modelling framework in TMB. Our final workshop was rescheduled to Spring 2017 (from Spring 2016) so that KW and MAM could attend the International Statistics Ecology Conference and its associated workshops in Seattle USA. KW successfully switched from an MSc to PhD program and will be doing her thesis proposal in early December. MAM recently accepted a CRC Tier II in Statistical Ecology at the University of British Columbia which will see her cross-appointed in their Department of Statistics and Institute for the Oceans and Fisheries. MAM also became an Associate Editor for Methods in Ecology & Evolution and continues to co-chair ideasOTN. Despite some significant health problems SC has resubmitted his research to PlosONE and is now hard at work finishing up his PhD thesis which he will defend in January 2017. JMF continues to oversee all aspects of this cross-cutting activity while also serving on OTN's International Scientific Advisory Committee (ISAC) and International Data Management Committee (IDMC).

## 6. Networking, outreach, and synthesis

### *a) Interaction/Outreach to Broader Community/Public (including radio or television interviews or contribution to a programme/documentary, stakeholder workshops, etc.)*

The lead PIs and key HQP of Projects 4.7 and 4.8, and more recently 4.3 (S Iverson, D Bowen, D Lidgard, B Nowak, S Lang, J Mills Flemming, M Auger-Methe, S Carson, K Whoriskey, F Broell) meet once monthly to review the past month's activities and progress, address any concerns or questions, and to discuss planned activities and progress for the next month. This group also works together on many joint publications and presentations (see below).

This cross-cutting activity works at ensuring that visualization and modelling techniques for complex marine observations as used by various OTN Canada participants and HQP are optimal for dealing with OTN (and other) tracking data and the ensuing large complex data sets that arise as we attempt to link environmental features with animal movements. In addition, it attempts to ensure that observing technologies (acoustic transmitters and receivers, tracking devices, environmental sensors) and accompanying modeling techniques are properly integrated into the network (as well as globally).

As stated in our original proposal, our annual workshops bring together OTN HQP and experts in statistical modelling and data visualization so as to develop the tools necessary to effectively analyze OTN related data in order to answer important scientific questions. All of the workshops that we have offered to date have been at capacity with participants from both within and outside of OTN as well as from both within and outside of Dalhousie U. This speaks to the intra-network collaborations this group both generates and supports. To this end project leaders and HQP attended a number of workshops and international conferences during the past year in order to ensure that they were well abreast of the latest



research developments in this area as well as to connect with world-renowned experts in the field. Our final workshop will take place in Spring 2017 and will bring in relevant experts for discussion of both current and future research directions as well as funding. Finally, in late summer of 2017 JMF and various HQP will travel to Casa Matemática Oaxaca (CMO) to co-organize and participate in a scientific activity 'New perspectives on State Space Models' for which one of the major themes is marine animal movement modelling.

Another objective of our cross-cutting activity was to create a repository of documented shared code and freely available software for OTN researchers as well as the broader scientific community. We now have the OTN Statistical Modelling Group on GitLab. MAM currently maintains this open and public account on the GitLab (with KW planning to take over in early 2017) which serves as a repository for tools (many of which were taught in our workshops) and documentation to facilitate using TMB for the efficient and robust fitting of state-space models. Once a research article associated with these projects is published, the code repository is made open to the public and a link added into the published article, thus allowing all readers access to the code. We remain very confident that our platform of choice (R/TMB) can efficiently fit all of the statistical models we require and also interface well with rgl to produce desired data visualizations. In the next few months we will be introducing several new versions of our state-space models including one that can handle discrete behaviours. This will be a huge addition to our toolbox and is highly anticipated by the animal movement modelling community.

We continue to facilitate the exchange of HQP between OTN arenas, and internationally as resources permit, in order to foster stronger collaboration on modelling and visualization tools useful in many OTN projects. Our long list of collaborators from both within and outside of OTN serves as a testament to the success we have had in not only making it possible for HQP to be involved in interesting research projects but also in attracting researchers interested in learning about our tools from all over the world. We anticipate that our third and final workshop will be extremely well received and again at capacity.

### *b) Synthesis activities*

There is not the space to detail all of our synthesis activities so I have selected a few to highlight (below).

KW is leading a collaborative review project on the available statistical methods for presence-absence data in the aquatic realm collected by radio, pit tag, and acoustic telemetry. This project group includes JMF, Lee Gutowsky, Vivian Chu, Eduardo Martins, and MAM. She is also working with Don Bowen and JMF to determine the differences in foraging tactics of two distinct grey seal populations (Sable Island and Hay Island, Nova Scotia). KW collaborates with Glenn Crossin to help tag Atlantic salmon smolts and adults in the Bras d'Or lakes of Cape Breton, Nova Scotia, and has already provided feedback on analyzing the results of this telemetry project. Finally she is working with Aaron Fisk and Eddie Halfyard to visualize the data from a VPS system monitoring the movements of yellow perch and largemouth bass in an experimental pond in Southern Ontario. In Spring 2016 JMF and KW visited Saint Agnes Junior High School to talk about the Ocean Tracking Network. Some of the technologies currently used by OTN were demonstrated to the students including a VR100 mobile receiver and V8 tag. A small demonstration of mark-recapture techniques was also performed. KW's superior performance in all aspects of her graduate studies led to her moving seamlessly from an MSc to PhD program.

MAM has substantially expanded her statistical expertise while a PDF (and more recently RA) with our team. She showcased these impressive skills while interviewing at the University of British Columbia

(UBC) and will be taking up a CRC Tier II in Statistical Ecology at UBC in September 2017. JMF and MAM will continue their many OTN-related collaborations from coast to coast.

## 7. Dissemination of information and results

### *a) Refereed journal articles (2 total) – accepted/published*

**\*\*Note:** In order to avoid double-listing of dissemination/publications given the extensive cross-collaboration of Projects 4.7 and 4.8, all but one of 4.7 publications are listed here instead of under Project 4.7 report.

Auger-Méthé, M, C Field, CM Albertsen, AE Derocher, MA Lewis, ID Jonsen, J Mills Flemming. State-space models' dirty little secrets: even simple linear Gaussian models can have estimation problems. *Scientific Reports* 6:26677

Auger-Méthé, M, CM Albertsen, ID Jonsen, AE Derocher, DC Lidgard, KR Studholme, WB Bowen, GT Crossin, J Mills Flemming. Spatiotemporal modelling of animal behaviour using Template Model Builder: from seabirds to polar bears. In revision for *Marine Ecology Progress Series*.

### *b) Refereed journal articles (4 total) – submitted*

Carson, S, N Shackell, J Mills Flemming. Local Overfishing may be avoided by monitoring parameters of a Spatio-Temporal Model. Submitted to *PLOS ONE*.

Whoriskey, K, M Auger-Méthé, CM Albertsen, F Whoriskey, T Binder, C Krueger, J Mills Flemming. A Switching Hidden Markov Movement Model for rapidly identifying behavioural states from animal tracks. Submitted to *Ecology and Evolution*.

Hussey, NE, RG Harcourt, M Auger-Méthé. Is the Arctic circumpolar marine protected area network frozen? A call for proactive leadership. Submitted to *Conservation Letters*.

Wong KB, M Auger-Méthé. Using laser photogrammetry to measure long-finned pilot whales (*Globicephala melas*) in the field. Submitted to *Aquatic Mammals*.

### *c) Conference/workshop/seminar presentations (10 total) – invited or contributed*

Whoriskey, K, M Auger-Méthé, CM Albertsen, F Whoriskey, T Binder, C Krueger, J Mills Flemming. A Switching Hidden Markov Movement Model for rapidly identifying behavioral states from animal tracks (Contributed Presentation). International Statistical Ecology Conference, Seattle USA.

Whoriskey, K, M. Auger-Méthé, S Carson, D Murdoch, and J Mills Flemming. Moving forward: Advances in modeling and visualizing animal movement data (Invited Presentation). Ocean Tracking Network 2016 Symposium, Halifax NS.

Auger-Méthé, M. State-space modeling for tracking marine life (Invited Presentation). International Union for Conservation of Nature (IUCN) World Conservation congress – Special session: Wildlife monitoring and data repositories for conservation and protected area management: advances in technology, analytical tools, and databases, Honolulu USA.

- Auger-Méthé, M. From footsteps to foraging: using movement models to understand animal behaviour (Job Interview Talk). Department of Statistics/Institute for the Oceans & Fisheries, University of British Columbia, Vancouver BC.
- Auger-Méthé, M. From footsteps to foraging: using movement models to understand animal behaviour (Job Interview Talk) Departments of Biology and Mathematics & Statistics, Acadia University, Wolfville NS.
- Auger-Méthé, M. From footsteps to foraging: using movement models to understand animal behavior (Job Interview Talk) Department of Ecology, Evolution & Marine Biology, University of California, Santa Barbara USA.
- Auger-Méthé, M, C Field, CM Albertsen, AE Derocher, MA Lewis, ID Jonsen, J Mills Flemming. State-space model's dirty little secrets: even simple linear Gaussian models can have estimation problems (Contributed Presentation). International Biometric Conference, Victoria BC.
- Auger-Méthé, M, CM Albertsen, D Yurkowski, K Bøe, I Fleming, J Mills Flemming. Diving effects on surface movement: a state-space model approach. International Statistical Ecology Conference (Contributed Presentation), Seattle USA.
- Mills Flemming, J. Statistical Methods for Analyzing Marine Animal Movement Data, International Marine Conservation Congress (Invited Presentation), St. John's, NF.
- Mills Flemming, J. Spatiotemporal Modelling of Animal Movement: Challenges and Opportunities, International Conference on Robust Statistics (Invited Presentation), Geneva, Switzerland.
- d) Books, data/technical reports, or any other relevant output/contributions not included above*
- Carson, S, D Bowen, S Lang, and J Mills Flemming (2016). Spatial-point process models reveal relatively stable habitat use over time in a marine generalist predator, for submission to Ecology.
- R.J. Lennox, K Aarestrup, SJ Cooke, P Cowley, AT Fisk, R Harcourt, M Heupel, SG Hinch, K Holland, N Hussey, S Iverson, S Kesse, J Kocik, J Mills Flemming, VM Nguyen, M Stokesbury, S Vagle, D VanderZwaag, D Webber, FG Whoriskey, and N Young (2016). Envisioning the Future of Aquatic Animal Tracking: Technology, Science, and Application, for submission to BioScience.
- Whoriskey, K, WD Bowen, S Iverson, J Mills Flemming. Post-breeding foraging tactics of female grey seals in contrasting ecosystems: Comparison of a coastal and offshore breeding colony, for submission to Journal of Agricultural, Biological and Environmental Statistics.
- Whoriskey, K, E Martins, M Auger-Méthé, R Lennox, L Gutowsky, S Cooke, and J. Mills Flemming. (2017) Current and emerging statistical techniques for animal detections: A guide to analyzing telemetry data, for submission to Methods in Ecology and Evolution
- Cosandey-Godin, A, E Teixeira Krainski, A Hanke, J Mills Flemming, B Worm. Dynamic closures reduce shark bycatch in the Northwest Atlantic pelagic longline fishery, for submission to Conservation Biology.

**Ocean Tracking Network Canada****NSERC****Progress Report Year 7 Review: 1 October 2015 – 30 September 2016****1. Project Number:** 4.9**2. Project Title:** Salmonids in the north – species transition zones and beyond, predicting impacts of climate change**3. Project Leaders:** Ian Fleming (Memorial U), Michael Power (U Waterloo), Ross Tallman (DFO-Arctic, U Manitoba), Aaron Fisk (U Windsor)**Other OTN Canada participants:** S. Vagle, S. Hinch, S. Cooke, G. Crossin**Collaborators:** Ian Bradbury (DFO-Atlantic, Memorial U), Brian Dempson (DFO-Arctic, U Waterloo), Anders Finstad (Norwegian Institute for Nature Research), Corey Morris (DFO-Atlantic), Martha Robertson (DFO-Atlantic), Marie-Julie Roux (Falkland Island Fisheries Department, UK)**4. Training of Highly Qualified Personnel (and level of support)**

| Name  | Title*        | % Time in project | % Support from OTNC | Start Date (actual date HQP started with OTN) | End Date (actual or anticipated) |
|---|---------------|-------------------|---------------------|---|----------------------------------|
| Ingeborg Mulder   | PhD           | 100               | 100                 | 1 Sept 2014                                   | 31 Aug 2018                      |
| Research Topic: Nearshore marine habitat use by Arctic charr: competitive interactions with other salmonids                                       |               |                   |                     |   |                                  |
| Kristin Bøe   | PhD           | 100               | 100                 | 1 May 2014                                    | 30 Apr 2018                      |
| Research Topic: Life history of repeat spawning salmon and their temporal and spatial use of marine habitat and interactions with other salmonids |               |                   |                     |   |                                  |
| Jean-Sébastien Moore  | PDF           | 100               | 0                   | 1 Jan 2013                                    | 1 Sept 2016                      |
| Research Topic/current employment (if no longer OTNC HQP): Marine migrations of anadromous Arctic char in the Cambridge Bay region                |               |                   |                     |   |                                  |
| Sarah Arnold  | MSc           | 25                | 10                  | 1 Jan 2015                                    | 31 Dec 2016                      |
| Research Topic: Traditional knowledge, fishery independent data and tracking to understand the arctic charr of the Kivalliq region                |               |                   |                     |   |                                  |
| Gabrielle Grenier   | MSc           | 25                | 10                  | 1 May 2015                                    | 31 Dec 2016                      |
| Research Topic: Arctic charr movements in the Cumberland Sound region   |               |                   |                     |   |                                  |
| Lauren Wiens  | MSc           | 25                | 10                  | 1 May 2015                                    | 31 Dec 2016                      |
| Research Topic: Arctic charr movements in the Qikiqtaaluk region  |               |                   |                     |   |                                  |
| Jacob Burbank   | BSc (Hons)    | 60                | 50                  | 1 May 2016                                    | 31 April 2017                    |
| Research Topic/current employment (if no longer OTNC HQP): Otolith thermometry  |               |                   |                     |   |                                  |
| Jessie Pearson  | BSc (Hons)    | 25                | 0                   | 1 January 2016                                | 31 April 2017                    |
| Research Topic/current employment (if no longer OTNC HQP): Stable isotope lab technician  |               |                   |                     |   |                                  |
| Jacquelyn Saturno   | research assi | 35                | 35                  | 1 May 2016                                    | 1 Nov 2016                       |
| Research Topic/current employment (if no longer OTNC HQP): Tagging, tissue sampling and recovery of Atlantic salmon                               |               |                   |                     |   |                                  |

## 5. Public summary of report

### a) Summary: Project Component 1 - Salmonids in the species transition zone

The overall aim of the first project component is to quantify the migratory behaviour, and spatial and temporal patterns of estuarine and marine habitat use of co-existing salmonid populations as affected by niche segregation and life history in a changing climate. This is being studied in Atlantic salmon and Arctic charr, and secondarily brook trout, from targeted populations in a region of species transition (Newfoundland/Labrador). The data provided aim to answer ecological questions regarding the consequent impacts of predicted climate change across much of the north (e.g., latitudinally-driven environmental [temperature] changes in species' distributions through effects on fitness [growth and reproduction] and competitive abilities). There have been no deviations from these original objectives in 2016.

The main focus of 2016 activities was the completion of field work at the Muddy Bay Brook and Campbellton River sites, including the recovery of tags implanted in 2015 and the completion of detailed condition and stable isotope studies as described in the 2015 annual report. To that end activities in Muddy Bay Brook focused on Arctic charr (*Salvelinus alpinus*) and the completion of data acquisition that will allow the first time description of over-wintering activity in the species and an improved understanding of near-shore thermal habitat use. Stable isotope studies commenced in 2015 were extended to include consideration of co-occurring brook trout (*S. fontinalis*) that may compete with Arctic charr for both suitable thermal habitat and food resources. Completion of the data analyses associated with the Muddy Bay Brook component will be completed for publication in 2017, with thesis defence scheduled for 2018. At Campbellton field activities focused on the deployment of archival geo-location tags that recorded temperature, pressure and light for tagged ( $n=65$ ) out-migrating Atlantic salmon kelts. Non-lethal tissue sampling of kelts, returning maiden salmon, and returning repeat spawners was completed for stable isotope and lipid analyses, with the aim of the improved understanding of the consequences of differences in among-individual and life-stage foraging patterns for growth, energy status and survival. To that end, lethal tissue sample collections from smolts were also obtained. Finally, considerable efforts were put into the recapture of tagged kelts for purposes of tag retrieval and repeat stable isotope and lipid sampling, with differences between out-going and returning sample values permitting a direct estimate of foraging patterns on individual fish. Completion of the stable isotope and lipid analyses is currently being undertaken and should be finalized by the end of 2016. These results will be written up for publication during 2017, with theses completion in 2018.

The results of the research furthers our understanding of the effects of the marine environment and climate on fishes that are part of important subsistence (food) and recreational fisheries, as well as being of social and ceremonial value.

### b) Main Report: Project Component 1 - Salmonids in the species transition zone

Field work in 2016 for the Fleming-Power portion of Salmonids in the North project was completed in four locations: Campbellton River (primarily Atlantic salmon work), Muddy Bay Brook (primarily Arctic charr work) and Gilbert and Pistolet Bays (primarily supplemental data collection for contrasting with the main Campbellton and Muddy Bay Brook study sites). Summaries of key activities at each site are provided below.

## Campbellton River

2016 field activities conducted at the Campbellton River study were designed to meet three main objectives: [i] To obtain an additional year of movement data from migrating adult Atlantic salmon to assess inter-annual variation in migratory behaviour, migratory routes and thermal habitat; [ii] investigate marine diet and nutritional state as affected by migratory strategy/life history stage, using stable isotope and lipid chemistry analysis, and, [iii] couple movement data to inter-individual variation in diet and nutritional state. Objectives were met through: [1] the deployment of geo-location tags; [2] the non-lethal tissue collection from salmon kelts, returning maiden salmon, and returning repeat spawners, and lethal tissue collections from smolts; and, [3] the recapture of kelts to retrieve tags and to collect repeated tissue samples as described below.

## [1] Geo-location tag deployment

Sixty five kelts ranging in size from 49.5 to 75 cm were intercepted at the DFO maintained smolt enumeration facility on the Campbellton River and measured for fork length (cm), weight (g), and surgically implanted with Lotek archival geo-locator tags from May 11 to May 20th. Scales were collected from all fish to determine age and spawning history. Sex was visually determined based on the presence or absence of a kype. Caudal and adipose fin clips were collected for stable isotope analysis. An external T-bar anchor tag with reward and fish identification information was fitted to each fish. No mortalities during fish capture, handling, tagging and immediately after release was observed.

## [2] Biological tissue sampling

During tagging non-lethal tissue samples were also collected from out-migrating kelts, with a total of 83 kelts ranging from 48 to 73 cm being sampled during the tagging period. Efforts were made to sample fish in a size distribution that would encompass a minimum of: 20 first time spawning kelts (ca 48-54 cm), 20 2nd time consecutive repeat spawning kelts (ca 54-60 cm) and 20 fish consisting of a mixture of first time alternate repeat spawners or 3-4th time consecutive repeat spawners (<60 cm). Muscle tissue samples were collected using biopsy punches (Milltex (R), 4mm tissue plug collector). All fish were sampled for scales for aging and spawning history determination. Sex was visually determined based on the presence or absence of a kype. An external T-bar anchor tag with fish identification information were fitted to each fish. No mortalities during fish capture, handling, sample collection and immediately after release were observed.

Non-lethal tissue samples were also collected from maiden salmon and repeat spawners from 86 returning adult salmon ranging from 46.9 to 77.4 cm during the period June 21 to August 18th. A muscle biopsy was collected from each fish using a milltex (R) tissue plug collector, and a small piece of caudal and adipose fin tissue was removed using a pair of sterilized scissors. Efforts were made to sample fish in a size distribution that would encompass a minimum of: 20 maiden grilse (~48-54 cm), 20 first time consecutive repeat spawners (54-60) and 20 fish consisting of a mixture of first time alternate repeat spawners or 2-3rd time consecutive repeat spawners (>60 cm). Scales were collected from each fish to determine age and spawning history and caudal fin tissue was collected to genetically determine sex. Length and weight were obtained for all sampled fish. An external T-bar anchor tag with information on fish identification was fitted to each fish. Recaptures at the smolt enumeration facility in spring 2017 will provide information on individual overwintering survival which may be linked to nutritional state as inferred by the lipid chemistry analysis of the released salmon. During a shorter period of higher water temperatures, 4 mortalities occurred as a result of fish capture, handling, or sample collection procedures. These fish were immediately stored at -20 C and brought back to the

facilities in St. John's at the end of the field season for dissection and tissue collection. The muscle biopsies weighed on average 60mg. Approximately 10 mg was removed for stable isotope analyses, while the remainder was retained for use in lipid chemistry analysis. The destructively sampled smolts and recaptured kelts were dissected at the laboratory at the Department of Ocean Sciences, tissue samples being obtained to provide a baseline for the adult salmon samples. Details of fish sampling for tagging and isotope purposes are summarized in Table 1.

Table 1: Fish sampling and tagging overview with associated size distributions

| Life stage | Treatment     |          |                     | Size range, cm FL, (mean, sd) |
|------------|---------------|----------|---------------------|-------------------------------|
|            | Archival tags | Biopsies | Destructive samples |                               |
| Kelt       | 65            | 83       | 0                   | 48 – 74.7 ( 58.8, 6.3)        |
| Grilse     | 0             | 86       | 12                  | 46.9-77.4 ( 58, 7.2)          |
| Smolt      | 0             | 0        | 31                  | 14.2-29.4 (18.6, 3.2)         |

### [3] Kelt recaptures

To quantify potential treatment effects on marine survival and growth, tag returns and length increment were compared among treatment groups (non-lethal tissue samples and archival tags) and a third group that acted as a control. The control group consisted of 400 kelts that were length measured and externally tagged with a T-bar anchor tag in the period May 9th to June 26th at the DFO maintained smolt enumeration facility on the Campbellton River. In addition, 60 kelts that had been externally tagged in previous years were recaptured at the smolt counting facility where the tag ID was recorded and length measures taken prior to release. These fish were also included in the control group. The total number of externally tagged kelts leaving Campbellton River spring 2016 was 608 individuals (DFO program: 460, biopsied fish: 83 and geolocation tags: 65). Fish that returned following marine feeding were identified by the external tags and intercepted at the DFO maintained adult enumeration facility on the Campbellton River. Salmon fitted with geo-locator tags were destructively sampled to retrieve the archival tag and to collect otoliths, muscle tissue, fin tissue and gonads. The soft tissues will be analysed for lipids, fatty acids, and stable isotopes, with data to be used for dietary analysis and determination of nutritional state. Salmon that were biopsied as kelts were also destructively sampled to obtain repeated samples of muscle tissue and fin clips and to obtain liver and gonad tissue to be included in the dietary and nutritional state analysis. Tag ID, length (cm) and weight (g) were collected from fish from the control group and immediately released thereafter.

Previous mark recapture studies performed in Campbellton River have demonstrated a mean return rate of kelts (returning as consecutive repeat spawners) of 32 % (Downton 2004), and thus an optimistic estimate of tag returns was 182 fish (Control : 138, geo-location tags:19, biopsied fish:25). The first tag recapture occurred on July 5th and between this date and August 19th, 52 externally tagged kelts were recaptured at the adult salmon enumeration facility. Due to a lower than expected number of returns, a decision was made to extend the fence operation by two weeks. This lead to an additional 7 recaptures of which two were salmon biopsied as kelts. The overall kelt return rate summer 2016 (all groups combined) thus amounted to 8 % (59/608), a number considerably lower than the average return rate of

kelts previously demonstrated for Campbellton River. There was no statistically significant ( $P > 0.05$ ) difference in return rate among treatment groups, but the salmon fitted with geo-location tags experienced the lowest return at 3 % (2/65) followed by the control group at 8 % (37/460). The biopsied kelts had the highest return rate at 12 % (10/83). There were no statistically significant ( $P > 0.05$ ) differences in length increment (Length at recapture – length at release) or condition factor as measured at recapture among groups. There was, however, a positive correlation between fish length at release and the probability to return the following summer for all groups (logistic model, deviance: 298, df: 607,  $P = 0.02$ ).

The low returns of geo-location tags compromises the objective (i) of assessing inter-annual variation in Atlantic salmon migratory behaviour, migratory routes and thermal habitat use. The low return numbers also affect objective (ii) investigations into the marine diet and nutritional state of Atlantic salmon as affected by migratory strategy/life history stage, using stable isotope and lipid chemistry analyses.

The low return rates of kelts coincided with a lower than expected number of returning maiden salmon in Campbellton River that year. The count of 2971 fish represented a 36 % decrease from the 2011 to 2015 average, and a 16 % decrease from the 1993 to 2015 average. Similarly, rivers in Newfoundland and Southern Labrador generally experienced a considerable decrease in returning maiden fish as demonstrated by DFO operated salmon counts. Collectively the data suggest that adverse conditions at sea during the period between spring 2015 to summer 2016. The correlation between the low returns of kelts and maiden salmon in Campbellton River may also imply that adverse marine conditions were in effect in the time interval between spring and summer 2016, the period for which the two life stages co-occur at sea.

Table 2: Number and percentage of returned kelts, and size distribution at release and recapture in the three treatment groups,

| Group       | No. returned | % return | Size distr. at release (mean, sd) | Size distr. at recapture (mean, sd) |
|-------------|--------------|----------|-----------------------------------|-------------------------------------|
| Control     | 49           | 8%       | 42.6-77.8 cm (54.9, 5.4)          | 44.5-74 cm (60.9, 6.4)              |
| Biopsy      | 10           | 12%      | 48-73 cm (59.1, 6.3)              | 54-70 cm (63.9, 5.2)                |
| Geolocation | 2            | 3%       | 49-74 cm (58.4, 6.3)              | 56.3-69.5 cm (62, 9.3) *            |

\* Only 2 fish

### Preliminary results

Thus far, the isotope samples from the non-lethally sampled kelts, adults and the lethally sampled smolts have been analysed at the Isotope lab at Waterloo University. Preliminary analysis of the stable isotope signature data shows a significant ( $P < 0.05$ ) nitrogen and carbon enrichment in kelt caudal, adipose and muscle tissue compared to adult salmon. The enrichment is likely a result of lipid oxidation and protein catabolism associated with the spawning migration (Doucett et al. 1999) and fasting of the kelts rather than dietary input. The changes in the isotope signature associated with changes in nutritional status has to be accounted for when inferring dietary differences between maiden and repeat spawning salmon using stable isotopes. There was also a significant ( $P < 0.05$ ) relationship between kelt nitrogen



enrichment and lipid density, which may imply a correlation between feeding at higher trophic levels and nutritional state. Further, there was a significant ( $P < 0.05$ ) positive relationship between kelt lipid density and fork length.

The kelt lipid composition results are complete. Lipid composition and fatty acid composition data from returning adults, and fatty acid composition data from kelts are currently being processed at the Department of Oceans Sciences (Memorial University). Preliminary analysis showed no statistical significant ( $P > 0.05$ ) relationship between kelt lipid density and return probability the following summer.

Geo-locations have been estimated for the two recaptured geo-location tags and the positional data and temperature and depth records will be included in the analysis of the tags recaptured in 2014.

The otoliths collected from the geo-location fish in 2016 and 2014 ( $n=9$ ) have been sent in to the isotope lab in Waterloo for oxygen stable isotope composition analysis following protocols described in Minke-Martin et al. (2015). The highly detailed temperature record from these tagged fish coupled with otolith oxygen stable isotopes will provide a unique opportunity to examine/verify the use of otolith microchemistry to infer fish temperature history.

#### Muddy Bay Brook, Labrador

The field work at Muddy Bay Brook, Labrador, (53° 6' N, 57° 10' W), consisted of four main activities: (1) the recapture of Arctic charr implanted with data storage tags in 2015, (2) collection tissue samples from Arctic charr, brook trout and Atlantic salmon for stable isotope analyses examining niche breadth, overlap and prey resource use competition, (3) collection of additional stable isotope baseline samples and CTD profiles to improve characterization of the Sandwich Bay isoscapes, (4) retrieval of the acoustic telemetry receivers that were deployed in Muddy Bay Pond in 2015 to monitor over-winter activity of tagged Arctic charr, and (5) collection of supplementary samples from Gilbert and Pistolet Bay sample sites.

#### [1] Recaptures

Arctic charr were recaptured during their upstream migration at the Fisheries and Oceans Canada (DFO) maintained counting fence on Muddy Bay Brook in July and August 2016. In conjunction with DFO personnel, the trap at the counting fence was emptied twice daily and the counting fence was checked for holes on a daily basis. During the peak run, the trap was emptied several times in a row when needed as it was not uncommon to see between 500-800 Arctic charr move through in one evening.

Previously tagged Arctic charr were marked in 2015 with an external floy tag placed near the dorsal fin so as to make them clearly distinguishable from untagged Arctic charr. All previously tagged Arctic charr were removed from the run and sampled for scientific purposes. In addition, previously tagged brook trout and Atlantic salmon were identified and removed for scientific purposes. All removed fish were measured to compute the annual growth increment and sampled for tissues (dorsal muscle tissue, otoliths and scales) following protocols as described in Kelly et al. (2015) and Dixon et al. (2015). collect stable isotope samples. A summary of the numbers of Arctic charr, brook trout and Atlantic salmon that were recaptured is provided below in Table 3.

Table 3: Summary of numbers and types of tags recaptured in summer 2016 for Arctic charr, brook trout and Atlantic salmon implanted with acoustic and archival tags in summer 2015. All fish were lethally sampled.

| Species         | Tag Type         | # of tags | Sampled for tissues | Size range (cm) |
|-----------------|------------------|-----------|---------------------|-----------------|
| Arctic charr    | Data storage tag | 15a       | 13                  | 36.0-49.0       |
|                 | Acoustic         | 23b       | 19                  | 33.0-50.0       |
| Brook trout     | Acoustic         | 5         | 5                   | 39.0-43.5       |
| Atlantic salmon | Acoustic         | 0         | -                   |                 |

a. Thirteen Arctic charr were recaptured at the counting fence and two by local fisherman in Sandwich Bay. Only three of the fifteen Arctic charr originally implanted with the archival tags still contained the tag, the remaining twelve charr expelled the tag somewhere between Sept 2015 and July 2016.

b. Four of the 23 Arctic charr were recaptured by fisherman and either sat in the freezer or smoke house and were deemed not suitable for stable isotope sampling. Types of acoustic tags recovered: N=9 accelerometer tags (V9A), N=5 V13T, N=4 V9T, N=5 V9 (no sensor). Only one of the 23 recaptured Arctic charr expelled the acoustic tag (V13).

## [2] Biological tissue samples

The issued DFO field permit allowed lethal sampling of 65 Arctic charr, 50 brook trout and non-lethal sampling of 30 Atlantic salmon. All Arctic charr and brook trout were sampled for: adipose fin clip, dorsal muscle, liver, otolith, length (cm), and sex. Marten and otters caused numerous problems at the counting fence as a result of their chasing and predating on fish in the vicinity of the counting fence. As a result several natural mortalities of Atlantic salmon (n=5) and Arctic charr (n=15) were observed and these fish were collected and sampled if the carcass permitted obtaining the complete suite of samples listed above. Brook trout were sampled for stable isotope analyses in the marine and the freshwater environment for length (cm), adipose fin clip, muscle, liver, otolith and sex. In the freshwater environment brook trout were sampled at the counting fence to the limit of the field permit. Brook trout in the marine environment were sampled from the catch of local fisherman or by angling.

Atlantic salmon returns were 40% lower this year as only about ~230 Atlantic salmon passed the counting fence as compared to ~380 last year. However, Arctic charr returns were substantially better in 2016 than 2015 (106%) with some ~6200 counted at the fence in 2016 as compared to the ~3000 counted in 2015. Similarly, brook trout returns were substantively better in 2016 with a six-fold increase in 2016 (~180) as compared to 2015 (~33), with one day seeing as many as 40 captured. Arctic charr in 2016 were also larger (52-54 cm) than in 2015 (#51cm). A summary of the number of biological samples collected can be found in Table 4.

Table 4: Summary of 2016 biological samples collected from Arctic charr, brook trout and Atlantic salmon. MBB=Muddy Bay Brook

| Species         | Location           | # Lethally sampled | #Non-lethally sampled |
|-----------------|--------------------|--------------------|-----------------------|
| Arctic charr    | Counting fence MBB | 57                 |                       |
| Brook trout     | Counting fence MBB | 26                 |                       |
|                 | Sandwich Bay       | 17                 |                       |
| Atlantic salmon | Counting fence MBB | 1                  | 30                    |

### [3] Baseline stable isotope samples

Samples to improve the stable isotope baseline were collected in both Muddy Bay Brook (near the counting fence) and in Sandwich Bay. Samples collected in the river included: macro-invertebrates and freshwater clams. Samples collected from Sandwich Bay included: plankton, amphipods, mussels and snails. The main purpose of collecting additional samples for the baseline was to facilitate improved characterization of the heterogeneity the Sandwich Bay nearshore marine habitats used by both Arctic and brook charr for summer feeding.. Methods used to collect the baseline included: kick sampling, snorkeling, and towing a 50: plankton net.

Additional CTD measurements were taken from 15 sample locations throughout Sandwich Bay ranging from locations near the river mouths (Muddy Bay Brook, Paradise River, Eagle River/White Bear River, North River) to the outer headlands with a few kilometers between sampling points. Data will be used to improve bathymetry maps of the Bay and for interpretive purposes when analysing collected telemetry and stable isotope data

### [4] Receiver retrieval

Ten receivers were deployed last summer (2015) before fish started their upstream migration. Before the end of the field season in 2015 (end of August ), a single receiver was retrieved located near where the river leaves the lake, as the depth in that area was only 3m and the site was considered likely to freeze to the bottom during the winter. As Arctic charr likely do not reside in these shallower areas during the winter, and spring break-up risked dislodging the receiver from its mooring move the receiver, precaution dictated its removal prior to freeze-up. The remaining 9 receivers were retrieved this summer: N=1 on July 22, N=8 on July 30. The number of fish detected during the wintering monitoring period are summarized in Table 5.

Table 5: Summary of the number of fish and tag types detected on receivers deployed in Muddy Bay Pond throughout the 2015-2016 winter period.

| Species         | Total # fish detected | Tag type            |
|-----------------|-----------------------|---------------------|
| Atlantic salmon | 2                     | V9A (accelerometer) |
| Brook trout     | 11                    | V13T                |

|              |    |                |
|--------------|----|----------------|
| Arctic charr | 60 | V9 (N=8)       |
|              |    | V9T (N=15)     |
|              |    | V13T (N=13)    |
|              |    | V9A/V9T (N=24) |

To better determine if fish moved through the counting fence undetected at Muddy Bay Brook, a receiver was deployed just upstream of the counting fence on July 27 and retrieved just before departure on August 25. Prior to that a portable hydrophone (VR100) was used twice daily (when the trap was emptied) to listen for any recaptures. Finally a temperature logger was deployed at the counting fence from early July till late August.

Temperature logger strings were attached to three receivers (Fig 2: receiver 8 = 4 loggers, receiver 5 = 6 loggers, receiver 3 = 10 loggers) to better characterize the availability of thermal habitats in Muddy Bay Pond throughout the winter. Temperature loggers were retrieved at the same time as the receivers. Most of the temperature loggers were still functionally recording at the time of retrieval, however, a few stooped recording in late March owing to battery failure.

#### [5] Supplementary Sampling in Gilbert and Pistolet Bays

Extensive data on summer marine environmental use and over-wintering behaviour were collected from Gilbert Bay in 2012 -15. To supplement previous data collection from Gilbert Bay, DFO organized the opportunistic collection of supplemental samples. The NunatuKavut in Port Hope Simpson provided a day (Aug 2) of supplemental gill-netting in Alexis and Gilbert Bays from which a small (n=3) Arctic charr were captured. At the same time baseline samples for stable isotope were collected as well, which will help in the interpretation of forage related movement data gathered via acoustic telemetry.

Finally an opportunistic sampling of fish from Pistolet Bay (St. Anthony, Newfoundland) was attempted to supplement data collected in 2013 and 2014. Owing to the prevailing environmental conditions (rain, wind) no samples were successfully collected. However, on July 17 a fish kill occurred at Parkers Brook from which roughly 100 Arctic charr were collected. Some 70 were in good enough condition to warrant freezing and subsequent biological sampling. All the frozen Arctic charr were transported to the DFO freezer in St. John's and sampled at the end of the field season (August 31 – Sept 2) for: length, weight, fin clip, muscle, liver, otolith, sex, maturity, stomach content, gonad weight, and the eggs were frozen. Samples will be twinned with stable isotope baseline sampling completed for Pistolet in 2014.

#### References

Dixon, H. J., Dempson, J. B. and Power, M. 2015. Assessing the use of different marine growth zones of adult Atlantic salmon scales for studying marine trophic ecology with stable isotope analysis. *Fisheries Research*. 164:112-119.

Doucett, R. R. Booth, R. K., Power, G., McKinley, R. S. 1999. Effects of the spawning migration on the nutritional status of anadromous Atlantic salmon (*Salmo salar*): insights from stable-isotope analysis. *Canadian Journal of Fisheries and Aquatic Sciences*. 56: 2172-2180.

Downton, P. R. Reddin, D. G. 2004. Status of Atlantic salmon (*Salmo salar* L) in Campbellton River, Notre Dame Bay (SFA 4), Newfoundland in 2003. CSAS research document 2001/031

Kelly, B., Amundsen, P.-A. and Power, M. 2015. Thermal habitat segregation among morphotypes of whitefish (*Coregonus lavaretus*: Salmonidae) and invasive vendace (*C. albula*): a mechanism for coexistence. *Freshwater Biology*. 60:2337-2348.

Minke-Martin, V., Dempson, J. B., Sheehan, T. F. and Power M. 2015. Otolith-derived estimates of marine temperature use by West Greenland Atlantic salmon (*Salmo salar*). *ICES Journal of Marine Science*. 72:2139-2148.

#### Ecology of Arctic Charr, *Salvelinus alpinus*, within the Nunavut Territory (R. Tallman)

The resources supplied by OTN were used to support graduate students engaged in work on the ecology of Arctic Charr, *Salvelinus alpinus*, within the Nunavut Territory and a species under special concern Inconnu in the Northwest Territories. The interest of DFO is to understand factors affecting Charr migration and productivity throughout their life cycle. Three main regions are involved in the management of Arctic Charr in the north – the Kitimeot (principal community is Cambridge Bay), the Kivalliq (western Hudson Bay, principal community Rankin Inlet) and the Qikiqtaaluk (Cumberland Sound – Principal community, Pangnirtung). In addition to the extensive work in the Kitikmeot in Cambridge Bay to study the marine and freshwater movements of Arctic Charr (University of Windsor and Université de Laval), coupling them with population dynamics and genetic variation, the University of Manitoba portion considered the effects inter-specific interactions on habitat use, migration, and productivity (Kivalliq and Qikiqtaaluk Regions). The project of Sarah Arnold (M.Sc. Candidate, University of Manitoba) in the Kivalliq Region is using traditional ecological knowledge, fishery independent surveys and ocean tracking techniques to explore the seasonal habitat sub-division and migration by Arctic Charr, Lake Trout and Round Whitefish. The aim of the work is to build a model of the effect of stock productivity for each species. The Cumberland Sound (Qikiqtaaluk Region) project is combining the work of University of Manitoba M.Sc. candidates Gabrielle Grenier and Angela Young to determine Charr movements, productivity and impact of new species (capelin) within the system. In the Northwest Territories OTN techniques were applied to the problem of Inconnu, *Stenodus leucichthys* in Great Slave Lake. The understanding of migration and critical habitats as inferred from acoustic telemetry studies is essential to successful conservation of Inconnu stocks and maintenance of the Great Slave Lake whitefish fishery – the largest inland fishery managed by the federal government. A graduate student, Lauren Wiens, commenced an M.Sc. program under Dr. Tallman at the University of Manitoba. The OTN stipend was used to provide a partial stipend and travel support to Gabrielle Grenier, Sarah Arnold and Lauren Wiens.

## 6. Networking, outreach, and synthesis

- a) Interaction/Outreach to Broader Community/Public (including radio or television interviews or contribution to a programme/documentary, stakeholder workshops, etc.)

Outreach consisted of extensive community consultation and engagement as part of completing project information exercises in the communities of Cartwright and Campbellton. Given the importance of having the established subsistence fishery return tags from captured fish, students stationed at Cartwright for the field season spent considerable time and effort in talking to local fisherman to inform them of project objectives, needs and results to date. Similarly, at Campbellton, the students interacted extensively with the large number of public visiting the counting/tagging facilities, informing them about the project and findings thus far. As a result the two communities provided substantial aid to the project in the form of access to fishery landings, tag recoveries and aid with receiver retrieval. In addition, the NunatuKavut Community Council in Port Hope provided direct assistance with supplemental sampling in Gilbert Bay which provided a direct opportunity for community engagement with the project and direct transfer of project information to the community.

### *b) Synthesis activities*

Synthesis activities involved collaboration with Marie Auger-Méthé, Christoffer Albertsen and Joanna Mills-Flemming to explore how information on diving activity might be incorporated into a state-space model approach to better measure surface movement. Data we had collected from salmon kelt tagged with both acoustic and geolocation data storage tags were used to this purpose. These data were combined with those collected on marine mammals (David Yurkowski).

## **7. Dissemination of information and results**

### *c) Conference/workshop/seminar presentations (7 total) – invited or contributed*

- Bøe, K., Robertson, M., Power, M., Morris, C., Auger-Méthé, M., Dempson, B., Fleming, I. Spatial Extent and Temperature Use During the Marine Migration of Consecutive Repeat Spawning Atlantic Salmon (*Salmo salar*). Canadian Conference for Fisheries Research, Jan. 7-9, 2016. St. John's, NF. Oral presentation.
- Bøe, K., Robertson, M., Power, M., Morris, C., Auger-Méthé, M., Dempson, B., Fleming, I. Spatial Extent and Temperature Use During the Marine Migration of Consecutive Repeat Spawning Atlantic Salmon (*Salmo salar*). 6th Annual Ocean Tracking Network Symposium, June 1-2, 2016, Halifax, NS. Poster presentation.
- Bøe, K., Robertson, M., Power, M., Morris, C., Auger-Méthé, M., Dempson, B., Fleming, I. Marine behavior of repeat spawning Atlantic salmon in a Newfoundland population. Canadian Society for Ecology and Evolution meetings, July 7-11, St. John's, NF. Poster presentation.
- Mulder, I.M., Morris, C., Dempson, B., Robertson, M., Green, J.M., Fleming, I., Power, M. 2016. The overwintering behaviour of Arctic charr (*Salvelinus alpinus*) in Gilbert Bay, Labrador. Canadian Conference for Fisheries Research, Jan. 7-9, 2016. St. John's, NF. Oral presentation.
- Mulder, I.M., Morris, C., Dempson, B., Robertson, M., Fleming, I., Power, M. 2016. Overwintering behaviour of anadromous Arctic charr (*Salvelinus alpinus*) in Gilbert Bay, Labrador. 6th Annual Ocean Tracking Network Symposium, June 1-2, 2016, Halifax, NS. Poster presentation.

Moore, J-S., Bøe, K., Mulder, I.M., Fleming, I, Power, M. Tallman, R. and Fisk, A.2016. Salmonids in the North – Species transition zones and beyond, predicting impacts of climate change. 6th Annual Ocean Tracking Network Symposium, June 1-2, 2016, Halifax, NS. Oral presentation.

Auger-Méthé, M., Albertsen, C.M., Yurkowski, D.J., Bøe, K., Fleming, I.A. and Mills Flemming, J. 2016. Diving effects on surface movement: a state-space model approach. International Statistical Ecology Conference, June 28 - July 1, 2016, Seattle, USA. Oral presentation.

## 8. Contributions from industrial and government partners

| Name of supporting organization:<br><b>Fisheries and Oceans Canada</b> | <b>Year 7<br/>(2016)</b> |
|--|--------------------------|
| <b>Cash contributions to direct costs of research</b>                  |                          |
| <b>In-kind contributions to direct costs of research</b>               |                          |
| 1) Salaries for scientific and technical staff                         | 30,000                   |
| 2) Donation of equipment, software                                     | 10,000                   |
| 3) Donation of material  | 5,000                    |
| 4) Field work logistics  | 15,000                   |
| 5) Provision of services   |                          |
| 6) Other (specify): contribution of historical data                    | 15,000                   |
| <b>In-kind contributions to indirect costs of research</b>             |                          |
| 1) Use of organization's facilities                                    | 5,000                    |
| 2) Salaries of managerial and administrative staff                     | 5,000                    |
| 3) Other (specify):  |                          |
| <b>Total of all in-kind contributions</b>                              |                          |
| <b>Is this new funding (acquired during this reporting period)?</b>    | yes                      |

**Ocean Tracking Network Canada****NSERC****Progress Report Year 7 Review: 1 October 2015 – 30 September 2016****1. Project Number:** 4.10**2. Project Title:** Fish and marine mammal interactions in the high Arctic**3. Project Leaders:** Aaron Fisk (U Windsor), Svein Vagle (DFO-Arctic, U Victoria), Steve Ferguson (DFO-Arctic, U Manitoba)**Other OTN Canada participants:** D. Heath, K. Fennel, J. Sheng, J. Mills Flemming, D. Bowen, S. Iverson**Collaborators:** Dale Webber (Vemco), Aaron McNeil (Australian Institute of Marine Science), Richard Crawford (East Carolina University), Robert Harcourt (MacQuarie University, Australia), Aqqaal Rosing-Asvid (Greenland Institute of Natural Resources), Rune Dietz (Aarhus Universitet, Denmark)**4. Training of Highly Qualified Personnel (and level of support)**

| Name   | Title* | % Time in project | % Support from OTNC | Start Date (actual date HQP started with OTN) | End Date (actual or anticipated) |
|--|--------|-------------------|---------------------|---|----------------------------------|
| Steven Kessel  | RA     | 100               | 100                 | 1-Jan-2012                                    | 30-Jun-2016                      |
| Research Topic: Movements of fish species in the high Arctic; Project leader for Resolute Bay fieldwork; new RA position at Michigan State focusing on lake sturgeon telemetry |        |                   |                     |   |                                  |
| Caitlin O'Neill  | MSc    | 100               | 100                 | 1-Sep-2013                                    | 30-Jun-2016                      |
| Research Topic: Oceanography and Underwater Acoustics in Resolute Bay, Nunavut: 2012-2015. Currently employed at private company.  |        |                   |                     |   |                                  |
| Justin Landry  | MSc    | 100               | 0                   | 1-Jul-2014                                    | May-2016                         |
| Research Topic/current employment (if no longer OTNC HQP): Sculpin ecology   |        |                   |                     |   |                                  |
| Silviya Ivanova  | MSc    | 100               | 100                 | 1-Jul-2014                                    | Aug-2016                         |
| Research Topic: Anthropogenic disturbances to sculpin behaviour and community relations between scientist and Inuit in the high Arctic   |        |                   |                     |   |                                  |

**5. Public summary of report**

All equipment was retrieved during the August 2015 field season from Resolute Bay, and redeployed in other areas of the Arctic (Cambridge Bay and Baffin Island). All data were downloaded and analysis commenced October 2015, including sending the data for VPS processing by VEMCO. Isotope analysis and stomach content analysis were conducted on the biological samples of Shorthorn sculpin and Arctic cod, and isotope analysis was performed on invertebrate collected during the field season; briefly Arctic cod was found to feed pelagically and sculpin trophic ecology changed with total length and based on prey availability. Telemetry analysis from previous years' data found three different movement patterns for sculpin, and that sculpin changed between these based-on abundance levels of Arctic cod. Data analysis on the influence of ship traffic on Arctic cod demonstrated a horizontal displacement of cod by vessel traffic and significant decrease in movement patterns associated with foraging. Receivers deployed at Maxwell Bay in 2011 were also recovered and downloaded. These data revealed the first large scale movements of individual Arctic cod (~192 km). Oceanographic data retrieved in August 2015 showed water properties in Resolute Bay differed from the waters outside of the bay. Dissolved oxygen saturation levels in Resolute Bay decreased during ice-covered times, and was replenished after



the ice left the bay. Underwater acoustic data retrieved in August 2015 was analyzed for baseline ambient noise levels and marine mammal vocalizations. Belugas were only present in periods of low ice concentration, while bearded seals and ringed seals remained throughout the entire year.

## 6. Networking, outreach, and synthesis

### *a) Interaction/Outreach to Broader Community/Public (including radio or television interviews or contribution to a programme/documentary, stakeholder workshops, etc.)*

Ivanova S, Kessel ST, Fisk AT (2016). TEKnology: Traditional Ecological Knowledge and Cutting Edge Technology working together (Presentation), Naturalized Habitat Network of Essex County and Windsor, Essex, ON, Canada.

Kessel ST (2015) From the Bermuda Triangle to the Arctic Circle: a journey of adaptable aquatic research techniques. Lake Ontario Fisheries Station, Ontario Ministry of Natural Resources, Picton, ON, Canada (Seminar Series)

### *b) Synthesis activities*

Statistical analysis of VPS data for Arctic cod and sculpin species began in 2014 and was facilitated through collaborations with OTN HQP Montana McLean (PhD Dalhousie University) and international collaborator Dr. Mario Espinoza (James Cook University, Australia and University of Costa Rico). This involved a workshop in Windsor and contributed directly to the completion of Silviya Ivanova and Justin Landry's MSc thesis. These collaborations have continued and will result in a number of multi-authored papers. The expertise on analyzing VPS data that Montana McLean has developed as an OTN HQP expedited our analysis.

Steve Kessel and Aaron Fisk continue to collaborate with University of South Carolina adjunct professor Dr. Richard Crawford. Sharing of data and knowledge has resulted in a number of scientific publications on Arctic Cod and changes to the Resolute Bay ecosystem.

Collaboration occurred while examining effects of vessel activity on Arctic cod between Silviya Ivanova, Svein Vagle, Aaron Fisk, Steve Kessel and Caitlin O'Neill. Underwater sound was recorded in Resolute Bay during the August 2015 field season, and the data used to model sound propagation losses and levels of noise produced by a passenger vessel while at dock and moving. Additional, collaboration for the same project occurred with Montana McLean for processing movement trajectories of Arctic cod and for Sculpin for Justin Landry's project.

## 7. Dissemination of information and results

### *a) Refereed journal articles (6 total) – accepted/published*

Kessel ST, Hussey NE, Crawford RE, Yurkowski DJ, Webber DM, Dick TA, Fisk AT. First documented large-scale horizontal movements of individual Arctic cod (*Boreogadus saida*). Canadian Journal of Fisheries and Aquatic Sciences (In Press)

Crawford RE. 2016. Occurrence of a gelatinous predator (*Cyanea capillata*) may affect the distribution of *Boreogadus saida*, a key Arctic prey fish species. Polar Biol. 39: 1049-1055.

- Kessel, S.T., N.E. Hussey, R. Crawford, C. O'Neill, D.Y. Yurkowski and A.T. Fisk. 2016. Distinct patterns of Arctic cod (*Boreogadus saida*) presence and absence in a shallow high Arctic embayment, revealed across open-water and ice-covered periods through acoustic telemetry. *Polar Bio.* 39: 1057-1068.
- Yurkowski, D.J., S.H. Ferguson, C.A.D. Semeniuk, T.M. Brown, D.C.G. Muir and A.T. Fisk. 2016. Spatial and temporal variation of an ice-adapted predator's feeding ecology in a changing Arctic marine ecosystem. *Oecologia* 80(3): 631-644. DOI 10.1007/s00442-015-3384-5
- Yurkowski, D.J., S.H. Ferguson, E. S. Choy, L.L. Loseto, T.M. Brown, D.C.G. Muir, C.A.D. Semeniuk and A.T. Fisk. 2016. Latitudinal variation in ecological opportunity and intra-specific competition indicates differences in niche variability and diet specialization of Arctic marine predators. *Ecol. & Evol.* 6(6): 1666-1678. doi: 10.1002/ece3.1980
- Yurkowski, D.J., A.J. Hussey, N.E. Hussey and A.T. Fisk. Effects of decomposition on carbon and nitrogen stable isotope values of muscle tissue of varying lipid content from three aquatic vertebrate species. *Rapid Communications in Mass Spectrometry*. *In press*.

***b) Refereed journal articles (1 total) – submitted***

- Landry JJ, Yurkowski DJ, Fisk AT, Hussey NE, Dick T, Crawford RE, Kessel ST (2016). Diet specialization and habitat coupling of a common benthic fish Shorthorn Sculpin (*Myoxocephalus scorpius*) in the high arctic. *Mar. Ecol. Prog. Ser.* Rejected to be resubmitted to *Polar Biology* in December 2016.

***c) Conference/workshop/seminar presentations (3 total) – invited or contributed***

- Ivanova S, Kessel ST, Vagle S, Espinoza M, McLean M, O'Neill C, Landry J, Hussey NE, Yurkowski D, Fisk AT (2016). Project 4.10: Fish and marine mammal interactions in the high Arctic (Oral Presentation), Ocean Tracking Network (OTN) Symposium, Halifax, NS, Canada.
- Ivanova S, Kessel ST, Landry J, McLean M, O'Neill C, Fisk AT, Nelson K (2015). Shipping traffic displaces key fish species in the Canadian high Arctic (Presentation), GLIER Colloquium, University of Windsor, ON, Canada.
- Landry JJ, Yurkowski DJ, Fisk AT, Hussey NE, Dick T, Crawford RE, Kessel ST (2016). Using acoustic telemetry and stable isotopes to determine trophic ecology of sculpin in the Arctic. (Presentation), GLIER Colloquium, University of Windsor, ON, Canada

## **8. Contributions from industrial and government partners**

As there was not field season in 2016, there are no contributions from industrial or government partners.

**Ocean Tracking Network Canada****NSERC****Progress Report Year 7 Review: 1 October 2015 – 30 September 2016****1. Project Number: 4.11****2. Project Title:** Deep-water Arctic marine fishes: developing commercial fisheries and interactions with marine mammals**3. Project Leaders:** Aaron Fisk (U Windsor), Kevin Hedges (DFO-Arctic, U Manitoba), Svein Vagle (DFO-Arctic, U Victoria), Steve Ferguson (DFO-Arctic, U Manitoba), Daniel Heath (U Windsor)**Other OTN Canada participants:** I. Fleming, S. Hinch, S. Cooke, R. Tallman, K. Fennel, J. Sheng, J. Mills Flemming**Collaborators:** Wayne Lynch (Government of Nunavut), Margaret Treble (DFO-Arctic), Dale Webber (Vemco), Fred Whoriskey (OTN), Aaron McNeil (Australian Institute of Marine Science)**4. Training of Highly Qualified Personnel (and level of support)**

| Name  | Title* | % Time in project | % Support from OTNC | Start Date (actual date HQP started with OTN) | End Date (actual or anticipated) |
|---|--------|-------------------|---------------------|---|----------------------------------|
| Jeannette Bedard  | PhD    | 100               | 100                 | Sept-2011                                     | April 30, 2016                   |
| Research Topic: Physical oceanography and acoustics   |        |                   |                     |   |                                  |
| Nigel Hussey  | RA     | 75                | 0                   | 1-Jan-2010                                    | 30-Jun-2016                      |
| Research Topic/current employment (if no longer OTNC HQP): Oversight/development of acoustic telemetry mooring placements, tagging of fish, analysis of data, co-supervision of MSc |        |                   |                     |   |                                  |
| Chen Liu  | MSc    | 100               | 100                 | 1-Jan-2015                                    | April 31, 2017                   |
| Research Topic: genetic analysis of arctic char samples   |        |                   |                     |   |                                  |
| Amanda Barkley  | PhD    | 100               |                     | 1-Jan-2017                                    | 1-Jan-2021                       |
| Research Topic/current employment (if no longer OTNC HQP): Greenland halibut tracking in Scott Inlet/Baffin Bay   |        |                   |                     |   |                                  |
| Maha Ghazal   | MSc    | 100               | 100                 | Jan 1, 2016                                   | April 31, 2017                   |
| Research Topic/current employment (if no longer OTNC HQP): Ringed seals (harp seals, capeling, cod) along Baffin Island   |        |                   |                     |   |                                  |

**5. Public summary of report**

This past year, monitoring in the Arctic was expanded to now encompass areas throughout Baffin Bay in an effort to develop the offshore component of this research where much of the Greenland halibut fisheries currently operate. To this effect, 42 moorings were placed in lines of three along the banks of Baffin Bay at depths of approximately 700, 900 and 1100 m and the acoustic arrays of both Scott Inlet and Qikiqtarjuaq were both serviced and re-deployed as in previous years. Many of the Greenland halibut tagged in Scott Inlet, Baffin Island in September move offshore directly after release potentially only using the area for foraging in the summer months, yet we know nothing about their movements after they exit the system. Through multiple years of acoustic tracking Scott Inlet Greenland halibut, we have also identified a resident population that remains within the coastal system from December/March to October/November every year, however these fish also migrate into the offshore during that gap of time in the fall, similar to the transient fish. The timing of this offshore migration fits with previous research on the spawning time for this species in the Davis Strait. The offshore gates will potentially indicate if fish are moving south at this time, and provide greater evidence for a spawning migration within this population. Approximately 200 Greenland halibut were also tagged this year in the offshore,

Scott Inlet and Qikiqtarjuaq to jumpstart this expanded monitoring effort. Work has also continued on acoustic tagging by-catch species such as Arctic Skate and Greenland sharks, where the use of high resolution accelerometer tags for the latter is also providing unique insight into both post-release behaviour and potential burst swimming associated with prey capture. All moorings were removed and data collected from Cumberland Sound, telemetry research in this ecosystem has come to an end. The Arctic Charr genetic project has progressed well, genotyping is progressing well, and over 100 new samples were collected in the summer of 2016. Acoustic monitoring of marine mammals is an important tool to observe several species simultaneously and assess trophic relations. Here, we used passive acoustic monitoring (PAM) methods to monitor the occurrence of marine mammals over an annual cycle in Scott Inlet, Nunavut. We investigated the environmental correlates of the presence of marine mammals and found that sea ice coverage strongly influenced our detections of marine mammal sounds. Narwhal and bowhead whales were only present before the area was covered in ice in the fall while the presence of bearded seals and walruses could only be detected after the ice was formed.

Expanding the offshore moorings has also allowed for the expansion of oceanographic data collection and marine mammal monitoring. Many of the moorings are equipped with temperature loggers with the hopes of including more temperature loggers as well as additional dissolved oxygen, salinity and turbidity recorders in the future. An SM2M marine mammal recorder was deployed on the banks of Baffin Island, and a deep-water SM3M in the narwhal closure to look at possible associations with the presence of Greenland halibut and other marine mammals. The offshore monitoring is complemented by continued coastal work that includes multiple oceanographic stations including benthic pods as well as four more SM2Ms for marine mammal presence.

## 6. Networking, outreach, and synthesis

### *a) Interaction/Outreach to Broader Community/Public (including radio or television interviews or contribution to a programme/documentary, stakeholder workshops, etc.)*

Local Arctic communities have had a major role in supporting this research and in return it has been a primary focus of the scientific group to provide outreach and discuss scientific findings with the communities. Meetings with the Hunters and Trappers Association of Clyde River (Scott Inlet) and Qikiqtarjuaq facilitate this outreach by explaining our goals and objectives to community leaders. We also invite a member of the Clyde River community to participate in field work in Scott Inlet for a direct experience of the work being undertaken. Clyde River also typically requests a community meeting or a radio interview to share the scientific work with the community as a whole and allow for individual input and contributions from all area residents.

### *b) Synthesis activities*

Regular conference calls among PIs and HQP to plan and organize field work (particularly sample needs), report on data and discuss papers, were held (about once per month). Data analysis for papers has also been integrative, to combine oceanography with multi-species animal tracking. We are also working with other researchers within OTN such as Franziska Broell to use her newly developed accelerometer tags on Greenland halibut. Collaboration work has also started with Yuuki Watanabe from the National Institute of Polar Research in Japan, who has been a part of the field team in the arctic for the past two years, to attach accelerometer tags as well as cameras to Greenland sharks and Greenland halibut. In September, Dr. Michael Conroy (University of Georgia) was awarded a Fulbright

Visiting Scholar to come to University of Windsor to working on modeling the OTN arctic telemetry dataset for Greenland Halibut.

## 7. Dissemination of information and results

### *a) Refereed journal articles (12\*\* total) – accepted/published*

\*\*Note: In order to avoid double listing of dissemination/publications given the extensive cross-collaboration with Project 4.10, three publications (D. Yurkowski et al.) are listed under Project 4.10's report (previous section).

Barkley, A.N., Cooke, S.J., Fisk, A.T., Hedges, K., Hussey, N.E. 2016. Capture-Induced Stress in Deep-water Arctic Fish Species. *Polar Biology* doi:10.1007/s00300-016-1928-8

Hussey, N.E., Hedges, K.J., Barkley, A.N., Teble, M.A., Peklova, I., Webber, D.M., Ferguson, S.H., Yurkowski, D.J., Kessel, S.T., Bedard, J.M., Fisk, A.T. 2016. Movements of a deep-water fish: establishing marine fisheries management boundaries in coastal Arctic fisheries. *Ecological Applications* In press.

Brown, T.A., Chrystal, E., Ferguson, S.H., Yurkowski, D.Y., Watt, C., Hussey, N.E. and Belt, S.T. Coupled changes in the sea ice carbon contribution to diet and trophic position of Cumberland Sound beluga whales identified by H-Print and  $\delta^{15}\text{N}$  analysis. *Limnology and Oceanography*. In revision.

Watt, C.A., Orr, J.R., and Ferguson, S.H. 2016. Critical foraging habitats for the Canadian narwhal (*Monodon monoceros*) populations inferred from dive behaviour. *Canadian Journal of Zoology*. CJZ-2015-0231 In press.

Crossin, G.T., Heupel, M., Holbrook, C.M., Hussey, N.E., Lowerre-Barbieri, S., Nguyen, V.M., Raby, G.D. and Cooke, S.J. Acoustic telemetry and fisheries management. *Ecological Applications*. In revision.

Yurkowski, D; Semeniuk, C; Harwood, L; Rosing-Asvid, A; Dietz, R; Brown, T; Clackett, S; Grgicak-Mannion, A; Fisk, A; Ferguson, S. 2016. The influence of sea ice phenology on the movement ecology of ringed seals across their latitudinal range. *MEPS* in press.

Marcoux M, Ferguson, S.H., Roy, N., Bedard, J.M. and Simard, Y. 2016. Seasonal marine mammal occurrence detected from passive acoustics monitoring in Scott Inlet, Nunavut, Canada. *Polar Biology* In press.

Watt, C.A., Orr, J.R., and Ferguson, S.H. 2016. A shift in foraging behaviour of beluga whales (*Delphinapterus leucas*) from the threatened Cumberland Sound population may reflect a changing Arctic food web. *Endangered Species Research*. In press. Doi: 10.3354/esr00768.

Pleskach K, W Hoang, M. Chu, T Halldorson, L Loseto, SH Ferguson, G Tomy. 2016. Use of mass spectrometry to measure aspartic acid racemization for ageing beluga whales. *Polar Biology* in press.

Matthews, CJD, FJ Longstaffe, SH Ferguson. 2017. Dentine oxygen isotopes ( $\delta^{18}\text{O}$ ) as a proxy for odontocete distributions and movements. Ecology and Evolution. In press.

Brown, TM, DCG Muir, SH Ferguson, BG Young, AT Fisk, KJ Reimer, X Wang. 2016. Mercury and cadmium in ringed seals in the Canadian Arctic: influence of location and diet. Science of the Total Environment 545–546: 503–51

Trana, MR, JD Roth, GT Tomy, WG Anderson, SH Ferguson. Increased blubber cortisol in ice-entrapped beluga whales (*Delphinapterus leucas*). Pol Biol. In press. DOI 10.1007/s00300-015-1881-y

*b) Refereed journal articles (1 total) – submitted*

Cooke, S.J., Nguyen, V.M., Kessel, S.T, Hussey, N.E., Young, N. and Ford, A. The tenebrous frontier of animal tracking. Conservation Biology. In review.

*c) Conference/workshop/seminar presentations (6 total) – invited or contributed*

Hussey, N.E., Bégue, M., Lennox, R., Nguyen, V., Eliason, E., Kessel, S., Lidgard, D., Martins, E. and Auger-Méthé, M. (2016) The Ocean Tracking Network : Management and conservation of aquatic ecosystems. Ocean Tracking Network Annual Conference, Halifax, Nova Scotia, Canada., Hussey, N.E., Auger-Méthé, M. and Fisk, A.T. (2016) Does the distribution of telemetry effort bias our understanding of global aquatic ecosystems? Ocean Tracking Network Annual Conference, Halifax, Nova Scotia, Canada.

Hussey, N.E., Hedges, K.J., Barkley, A. and Fisk, A.T. (2016) Deep-water Arctic ecosystems and developing commercial fisheries. Ocean Tracking Network Annual Conference, Halifax, Nova Scotia, Canada.

Hussey, N.E. (2016) From the poles to the tropics: Animal movements and trophic dynamics and their interaction for conservation and management planning. IX SBEEL, Brazilian Elasmobranch Society Meeting, Aracaju, Brazil.

Hussey, N.E. (2016) Sharks, Canada and the Arctic's largest fish. IX SBEEL, Brazilian Elasmobranch Society Meeting, Aracaju, Brazil.

Burmester, C., Whoriskey, F. and Hussey, N.E. (2016) Diving deep with *Somniosus microcephalus*: Inferring behavior from vertical movements of the Greenland shark. Cameron Conference, Dalhousie University, Nova Scotia, Canada

Burmester, C., Whoriskey, F. and Hussey, N.E. (2016) Diving deep with *Somniosus microcephalus*: Inferring behavior from vertical movements of the Greenland shark. Cameron Conference, Dalhousie University, Nova Scotia, Canada

## 8. Contributions from industrial and government partners

|   |                         |
|---|-------------------------|
| Name of supporting organization:<br><b>Government of Nunavut</b>    | <b>Year 7</b><br>(2016) |
| <b>Cash contributions to direct costs of research</b>               |                         |
| <b>In-kind contributions to direct costs of research</b>            |                         |
| 1) Salaries for scientific and technical staff                      | \$200,000               |
| 2) Donation of equipment, software                                  | \$100,000               |
| 3) Donation of material   |                         |
| 4) Field work logistics   | \$270,000               |
| 5) Provision of services  |                         |
| 6) Other (specify): Travel  | \$56,000                |
| <b>In-kind contributions to indirect costs of research</b>          |                         |
| 1) Use of organization's facilities                                 | \$626,000               |
| 2) Salaries of managerial and administrative staff                  |                         |
| 3) Other (specify):   |                         |
| <b>Total of all in-kind contributions</b>                           |                         |
| <b>Is this new funding (acquired during this reporting period)?</b> | no                      |

**Ocean Tracking Network Canada****NSERC****Progress Report Year 7 Review: 1 October 2015 – 30 September 2016****1. Project Number:** 4.12, 4.13, 4.14, 4.15**2. Project Titles:**

**4.12** Pacific salmon commercial and First Nations fisheries: delayed mortality, behaviour and physiology of released bycatch in coastal waters

**4.13** Tracking anadromous adult salmonids in Canada's three oceans to evaluate the sustainability of catch-and-release angling practices – behavioural and physiological perspectives on estuarine fisheries

**4.14** Seasonal movements and spawning migrations of White Sturgeon

**4.15** Survival and movement rates of out-migrating juvenile Pacific and Atlantic salmon

**3. Project Leaders (4.12):** Scott Hinch (UBC)

**Other OTN Canada participants:** S. Cooke, T. Farrell, K. Miller, D. Patterson, A. Fisk, I. Fleming, M. Stokesbury

**Collaborators:** Michael Davis (United States NOAA)

**Project Leaders (4.13):** S. Cooke (Carleton U)

**Other OTN Canada participants:** S. Hinch, T. Farrell, A. Fisk, R. Tallman, I. Fleming

**Collaborators:** Dave Patterson (DFO-Pacific), M. Robertson (DFO-Atlantic)

**Project Leaders (4.14):** G. Crossin (Dalhousie U)

**Other OTN Canada participants:** S. Cooke, S. Hinch, T. Farrell, M. Litvak, M. Stokesbury

**Collaborators:** Dave Patterson (DFO-Pacific), Kyle Hanson

**Project Leaders (4.15):** S. Hinch (UBC)

**Other OTN Canada participants:** S. Cooke, K. Miller, R. Thomson, I. Fleming, J. Mills Flemming

**Collaborators:** Dave Patterson (DFO-Pacific), Fred Whoriskey (OTN)

**4. Training of Highly Qualified Personnel (and level of support)**

| Name  | Title* | % Time in project | % Support from OTNC | Sources of other support | Start Date (actual date HQP started with OTN) | End Date (actual or anticipated) |
|---|--------|-------------------|---------------------|--------------------------|---|----------------------------------|
| Eduardo Martins   | RA     | 10                | 0                   | Ero Liber                | 1 Sept 2009                                   | Dec 2017                         |
| Research Topic/current employment (if no longer OTNC HQP): salmon life history modeling |        |                   |                     |                          |   |                                  |
| Doug Braun  | RA     | 10                | 0                   | Instream Ltd             | 1 June 2011                                   | Dec 2016                         |
| Research Topic/current employment (if no longer OTNC HQP): salmon movement biology      |        |                   |                     |                          |   |                                  |
| Erika Eliason   | RA     | 100               | 0                   | maternity leave support  | 1 Jan 2011                                    | July 2016                        |



| Name  | Title* | % Time in project | % Support from OTNC | Sources of other support | Start Date (actual date HQP started with OTN) | End Date (actual or anticipated) |
|---|--------|-------------------|---------------------|--------------------------|---|----------------------------------|
| Research Topic/current employment (if no longer OTNC HQP): salmon physiology  |        |                   |                     |                          |   |                                  |
| Katrina Cook  | PhD    | 100               | 25                  | NSERC                    | 1 Sept 2012                                   | Dec 2017                         |
| Research Topic/current employment (if no longer OTNC HQP): capture/release physiology and behaviour   |        |                   |                     |                          |   |                                  |
| Amy Teffer  | PhD    | 50                | 0                   | NSERC                    | 1 Sept 2011                                   | Dec 2017                         |
| Research Topic/current employment (if no longer OTNC HQP): pathogens and disease in salmon  |        |                   |                     |                          |   |                                  |
| Arthur Bass   | PhD    | 50                | 0                   | NSERC/Mitacs             | 1 Sept 2012                                   | Dec 2017                         |
| Research Topic/current employment (if no longer OTNC HQP): capture/release and disease in salmon  |        |                   |                     |                          |   |                                  |
| Nolan Bett  | PhD    | 50                | 0                   | NSERC/Mitacs             | 1 Sept 2011                                   | Dec 2017                         |
| Research Topic/current employment (if no longer OTNC HQP): homing physiology and behaviour in salmon  |        |                   |                     |                          |   |                                  |
| Nathan Furey  | PhD    | 100               | 10                  | NSERC/Mitacs             | 1 Sept 2011                                   | Dec 2017                         |
| Research Topic/current employment (if no longer OTNC HQP): salmon smolt movement and survival   |        |                   |                     |                          |   |                                  |
| Vivian Nguyen   | PhD    | 100               | 0                   | NSERC                    | 1 Jan 2014                                    | Dec 2017                         |
| Research Topic/current employment (if no longer OTNC HQP): human dimensions of salmon capture and management                                |        |                   |                     |                          |   |                                  |
| Montana McLean  | PhD    | 100               | 50                  | NSERC                    | 1 Jan 2014                                    | Dec 2017                         |
| Research Topic/current employment (if no longer OTNC HQP): white sturgeon movement ecology  |        |                   |                     |                          |   |                                  |
| Vanessa Minke-Martin  | MSc    | 50                | 0                   | NSERC/Mitacs             | 1 Sept 2013                                   | Dec 2016                         |
| Research Topic/current employment (if no longer OTNC HQP): thermal ecology of migrating adult salmon  |        |                   |                     |                          |   |                                  |
| Melissa Dick  | MSc    | 100               | 40                  | NSERC                    | 1 July 2014                                   | Dec 2016                         |
| Research Topic/current employment (if no longer OTNC HQP): effects of handling on maturing salmon   |        |                   |                     |                          |   |                                  |
| Stephen Healy   | MSc    | 100               | 0                   | NSERC/Mitacs             | 1 Sept 2013                                   | Dec 2017                         |
| Research Topic/current employment (if no longer OTNC HQP): salmon smolt movement and survival   |        |                   |                     |                          |   |                                  |
| Jacqueline Chapman  | PhD    | 100               | 20                  | NSERC                    | 1 June 2014                                   | Dec 2017                         |
| Research Topic/current employment (if no longer OTNC HQP): effects of handling/release on salmonids in our 3 oceans                         |        |                   |                     |                          |   |                                  |
| Collin Middleton  | MSc    | 50                | 0                   | NSERC/Mitacs             | 1 Sept 2013                                   | Oct 2016                         |
| Research Topic/current employment (if no longer OTNC HQP): physiology, temperature and water quality effects on migrating salmon            |        |                   |                     |                          |   |                                  |
| Robert Lennox   | PhD    | 30                | 30                  | NSERC                    | 1 Oct 2015                                    | Dec 2017                         |
| Research Topic/current employment (if no longer OTNC HQP): catch/release science and biologists   |        |                   |                     |                          |   |                                  |
| Mike Donaldson  | PDF    | 25                | 25                  |                          | 1 Oct 2015                                    | Apr 2016                         |
| Research Topic/current employment (if no longer OTNC HQP): synthesis of the literature on fish capture/release 'vitality indicators'        |        |                   |                     |                          |   |                                  |
| Natalie Sopinka   | PDF    | 10                | 0                   | NSERC/Mitacs             | 1 Jan 2011                                    | Dec 2017                         |
| Research Topic/current employment (if no longer OTNC HQP): science communication/extension; syntheses                                       |        |                   |                     |                          |   |                                  |
| Matt Drenner  | PDF    | 50                | 0                   | Mitacs                   | 1 June 2015                                   | 1 June 2017                      |
| Research Topic/current employment (if no longer OTNC HQP): effects of riverine hydrological changes on adult salmon                         |        |                   |                     |                          |   |                                  |
| Christine Stevenson   | MSc    | 100               | 0                   | PSF/Mitacs               | 1 Jan 2016                                    | Dec 2017                         |
| Research Topic/current employment (if no longer OTNC HQP): smolt migration survival and behaviour   |        |                   |                     |                          |   |                                  |
| Andrea Reid   | PhD    | 100               | 0                   | NSERC                    | 1 Jan 2016                                    | Dec 2017                         |
| Research Topic/current employment (if no longer OTNC HQP): effects of ocean fisheries handling on survival and timing of Nass River sockeye |        |                   |                     |                          |   |                                  |
| Mike Lawrence   | PhD    | 25                | 0                   | NSERC                    | 1 Sept 2014                                   | Dec 2017                         |
| Research Topic/current employment (if no longer OTNC HQP): biologging physiology and cardiac function in salmonids                          |        |                   |                     |                          |   |                                  |
| Taylor Wale   | BSc    | 100               | 10                  | NSERC                    | 1 May 2016                                    | Sept 2016                        |
| Research Topic/current employment (if no longer OTNC HQP): assisted with marine capture/release study                                       |        |                   |                     |                          |   |                                  |
| Laura Elmer   | MSc    | 25                | 0                   | Carleton                 | 1 July 2016                                   | Dec 2016                         |

| Name   | Title* | % Time in project | % Support from OTNC | Sources of other support | Start Date (actual date HQP started with OTN) | End Date (actual or anticipated) |
|--|--------|-------------------|---------------------|--------------------------|---|----------------------------------|
| Research Topic/current employment (if no longer OTNC HQP): assisted with marine capture/release study              |        |                   |                     |                          |   |                                  |
| Tanya Prystay  | MSc    | 25                | 0                   | NSERC                    | 1 July 2016                                   | Dec 2016                         |
| Research Topic/current employment (if no longer OTNC HQP): heart rate biollogger and salmon fisheries interactions |        |                   |                     |                          |   |                                  |

## 5. Public summary of report

The OTN Pacific Arena research is focused on Pacific salmon and white sturgeon given their ecological, cultural and socio-economic importance. All of the research involved using innovative high-tech telemetry tags that transmit information to receivers spread throughout the coast and rivers. Prior to the development of such technology it was impossible to study these fish across large spatial scales. Research has covered several life stages including outmigrating salmon smolts and upriver migrating adult salmon and sturgeon. For example, team members traveled to the Chilko watershed where they tagged sockeye salmon smolts and predatory bull trout in an effort to identify where and how mortality occurs during their journey to the ocean. Team members also worked in the ocean where they tagged adult salmon to understand the behaviour of different stocks on their way to spawning grounds. The team utilized novel telemetry tags that measure tailbeats of salmon enabling the estimation of swimming speeds and energy use. Given the prevalence of fisheries along their homeward migration, we also studied the effects of capture and release on survival and behaviour of adult salmon, Arctic char, and sturgeon incorporating assessments of stress physiology and disease using physiological biopsy. Laboratory work on adult salmon and sturgeon in captivity complemented the field work and are helping to identify physiological mechanisms of stress and mortality including tagging burden. The work conducted involved extensive partnerships with Fisheries and Oceans Canada, First Nations groups, ENGOs, anglers, and commercial fishers. Collectively OTN research in the Pacific Arena has already informed fisheries management and conservation by providing information on the behaviour and survival of salmon and sturgeon.

### *4.12 Pacific salmon commercial and First Nations fisheries: delayed mortality, behaviour and physiology of released bycatch in coastal waters*

AND

### *4.13 Tracking anadromous adult salmonids in Canada's three oceans to evaluate the sustainability of catch-and-release angling practices – behavioural and physiological perspectives on estuarine fisheries*

## Progress

In 2016 we used biopsy and acoustic telemetry, and field holding assessments to quantify mortality rates, sublethal consequences (behaviour, physiology, and injury) and recovery potential with different methods of fish capture, handling, and recovery. We examined adult chum, sockeye and Atlantic salmon. In the Seton River we tagged and tracked 120 sockeye with radio tags, 450 sockeye with PIT tags, and 60 with heart rate biolloggers. In the Nass River and northern coastal BC, we tagged and tracked 450 sockeye with radio tags. We examined recovery in field holding studies using 300 adult chum in northern coastal BC and 70 Atlantic salmon in the Campbellton River in Newfoundland. In all studies, we used capture time, amount of air exposure, RAMP and physiological factors (e.g. pathogen loads, injury) as predictors of survival (holding studies) and delayed mortality (tracking studies).

**Significance**

In the Seton River study we found that salmon survival to spawning grounds was facilitated by management changes to flow conditions in the regulated river portion of the migration indicating that small changes in water released from the Seton Dam can have large benefits to migratory success of sockeye. Survival and physiological results are still pending for the other studies. HQP associated with both 4.12 and 4.13 projects assisted in preparing and presenting CSAS documents as requested by DFO associated with capture/release 'science'. The present field work and the CSAS reports provides information to fisheries managers and fishers on mortality of coastal migrating adult salmon associated with release after capture using different fishing gears and practices which managers can use to assist with harvest decisions.

*4.14 Seasonal movements and spawning migrations of white sturgeon***Progress**

In 2016, we put 17 new acoustic tags (V16) into adult white sturgeon, which since 2013 brings the total white sturgeon carrying transmitters in the Fraser River to 174. All fish had a blood sample taken to measure stress hormones and RAMP scores were made.

**Significance**

This work continues to examine the efficacy of RAMP scores in predicting post-release behaviour and fate in the wild. This work provides basic information about the drivers of seasonal movements and reproductive patterns of white sturgeon in the Fraser River and its estuary, and provides information to fisheries managers and fishers on post-angling mortality patterns, which can guide management and conservation actions. Ultimately our work is assisting the development of potential best practices for minimizing angling related mortality, and identify areas and times of year when sturgeon are most susceptible to disturbance.

*4.15 Survival and movement rates of out-migrating juvenile salmon***Progress**

In 2016, we tagged 200 1-yr-old Chilko sockeye smolts (V4 acoustic transmitters) and 100 2-year-old smolts (V7 acoustic transmitters) and tracked individuals through the first ~1150km of their migration from in-land rearing areas in central BC to distant locales in northern coastal BC using large scale receiver arrays. Non-lethal gill biopsies were also collected in order to assess genes associated with immune responses and pathogen presence. The main objective is to characterize the migration rates and fate of juvenile sockeye as they migrate from natal freshwater areas into and through coastal areas, and to relate riverine, oceanographic, and climate features, and physiological/biological attributes of individuals, to behaviour and fate.

**Significance**

Preliminary results indicate that > 60% of fish did not make it into the marine environment, some of the poorest freshwater survival we have seen in > 6 years of tagging sockeye smolts. Less than 1% made it to the final acoustic array in northern coastal BC. We found that survival in freshwater was better in 1-year fish old containing the V4 transmitters than the 2-year old fish with the larger V7 transmitter indicating some potential tag burden effects with the 2-year old fish. One of the main significant aspects of this research is that this is one of the first studies of its kind to utilize new miniaturized V4

transmitters in a large scale tracking project of juvenile salmon – revealing the technical feasibility to being able to tag one year smolts which comprise 98% of the migratory population.

## 6. Networking, outreach, and synthesis

### *a) Interaction/Outreach to Broader Community/Public (including radio or television interviews or contribution to a programme/documentary, stakeholder workshops, etc.)*

#### Within OTN

October 1, 2015 – S. Healy, A. Bass, N. Bett, N. Furey, K. Cook, J. Chapman, and S. Hinch had conference call with Kristi Miller (DFO, Pacific Biological Station) to discuss plans for running samples at the Molecular Genetics Lab (Department of Fisheries and Oceans, Nanaimo).

December 2015 – May 2016 – S. Healy, A. Bass, N. Bett, N. Furey, K. Cook, J. Chapman moved to Nanaimo BC and were embedded into the DFO Molecular Genetics Lab for several weeks of sample processing and meetings with DFO.

December 2015 to October 2016 – Cooke serves as “mentor” for the IDEAS OTN team, participating in several conference calls and meeting with their team during the OTN annual meeting.

January 2016 – J. Chapman and S. Cooke meet with DFO collaborator Dr. Martha Robertson at CCFFR to discuss summer field work.

June 1, 2016 – S. Hinch, S. Cooke, S. Healy, A. Bass, C. Stevenson attended the OTN annual symposium in Halifax, NS.

June 21, 2016 – S. Healy and S. Hinch met with David Welch and Erin Rechisky (Kintama Ltd) to discuss plans for collaboration on Seymour River steelhead acoustic telemetry data handling.

August 2016 - M. Philipp, T. Prystay, K. Peiman and R. deBruijn met several times with David Patterson (DFO OTN collaborator) re field work at Gates Creek.

August 21, 2016 – A. Teffer met with Kristi Miller at the Pacific Biological Station, Nanaimo, BC, to discuss manuscript preparations, study design for validating the effectiveness using of various tissue types for genomic pathogen screening.

September 15, 2016 – J. Chapman met with V. Nguyen and J. Brooks regarding OTN Ideas synthesis manuscript on the use of telemetry in fisheries management.

#### Outreach

October 2015-September 2016 – M. McLean sat on the board for the Technical Working Group of the Fraser River Sturgeon Conservation Society (non-profit organization).

October 2015 – September 2016 – Cook served as president of BC subunit of American fisheries society which required attending conference calls, scheduling meetings, and organizing events, and where possible promoting OTN activities

October 2015-January 2016 – K. Cook regularly conducted interviews with commercial salmon fishermen from British Columbia to understand their perspectives on bycatch issues within the fishery and disseminate relevant research findings on post release mortality in Pacific Salmon

October 2015 – March 2016 – K. Cook met in person and had several conference calls with researchers from consulting company LGL limited to discuss research collaborations for a new OTN project on the Nass River

October 14, 2015 – M. Dick, A. Bass, A. Lotto, K. Cooke attended a First Nations Fisheries Council science workshop (Katzie First Nation Health and Community Centre, Pitt Meadows, BC.) and presented research summaries.

October 16 2015 – M. Dick facilitated and led a site visit at the DFO / UBC Cultus Lake Salmon Research Laboratory in Cultus Lake, BC by the Fraser River Panel of the Pacific Salmon Commission and discussed recent research that has taken place at the facility by Pacific arena investigators.

November 5, 2015 – Cook met with executive staff of Canfisco to discuss funding and collaboration options for northern BC research with the purse seine fleet

November 19, 2015 – S. Healy attended the Seymour Salmonid Society Annual General Meeting and discussed preliminary telemetry results on Seymour River steelhead.

January 2016-September 2016 – M. McLean worked with the Fraser River Sturgeon Conservation Society (non-profit organization) as a science advisor and regularly discussed issues surrounding the conservation and management of the Lower Fraser River white sturgeon population.

January 29, 2016 – N. Young was invited to speak to the Annual Meeting of the Nova Scotia Aquaculture Association Sea Farmers' conference about inter-sectoral conflict, spatial planning and zoning issues, public perceptions of fisheries and aquaculture, and knowledge mobilization research. He also discussed how current OTN research on the relationship between science and policy could be extended to other sectors, including aquaculture.

February 4, 2016 – the Pacific Arena annual stakeholder and fisheries management research update meeting was held at UBC. All Pacific HQP and PIs were in attendance along with ~ 65 others from ENGOs, fisheries managers, First Nations, and other stakeholders and partners.

May 10, 2016 – M. Dick led a presentation and discussion seminar on the topic of “The physiological, behavioural, and survival consequences of two radio transmitter attachment techniques on migrating adult sockeye salmon” at the Queen's University Biological Station (QUBS) in Elgin, ON.

May 12, 2016 – K. Cook met with Mark Cleveland, head biologist of the Fisheries division of the Gitanyow First Nation to discuss collaborative potential with proposed Nass River research

May 16-18, 2016 – K. Cook and A. Reid had a site visit to northern BC and the Nass River to visit staff at Canfisco plant and meet commercial purse seine fishermen in Prince Rupert, BC, scientists from the local DFO office, and members of both the Nisga'a and Lax Kw'alaams First Nation communities as part of ongoing extension and collaboration efforts

May 21, 2016 – Nguyen and Chapman spearheaded the World Fish Migration Day event, showcasing some research gear used by OTN and other researchers at the Canadian Museum of Nature in Ottawa, Ontario.

May 27, 2016 – K. Cook met with Canfisco executives to discuss collaborative research.

June 10, 2016 – K. Cook met with biologists from Gitanyow First Nation to develop an MOU outlining direction of collaborations with UBC within joint Gitanyow and Nisga’a First Nations territory on the Nass River

July 12, 2016 – K. Cook met with Lax Kw’alaams biologists and members of their First Nations council to provide science advice and disseminate information regarding planning research to local community

August 2016 – M. Philipp, T. Prystay, K. Peiman and R. deBruijn met daily with the Chief of the D’Arcy Band in BC to facilitate field work at the Gates Spawning Channel

#### Media coverage or interviews

January 21, 2016 – K. Cook interviewed on CBC Radio, ‘On The Island’ show about OTN funded research

April 14, 2016 – Research by K. Cook highlighted in presentation by Aaron Hill representing NGO Watershed Watch at panel discussion, “Tools for Grassroots Activists” at Patagonia, Vancouver, British Columbia.

April 30, 2016 – the Hinch Lab, its OTN research program, and the Pacific Arena annual stakeholder/manager research meeting was overviewed and featured in UBC Branchlines Magazine article written by C. Stevenson (<http://forestry.sites.olt.ubc.ca/files/2011/11/bl-72.11.pdf>)

May 2016 – N. Furey’s research on smolt migrations was sent out as a press release by UBC “Salmon smolts find safety in numbers.” Available at <http://news.ubc.ca/2016/05/09/salmon-smolts-find-safety-in-numbers>. The article was picked up by Science Daily, EurekAlert, Vancouver News, the Leader Post (among others), and was featured on Discovery Channel’s Daily Planet.

May 10, 2016 – N. Furey interviewed on CBC Radio the ‘Early Edition’ and four other BC radio stations about his smolt tagging research. <http://www.cbc.ca/player/play/2688327331/>

July 26, 2016 – N. Furey’s bull trout tagging research profiled in Cool Green Science, the online magazine of the Nature Conservancy. “New Research on the Remarkable Binge-Eating Bull Trout.” <http://blog.nature.org/science/2016/07/26/new-research-remarkable-binge-eating-bull-trout/>

August 27, 2016 – M. McLean’s collaborative work with U.S. Fish and Wildlife is featured in an article in the Vancouver Sun online.

August 29, 2016 – N. Furey’s smolt and bull trout tagging research profiled in the Metro Newspaper. <http://www.metronews.ca/news/vancouver/2016/08/29/scientists-try-to-track-down-whats-killing-bc-salmon.html>

September 6, 2016 – M. McLean’s sturgeon tagging research publication profiled in the Vancouver Sun <http://vancouversun.com/news/local-news/doubts-over-catch-and-release-sturgeon-fishery-in-the-lower-fraser-river-after-new-study-finds-fish-endure-extreme-stress>

September 16, 2016 – E. Eliason interviewed for article in Hakai Magazine Coastal Science and Societies: ‘Fishing for a Glimpse of Salmon’s Future: Fraser River salmon felt the heat this summer. Can they cope with the hotter days to come?’ <https://www.hakaimagazine.com/article-short/fishing-glimpse-salmons-future>

October 1, 2015 - September 30, 2016. The most viewed story this past year entitled ‘Anglers’ Catch-And-Release Revival Techniques Shown To Not Always Benefit Fish’ on the web site of the Columbia Basin Fisheries Commission on-line bulletin was a review of the Pacific OTN paper, “Robinson, K.A., Hinch, S.G., Raby, G.D., Donaldson, M.R., Robichaud, D., Patterson, D.A., Cooke, S.J. (2015) Influence of post-capture ventilation assistance on migration success of adult sockeye salmon following capture and release. Transactions of the American Fisheries Society 144:693-704.” <http://www.cbbulletin.com/default.aspx>

#### Public presentations

January 29, 2016 - Young, N. Understanding public perception of fisheries and aquaculture in Canada: lessons from the social sciences” Address to Sea Farmers’ Annual Meeting, Halifax, NS.

April 6, 2016 – Cooke, S. The secret lives of fish: insights from tracking studies. Presentation for the St. Lawrence River Institute, Science on Tap Community Seminar at local pub in Cornwall, ON.

#### Policy or management consultations/meetings/contributions

May 16, 2016 – K. Cook attends a Nisga’a First Nation and DFO joint technical meeting in Prince Rupert, BC, to introduce research with the purse seine fleet and outline proposed research for summer 2016

May 16, 2016 – A. Reid was invited to remotely participate in the annual meeting of the Joint Fisheries Management Committee (JFMC) for the Nass Area, where K. Cook presented their joint proposed work on the fate and condition of sockeye and chum released from purse seine fisheries in Area 3, which included tracking research supported by OTN. The JFMC is a body with representatives from the Nisga’a Nation, Government of Canada and the Government of British Columbia.

June 2016 – M. McLean is consulted by the Fraser River Sturgeon Conservation Society to lead a review of temperature effects on stress in sturgeon. The society was trying to decide on a temperature threshold at which tagging procedures would be halted to reduce stress on the animal. The review was completed and included personal research that was recently finished. A temperature threshold was incorporated in both the provincial and society programs.

June 6-7, 2016 – S. Hinch and S. Cooke sit on CSAS panel and make presentations to CSAS secretariat on release mortality of Pacific salmon (Nanaimo, BC). Several HQP participated in associated preparatory activities.

June 17, 2016 – K. Cook attends a meeting of the Fisheries Committee of the Lax Kw'alaams First Nation Council via conference call to provide science update on the status of mortality rates of salmon discarded from commercial vessels.

#### Internet publishing or blogs

October 1, 2015 to September 30, 2016 - N. Sopinka writes a blog called Phish Doc ([www.phishdoc.com](http://www.phishdoc.com)) where she communicates concepts in fish and fisheries with poetry. Phish Doc is part of Science Borealis (<http://scienceborealis.ca/>), a platform featuring Canadian bloggers from a variety of scientific disciplines. Science Borealis is sponsored by Canadian Science Publishing and Genome Alberta. Sopinka featured as part of Science Borealis' "Reflections: 100 Voices for Canadian Science Communication". This initiative featured quotes from Canadian scientists, artists, and communicators including Science Minister Kristy Duncan, astronaut Chris Hadfield, among others.

Sopinka curated and edited blog series, Making Waves, for Canadian Science Publishing based on science communication symposium Sopinka co-organized for the 145th American Fisheries Society Annual meeting. Series featured articles from OTN HQP Sopinka, Minke-Martin, and Nguyen.

Sopinka wrote 3 articles for Library Nexus blog series hosted through Canadian Science Publishing. The series explored how, in a digital era, libraries shape the connections between scientist and science, history and science, and art and science.

November 4, 2015 – V. Minke-Martin's article titled "Narratives of Nature: Use Storytelling to Reach New Audiences with Your Research" is published on the Canadian Science Publishing blog. The post includes content revised from her presentation at the 2015 American Fisheries Society meeting in Portland, OR. Available at <http://www.cdnsiencepub.com/blog/narratives-of-nature-use-storytelling-to-reach-new-audiences-with-your-research.aspx>

January 15, 2016 – K. Cook's paper "Fishing out of Water: Of Much Air is Too Much" featured on the Columbia Basin Bulletin <http://www.cbbulletin.com/435859.aspx>

February 24, 2016 V. Minke-Martin's article, "Narratives of Nature" is also published online in Fisheries magazine (volume 41, issue 3). Available at <http://www.tandfonline.com/doi/full/10.1080/03632415.2016.1135691>

April 2016 – V. Nguyen published a science communication blog with Canadian Science Publishing MakingWaves and Fisheries Research cited as Vivian Nguyen (2016) 'Seriously, Get to Know Your Audience', Fisheries, 41:5, 217-218 (<http://dx.doi.org/10.1080/03632415.2016.1162568>)

May 2016 – N. Furey's research on Chilko sockeye salmon smolt telemetry is highlighted via a press release published by the University of British Columbia. This press release was picked up and published by Science Daily, EurekAlert, Vancouver News, the Leader Post (among others), and was featured on Discovery Channel's Daily Planet. Article titled "Salmon smolts find safety in numbers." Authored by Heather Amos. Available at <http://news.ubc.ca/2016/05/09/salmon-smolts-find-safety-in-numbers/>

July 2016 – N. Furey's research on Chilko bull trout feeding rates is highlighted on The Nature Conservancy's online news site Cool Green Science. Article titled "New Research on the Remarkable



Binge-Eating Bull Trout.” Authored by Matt Miller. Available at <http://blog.nature.org/science/2016/07/26/new-research-remarkable-binge-eating-bull-trout/>

September 2016 – Teffer published a website describing her research, with links to lab websites, recent publications, and her twitter account (@tefferfish).

September 2016 – S. Cooke and N. Sopinka featured as two of the “100 most influential science communicators” in Canada project by Science Borealis. .

### *b) Synthesis activities*

K. Cook and A. Reid in collaboration with DFO scientists plan a review paper covering the current state of knowledge of research on bycatch in commercial fisheries, much of what has been covered by OTN.

E. Martins compiled data on abundance, fecundity, spawning success, and telemetry (adults and smolts) for up to 19 stocks of Fraser River sockeye salmon. The data are been included in a database that will support, among other things, the development of stage-structured population models. This work will integrate years of telemetry data collected under OTN with stock assessment data to investigate the potential impact of cumulative effects of stressors on the dynamics of sockeye salmon populations.

E. Martins has been serving as co-chair of the ideasOTN committee and helping coordinate various synthesis projects. He has been particularly involved in the development of a synthesis manuscript on methods to analyze telemetry data (led by Kimberly Whoriskey, Dalhousie University).

E. Eliason and V. Nguyen participated in the OTN synthesis committee (ideasOTN), which included conference calls and presentations at the OTN annual meetings.

M. McLean joined the ideasOTN committee and metonthly to bring together comprehensive reviews related to telemetry work. McLean is leading a large review looking at acoustic telemetry use in all sturgeon species and working collaboratively with V. Nguyen on a perspective piece on the benefits of being part of a network (anticipated target – Career column in Nature).

M. Donaldson, K. Cook, G. Raby, S. Hinch, S. Cooke, and D. Patterson are working on a review article that summarizes the state of the literature on fish capture/release ‘vitality indicators’ and proposes new directions for future research. Vitality indicators can be used at the time of capture to make predictions on the likelihood that an individual will survive if released. This information can also be applied to fisheries in order to help make decisions about whether to retain or release fish. The review article synthesizes the results of a number of OTN studies that have investigated vitality indicators and also brings in outside literature on multiple fish and invertebrate species that are commonly captured by fisheries. The review article is in draft form and being prepared for submission to Fish and Fisheries in early 2017.

S. Cooke, V. Nguyen and G. Crossin collaborated with several scientists from Canada, the USA and Australia on an introductory paper on “Acoustic telemetry in fisheries management” for the special issue of Ecological Applications by the same name. The paper will be published in 2017.

S. Cooke and N. Young obtained funding from the Great Lakes Fishery Commission to generate a white paper to help fisheries managers interpret fish telemetry studies. Co-authors include S. Hinch, K. Whoriskey, J. Mills-Flemming, R. Lennox, K. Murchie, V. Nguyen, M. Stokesbury among others from

inside and outside of the OTN family. The white paper will be completed by Nov 2016 and submitted to a peer reviewed journal as an output of IDEAS OTN.

## 7. Dissemination of information and results

### *a) Refereed journal articles (32 total) – accepted/published*

- Bett, N.N., Hinch, S.G., Burnett, N.J., Donaldson, M.R., Naman, S.N. 2016. Causes and consequences of straying into small populations of Pacific salmon. Fisheries. In Press.
- Bett, N.N., Hinch, S.G., Yun, S.S., Dittman, A.H. 2016. Evidence of olfactory imprinting at an early life stage in pink salmon (*Oncorhynchus gorbuscha*). Scientific Reports. In Press.
- Bett, N.N., Hinch, S.G., Yun, S.S. 2016. Behavioural responses of Pacific salmon to chemical disturbance cues during the spawning migration. Behavioural Processes. 132: 76-84.
- Bett, N.N., Hinch, S.G. 2016. Olfactory navigation during spawning migrations: a review and introduction of the hierarchical navigation hypothesis. Biological Reviews. 91: 728-759.
- Burnett, N., Hinch, S., Bett, N., Braun, D., Casselman, M., Cooke, S., Gelchu, A., Lingard, S., Middleton, C., Minke-Martin, V., White, C. 2016. Reducing carryover effects on the migration and spawning success of sockeye salmon through a management experiment of dam flows. River Research and Applications. Wiley Online Library. DOI: 10.1002/rra.3051
- Clark, T., Furey, N., Rechisky, E., Gale, M., Jeffries, K., Porter, A., Casselman, M., Lotto, A., Patterson, D., Cooke, S., Farrell, A., Welch, D., Hinch S. 2016. Tracking the migration of wild sockeye salmon smolts to the ocean reveals distinct regions of nocturnal movement and high mortality. Ecological Applications. 26: 959-978. <http://onlinelibrary.wiley.com/doi/10.1890/15-0632/full>
- Cook, K., R. Lennox, S. Hinch, and S.J. Cooke. 2015. Fish out of water: How much air is too much?. Fisheries. 40 (9): 452-461
- Cooke, S.J, J.W Brownscombe, G.D Raby, F Broell, S.G Hinch, T.D Clark, J.M Semmens. 2016. Remote bioenergetics measurements in wild fish: opportunities and challenges. Comparative Biochemistry and Physiology A 00: 000-000. (invited contribution) In press
- Cooke, S.J., E.G. Martins, D.P. Struthers, L.F.G. Gutowsky, M. Power, S.E. Doka, J.M. Dettmers, D.A. Crook, M.C. Lucas, C.M. Holbrook and C.C. Krueger. 2016. A moving target – incorporating knowledge of the spatial ecology of fish into the assessment and management of freshwater fish populations. Environmental Monitoring and Assessment. 188:Article #239.
- Cooke, S.J. 2016. Unraveling the mystery of marine fish migration. Book review of Secor's "Ecology of Marine Fish Migration". Ecology. 97:1086–1087
- Lennox R.J., J.M. Chapman, C.M. Souliere, C. Tudorache, M. Wikelski, J.D. Metcalfe, and S.J. Cooke. 2016. Conservation physiology of animal migration. Conservation Physiology. 4: 10.1093/consphys/cov072.

- Cooke, S.J., A.D.M. Wilson, C.K. Elvidge, R.J. Lennox, N. Jepsen, A.H. Colotelo and R.S. Brown. 2016. Ten practical realities for Institutional Animal Care and Use Committees when evaluating protocols dealing with fish in the field. *Reviews in Fish Biology and Fisheries*. 26: 123-133.
- Donaldson, M.R., Burnett, N.J., Braun, D.C., Suski, C.D., Hinch, S.G., Cooke, S.J., Kerr, J.T. 2016. Taxonomic bias and international biodiversity conservation research. FACETS DOI: 10.1139/facets-2016-0011.
- Eliason, E.J., Farrell, A.P. 2016. Oxygen uptake in Pacific salmon: When ecology and physiology meet. *Journal of Fish Biology* 88: 359-388
- Furey, N., Hinch, S. Mesa, M., Beauchamp, D. 2016. Piscivorous fish exhibit temperature-influenced binge feeding during an annual prey pulse. *Journal of Animal Ecology*. 85:1307-1317. <http://onlinelibrary.wiley.com/doi/10.1111/1365-2656.12565/abstract>
- Furey, N., Hinch, S., Bass, A. Middleton, C. Minke-Martin, V. Lotto, A. 2016. Predator swamping reduces predation risk during nocturnal migration of juvenile salmon in a high-mortality landscape. *Journal of Animal Ecology*. 85:948-959. <http://onlinelibrary.wiley.com/doi/10.1111/1365-2656.12528/full>
- Furey, N., Vincent, S., Hinch, S., Welch D. 2015. Variability in migration routes influences early marine survival of juvenile salmon smolts. *PLoS ONE*. 10: e0139269. <http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0139269>
- Lennox R.J., G. Blouin-Demers, A.M. Rous, and S.J. Cooke. 2016. Tracking invasive animals with electronic tags to assess risks and develop management strategies. *Biological Invasions*. 18:1219–1233.
- McLean, M.F., Hanson, K.C., Cooke, S.J., Hinch, S.G., Patterson, D.A., Nettles, T.L., Litvak, M.K., Crossin, G.T. 2016. Physiological stress response, reflex impairment, and delayed mortality of white sturgeon *Acipenser transmontanus* exposed to simulated fisheries stressors. *Conservation Physiology*. 4: cow031. <http://conphys.oxfordjournals.org/content/early/2016/08/17/conphys.cow031.full.pdf>
- Nguyen, V.M., Young, M., Hinch, S.G., Cooke, S.J. 2016. Getting past the blame game: convergence and divergence in perceived threats to salmon resources among anglers and indigenous fishers in Canada's lower Fraser River. *AMBIO*. 10.1007/s13280-016-0769-6
- Nguyen, Vivian M., Abigail J. Lynch, Nathan Young, Ian G. Coux, Douglas Beard Jr., William W. Taylor, Steven J. Cooke. (2016) “To manage inland fisheries is to manage at the social-ecological watershed scale” *Journal of Environmental Management*. 181: 312-325.
- Nguyen, V.M., N. Young, and S.J. Cooke. 2016. A roadmap for knowledge exchange and mobilization research in conservation and natural resource management. *Conservation Biology*. 00:000-000. In Press
- Patterson, David A., Steven J. Cooke, Scott G. Hinch, Kendra A. Robinson, Nathan Young, Anthony P. Farrell, Kristina M. Miller. 2016. A perspective on physiological studies supporting the

provision of scientific advice for the management of Fraser River sockeye salmon. Conservation Physiology. 4(1): 1-15.

- Raby, G., Casselman, M., Cooke, S., Hinch, S., Farrell, A., Clark, T. 2016. Aerobic scope increases throughout an ecologically relevant temperature range in coho salmon. Journal of Experimental Biology. 219:1922-1931.
- Sopinka, N., Jeffrey, J., Burnett, N., Patterson, D., Gilmour, K., Hinch, S. 2016. Maternal programming of offspring hypothalamic–pituitary–interrenal axis in wild sockeye salmon (*Oncorhynchus nerka*). General and Comparative Endocrinology. In Press. [Link](#)
- Sopinka, N., Middleton, C., Patterson, D., Hinch, S. 2016. Does maternal captivity of wild, migratory sockeye salmon influence offspring performance? Hydrobiologia. 779: 1-10. \*Photo of juvenile sockeye salmon taken by Sopinka featured on the journal cover [Link](#)
- Sopinka, N., Hinch, S., Healy, S., Raby, G., Patterson, D. 2016. Effects of experimentally elevated egg cortisol on offspring traits in two species of wild Pacific salmon. Environmental Biology of Fishes 99:717-728. [Link](#)
- Sopinka, NM, SG Hinch, SJ Healy, GD Raby, DA Patterson. 2016. Effects of experimentally-elevated egg cortisol on offspring traits in two species of Pacific salmon. Environmental Biology of Fishes 00: 000-000. In press
- Taylor, J., Sopinka, N., Wilson, S., Hinch, S., Patterson, D., Cooke, S., Willmore, W. 2016. Examining the relationships between egg cortisol and oxidative stress in developing wild sockeye salmon (*Oncorhynchus nerka*). Comparative Biochemistry and Physiology Part A: Molecular & Integrative Physiology. 200:87-93. [Link](#)
- Whitney, J.E., Al-Chokhachy, R., Bunnell, D.B., Caldwell, C.A., Cooke, S.J., Eliason, E.J., Rogers, M., Lynch, A.J., Paukert C.P. 2016. Physiological basis of climate change impacts on North American Inland Fishes. Fisheries 41: 332-345
- Young, N., Corriveau, M., Nguyen, V.M., Cooke, S.J., Hinch, S.G. 2016. How do potential knowledge users evaluate new claims about a contested resource? Problems of power and politics in knowledge exchange and mobilization. Journal of Environmental Management. 00:000-000. In press.
- Young, N., Nguyen, V.M., Corriveau, M., Cooke, S.J., Hinch, S.G. 2016. Knowledge users' perspectives and advice on how to improve knowledge exchange and mobilization in the case of a co-managed fishery, Environmental Science & Policy. 66: 170-178.

*b) Refereed journal articles (6 total) – submitted*

- Crossin, G.T., Heupel, M., Holbrook, C.M., Hussey, N., Lowerre-Barbieri, S., Nguyen, V.M., Raby, G.D., Cooke, S.J. In Review. Acoustic Telemetry and Fisheries Management. Ecological Applications

- Eliason, E.J., Gale, M.K., Whitney, C.K., Lotto, A., Hinch, S.G. Intraspecific differences in endurance swim performance and cardiac size in sockeye salmon (*Oncorhynchus nerka*) fry. Submitted to Canadian Journal of Zoology on Sept 30, 2016
- Furey, N., and S. Hinch. Bull trout movements match the life history of sockeye salmon: consumers can exploit seasonally distinct pulses. Transactions of the American Fisheries Society. In review
- Minke-Martin, V., Hinch, S., Braun, D., Burnett, N., Casselman, M., Eliason, E., Middleton, C. Physiological condition and migratory experience affect fitness-related outcomes in adult female sockeye salmon. Ecology of Freshwater Fish. In review
- Nguyen V.M., Brooks, J., Young, N., Lennox, R., Haddaway, N., Whoriskey, F., Harcourt, R., Cooke, S.J. (Submitted). To share or not to share in the emerging era of big data: Perspectives from fish telemetry researchers on data sharing. Submitted to the Canadian Journal of Fisheries and Aquatic Sciences.
- Teffer A., Hinch S., Miller K., Patterson D., Farrell A., Cooke S., Bass A., Szekeres P., Juanes F. (submitted) Capture severity, infectious disease processes, and sex influence post-release mortality of sockeye salmon bycatch. Conservation Physiology

*c) Conference/workshop/seminar presentations (31 total) – invited or contributed*

- Bass, A.L., V. Minke-Martin, M. Casselman, K.M. Miller, S.G. Hinch. 2016. Sockeye salmon escaping gillnet capture display altered gene expression, migratory behavior, and survival. Poster Presentation: OTN annual symposium June 1, 2016.
- Bass, A.L. Laboratory and Telemetry studies of Adult Pacific Salmon Migrations: Temperature, Fisheries, and Pathogens. 2016. 9th annual Workshop on Salmon Migrations, Climate Change, and Capture/Release Fisheries. University of British Columbia, Vancouver, BC, Canada. Feb. 4, 2016
- Bett, N.N. Sockeye salmon navigation in a regulated river system. 2016 Oregon Chapter of the American Fisheries Society, 52nd Annual Meeting. Seaside, Oregon. March 4, 2016.
- Cook, K.V. 2015 Mortality in Pacific salmon released from selective commercial fisheries. Lower Fraser Fishery Alliance Technical Meeting. Katzie Nation, British Columbia. October 29, 2015 (invited)
- Cook, K.V. 2015. Area 6 chum bycatch research initiative: Lessons learned and next steps. Canadian Fishing Company corporate office advisory meeting. Vancouver, British Columbia. November 5, 2015
- Cook, K.V. 2016. Mortality of Pacific Salmon Bycatch in Marine Commercial Fisheries: Telemetry, Holding Studies, and Perspectives from Fishers. 9th annual Workshop on Salmon Migrations, Climate Change, and Capture/Release Fisheries. University of British Columbia, Vancouver, BC, Canada. Feb. 4, 2016

- Cook, K.V. 2016. Fate and condition of sockeye and chum released from purse seine fisheries in Area 3. Nisga'a Lisims Government and DFO Joint Technical Committee meeting. Prince Rupert, British Columbia. May 16, 2016
- Cook, K.V., Bass, A.L., Teffer, A.K., Miller, K.M., Cooke, S.J. Hinch, S.G. 2016. Delayed Mortality, Behaviour, and Physiology of Pacific Salmon Bycatch. Ocean Tracking Network Annual meeting. Halifax, Nova Scotia. June 1, 2016
- Drenner, S.M. 2016. The influences of environmental conditions, physiological state, and river impoundment on homing sockeye salmon. Research Seminar. The Department of Watershed Sciences, Utah State University. Sept. 19, 2016.
- Drenner, S.M., S.G. Hinch, M.T. Casselman, N.N. Bett, N.J. Burnett, C.T. Middleton, V. Minke-Martin. Effects of hydropower operations and temperature on salmon behaviour and migration success in a regulated watershed. 9th Annual Workshop on Salmon Migrations, Climate Change, and Capture/Release Fisheries. University of British Columbia, Vancouver, BC, Canada. Feb. 4, 2016
- Eliason, E.J., Farrell, A.P., Cooke, S.J., Patterson, D.A., Hinch, S.G. Phenotypic plasticity across life stages in sockeye salmon populations. International Congress on the Biology of Fishes. San Marcos, Texas. June 14, 2016
- Eliason, E.J., Farrell, A.P., Cooke, S.J., Patterson, D.A., Hinch, S.G. Lessons learned from Fraser River salmon: local adaptation and thermal tolerance Folsom, California April 20, 2016
- Furey N.B. 2016. Migration ecology of juvenile salmon smolts across landscapes. "Fish and Chips" Departmental seminar, Fisheries Centre, University of British Columbia, Vancouver, British Columbia. March 1, 2016. (invited)
- Furey N.B. 2016. Effects of predation, pathogens, and landscape on survival and behaviour of migrating sockeye smolts. 9th annual workshop on Salmon Migrations, Climate Change, and Capture/Release Fisheries. University of British Columbia. Vancouver, British Columbia. February 4, 2016.
- Furey, N.B., Healy, S.J., Hinch, S.G. 2015. Movements of steelhead (and sockeye) smolts in the Strait of Georgia – via acoustic telemetry. Salish Sea Marine Survival Project (SSMSP) US-Canada Science Retreat. Richmond, British Columbia. December 8, 2015.
- Furey, N.B., Healy, S.J., Hinch, S.G. 2015. Movements of steelhead (and sockeye) smolts in the Strait of Georgia – via acoustic telemetry. Salish Sea Marine Survival Project (SSMSP) Canadian Retreat. Nanaimo, British Columbia. October 10, 2015.
- Healy, SJ, Furey, NB, Hinch, SG, Eliason, EJ, Porter, AD, Rechisky, EL, Welch, DW, Vincent, SP, 2016. Juvenile salmon smolt migrations through the Salish Sea: routes and survival of sockeye and steelhead. Ocean Tracking Network Symposium, Halifax, NS. June 1st, 2016
- Healy, SJ, Hinch, SG, Jeffries, KM, Furey, NB, Clark, TD, Rechisky, EL, Porter, AD, Welch DW, Miller, KM, Cooke, SJ, Farrell, AP. 2015 Disease and survival in migrating juvenile salmon. Salish Sea Marine Survival Project donors meeting. Dec 7, 2015 Richmond, BC.

- Hinch, S.G., Furey, N.B., Healy, S.J., Rechisky, E.L., Welch, D.W., Vincent, S.P. 2016. Juvenile salmon smolt migrations through the Salish sea: routes and survival of sockeye and steelhead. Salish Sea Ecosystem Conference, Vancouver, British Columbia. April 14, 2016.
- Lawrence, M.J., Prystay, T.S., Dick, M., Eliason, E.J., Elvidge, C.K., Hinch, S.G., Patterson, D.A., Lotto, A.P. and Cooke, S.J. 2016. Energetic constraints and individual variation shape the trade-off between physiological recovery and fright responses in adult sockeye salmon. The 12th International Congress on the Biology of Fish, Texas State University, San Marcos, TX. June 13, 2016. (contributed)
- McLean, M.F. 2016. Tracking fishes coast to coast: with focus on the ancient Acipenserids. Biologging lecture, Dalhousie University, Halifax, Nova Scotia, Canada (invited)
- McLean, M.F. 2016. Tracking fishes coast to coast: with focus on the ancient Acipenserids. SHAD group, Dalhousie University, Halifax, Nova Scotia, Canada (invited)
- McLean, M.F., Stoddard, E., Litvak, M., Cooke, S., Hinch, S., Patterson, D., Nettles, T., Hanson, K., Welch, D., Crossin, G. 2016. White sturgeon in the Fraser River, B.C. The 6th Annual Ocean Tracking Network Canada Symposium, Halifax, Nova Scotia (contributed)
- McLean, M.F., Hanson, K., Cooke, S., Hinch, S., Patterson, D., Nettles, T., Litvak, M., Stoddard, E., Crossin, G (February 2016) Physiological and behavioural impacts of C&R angling on white sturgeon in the Fraser River, B.C. The Sturgeon Project Work Team (interagency group consisting of USFWS, NMFS, CDFW, CDWR, USBR, and USACE) in California, U.S.A. (invited – presented by Hanson, K.)
- Prystay, TP, Eliason, EJ, Lawrence, MJ, Dick, M, Patterson, DA, Crossin GT, Hinch SG, Cooke SJ. Unpublished. The influence of water temperature on sockeye salmon cardiac recovery following simulated fisheries interactions assessed with heart rate loggers. 26th Science Atlantic Aquaculture and Fisheries Conference. Halifax, Nova Scotia. March 12, 2015.
- Raby, GD. 2015. Climate change and the physiology of ectotherms: can aerobic metabolic scope be used to define thermal niche? Great Lakes Institute for Environmental Research Seminar Series, Windsor, ON, Canada. (invited)
- Sopinka, N. 2016. An ode to the intergenerational effects of stress in Pacific salmon Great Lakes Institute of Environmental Research Seminar Series. Windsor, Ontario. September 23, 2016. (Invited, Seminar)
- Sopinka, N. 2016. The history of science and poetry. International Marine Conservation Congress, St. John's, Newfoundland. July 31, 2016. (Invited, Workshop)
- Sopinka, N. 2016. How does creativity fit into science communication? Canadian Conference for Fisheries Research, St. John's, Newfoundland. January 9, 2016. (Invited, Conference) \*Served as member of panel discussion on science communication
- Stevenson, CF, SG Hinch, NB Furey, SJ Healy, DW Welch, EL Rechisky. 2016. Survival and migration rates of 1-year-old sockeye salmon smolts in the freshwater and marine environment. Ocean

Tracking Network Annual Symposium, Halifax, Nova Scotia. June 2, 2016. (contributed - Poster Presentation)

Teffer A, Bass A, Miller K, Jeffries K, Patterson D, Farrell A, Cooke S, Juanes F and S Hinch. 2015. How capture and temperature impact the health and survival of released salmon bycatch. Biology Graduate Research Symposium, University of Victoria, Victoria, BC. November 10, 2015.

*d) Books, data/technical reports, or any other relevant output/contributions not included above*

Bett, N.N. 2016. Fish pheromones and related cues (Eds. Sorensen and Wisenden) – Book Review. Environmental Biology of Fishes. 99: 169-170.

Casselman, M.T., N.J. Burnett, N.N. Bett, C.T. Middleton, V. Minke-Martin, D.C. Braun, D. McCubbing, and S.G. Hinch. 2016. BRGMON-14 Effectiveness of Cayoosh flow dilution, dam operation, and fishway passage on delay and survival of upstream migration of salmon in the Seton-Anderson watershed. Annual Report – 2015. Report prepared for St’át’imc Government Services and BC Hydro. The University of British Columbia, Vancouver, BC. 93 p. + 2 Apps.

Patterson, DA, KA Robinson, RJ Lennox, TL Nettles, LA Donaldson, EJ Eliason, GD Raby, JM Chapman, KV Cook, MR Donaldson, AL Bass, SM Drenner, AJ Reid, SJ Cooke, SG Hinch. 2016. Review and evaluation of fishing-related incidental mortality for Pacific salmon. DFO Canadian Science Advisory Secretariat Research Document 2016/--- (accepted pending revisions).

Patterson, DA, KA Robinson, GD Raby, AL Bass, R Houtman, SG Hinch, SJ Cooke. 2016. Guidance to derive and update fishing-related incidental mortality rates for Pacific salmon. DFO Canadian Science Advisory Secretariat Research Document 2016/--- (accepted pending revisions).

Sopinka, N., Donaldson, M., O’Connor, C., Suski, C., Cooke, S.. In press. Stress indicators in fish. Pages 000-000 in Fish Physiology, Vol. 35, Biology of Stress in Fish (eds. C Schreck, L Tort, A Farrell, C Brauner), Academic Press, Amsterdam.

Sopinka writes articles and curates a Q&A photo series for the American Fisheries Society’s magazine, Fisheries. The articles are written in language accessible to all members of the Society. 21 articles/interviews to date.

Sopinka collaborated with science communication blog Squidtoons ([www.squidtoons.com](http://www.squidtoons.com)), co-writing and editing comic on the salmon life cycle (<http://www.squidtoons.com/sockeye-salmon-life-cycle-from-red-eggs-to-redd-eggs.html>)

Watson, M., Jain-Schlaepfer S., Fleming, J. Cook, K. 2016. Chumthing Fishy: The trials and tribulations of a commercial fishery study. The Confluence, Winter 2016, January 11, 2016



## 8. Contributions from industrial and government partners

|   |                         |
|---|-------------------------|
| Name of supporting organization:<br><b>DFO Pacific Region</b>       | <b>Year 7</b><br>(2016) |
| <b>Cash contributions to direct costs of research</b>               | \$0                     |
| <b>In-kind contributions to direct costs of research</b>            |                         |
| 1) Salaries for scientific and technical staff                      | \$64,900                |
| 2) Donation of equipment, software                                  | \$34,800                |
| 3) Donation of material   | \$8,000                 |
| 4) Field work logistics   |                         |
| 5) Provision of services  |                         |
| 6) Other (specify):   |                         |
| <b>In-kind contributions to indirect costs of research</b>          |                         |
| 1) Use of organization's facilities                                 |                         |
| 2) Salaries of managerial and administrative staff                  |                         |
| 3) Other (specify):   |                         |
| <b>Total of all in-kind contributions</b>                           | \$107,700               |
| <b>Is this new funding (acquired during this reporting period)?</b> | no                      |

|  |                         |
|--|-------------------------|
| Name of supporting organization:<br><b>Pacific Salmon Commission</b> | <b>Year 7</b><br>(2016) |
| <b>Cash contributions to direct costs of research</b>                | \$0                     |
| <b>In-kind contributions to direct costs of research</b>             |                         |
| 1) Salaries for scientific and technical staff                       | \$28,750                |
| 2) Donation of equipment, software                                   |                         |
| 3) Donation of material  |                         |
| 4) Field work logistics  |                         |
| 5) Provision of services   |                         |
| 6) Other (specify):  |                         |
| <b>In-kind contributions to indirect costs of research</b>           |                         |
| 1) Use of organization's facilities                                  |                         |
| 2) Salaries of managerial and administrative staff                   |                         |
| 3) Other (specify):  |                         |
| <b>Total of all in-kind contributions</b>                            | \$28,750                |
| <b>Is this new funding (acquired during this reporting period)?</b>  | no                      |

|   |                  |
|---|------------------|
| Name of supporting organization:                                    | <b>Year 7</b>    |
| <b>Pacific Salmon Foundation (Salish Sea Program)</b>               | <b>(2016)</b>    |
| <b>Cash contributions to direct costs of research</b>               | <b>\$150,000</b> |
| <b>In-kind contributions to direct costs of research</b>            |                  |
| 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): tags  | <b>\$100,000</b> |
| <b>In-kind contributions to indirect costs of research</b>          |                  |
| 1) Use of organization's facilities                                 |                  |
| 2) Salaries of managerial and administrative staff                  |                  |
| 3) Other (specify):   |                  |
| <b>Total of all in-kind contributions</b>                           | <b>\$100,000</b> |
| <b>Is this new funding (acquired during this reporting period)?</b> | no               |

|   |                  |
|---|------------------|
| Name of supporting organization:                                    | <b>Year 7</b>    |
| <b>Mitacs (Partnering with Pacific Salmon Foundation)</b>           | <b>(2016)</b>    |
| <b>Cash contributions to direct costs of research</b>               | <b>\$100,000</b> |
| <b>In-kind contributions to direct costs of research</b>            |                  |
| 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):  |                  |
| <b>In-kind contributions to indirect costs of research</b>          |                  |
| 4) Use of organization's facilities                                 |                  |
| 5) Salaries of managerial and administrative staff                  |                  |
| 6) Other (specify):   |                  |
| <b>Total of all in-kind contributions</b>                           |                  |
| <b>Is this new funding (acquired during this reporting period)?</b> | yes              |

|  |                 |
|--|-----------------|
| Name of supporting organization:                           | <b>Year 7</b>   |
| <b>NSERC Engage (Cooke)</b>                                | <b>(2016)</b>   |
| <b>Cash contributions to direct costs of research</b>      | <b>\$25,000</b> |
| <b>In-kind contributions to direct costs of research</b>   |                 |
| 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):  |                 |
| <b>In-kind contributions to indirect costs of research</b> |                 |
| 1) Use of organization's facilities                        |                 |
| 2) Salaries of managerial and administrative staff         |                 |

|   |     |
|---|-----|
| 3) Other (specify):   |     |
| <b>Total of all in-kind contributions</b>                           |     |
| <b>Is this new funding (acquired during this reporting period)?</b> | yes |

|   |                 |
|---|-----------------|
| Name of supporting organization:                                    | <b>Year 7</b>   |
| <b>Canfisco (Canadian Fishing Company)</b>                          | <b>(2016)</b>   |
| <b>Cash contributions to direct costs of research</b>               |                 |
| <b>In-kind contributions to direct costs of research</b>            |                 |
| 1) Salaries for scientific and technical staff                      | \$10,000        |
| 2) Donation of equipment, software                                  | \$12,000        |
| 3) Donation of material   |                 |
| 4) Field work logistics   |                 |
| 5) Provision of services  |                 |
| 6) Other (specify): vessel charter                                  | \$35,000        |
| <b>In-kind contributions to indirect costs of research</b>          |                 |
| 1) Use of organization's facilities                                 |                 |
| 2) Salaries of managerial and administrative staff                  |                 |
| 3) Other (specify):   |                 |
| <b>Total of all in-kind contributions</b>                           | <b>\$57,000</b> |
| <b>Is this new funding (acquired during this reporting period)?</b> | yes             |

|   |                 |
|---|-----------------|
| Name of supporting organization:                                    | <b>Year 7</b>   |
| <b>Pacific Salmon Foundation (Northern Endowment Fund)</b>          | <b>(2016)</b>   |
| <b>Cash contributions to direct costs of research</b>               | <b>\$42,000</b> |
| <b>In-kind contributions to direct costs of research</b>            |                 |
| 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):   |                 |
| <b>In-kind contributions to indirect costs of research</b>          |                 |
| 1) Use of organization's facilities                                 |                 |
| 2) Salaries of managerial and administrative staff                  |                 |
| 3) Other (specify):   |                 |
| <b>Total of all in-kind contributions</b>                           |                 |
| <b>Is this new funding (acquired during this reporting period)?</b> | yes             |

**Ocean Tracking Network Canada****NSERC****Progress Report Year 7 Review: 1 October 2015 – 30 September 2016****1. Project Number:** 4.16**2. Project Title:** Networking, HQP Exchange and Social Science Components**3. Project Leaders:** S. Iverson (Dalhousie U), Nathan Young (Ottawa U)**Other OTN Canada participants:** all other OTN Canada PIs**Collaborators:** F. Whoriskey (OTN), social science collaborators**4. Training of Highly Qualified Personnel (and level of support)**

| Name   | Title* | % Time in project | % Support from OTNC | Start Date (actual date HQP started with OTN) | End Date (actual or anticipated) |
|--|--------|-------------------|---------------------|---|----------------------------------|
| Marianne Corriveau   | RA     | 50                | 50                  | 1 November 2015                               | 30 April 2016                    |
| Research Topic: Involved in project design, data collection and analysis, social science project |        |                   |                     |   |                                  |
| Marie Auger-Methe  | RA     | 50                | 0*                  | 1 Aug 2014                                    | 31 Dec 2016                      |
| Research Topic: member ideasOTN  |        |                   |                     |   |                                  |
| Eduardo Martins  | RA     | 50                | 0*                  | 1 Jun 2011                                    | 31 Dec 2016                      |
| Research Topic: member ideasOTN  |        |                   |                     |   |                                  |
| Melanie Beguer   | RA     | 50                | 0*                  | 17 Sept 2010                                  | 30 Dec 2017                      |
| Research Topic: member ideasOTN  |        |                   |                     |   |                                  |
| Damian Lidgard   | RA     | 50                | 0*                  | 1 Jan 2010                                    | 31 Dec 2017                      |
| Research Topic: member ideasOTN  |        |                   |                     |   |                                  |
| Vivian Nguyen  | PhD    | 50                | 0*                  | 1 Jan 2014                                    | 31 Dec 2017                      |
| Research Topic: member ideasOTN  |        |                   |                     |   |                                  |
| Nigel Hussey   | RA     | 50                | 0*                  | 1 Jan 2010                                    | 31 Dec 2017                      |
| Research Topic: member ideasOTN  |        |                   |                     |   |                                  |
| Steve Kessel   | RA     | 50                | 0*                  | 1 Jan 2012                                    | 31 Dec 2017                      |
| Research Topic: member ideasOTN  |        |                   |                     |   |                                  |
| Erika Eliason  | PDF    | 50                | 0*                  | 1 Jan 2011                                    | 31 Aug 2016                      |
| Research Topic: member ideasOTN  |        |                   |                     |   |                                  |

*\*members of ideasOTN receive support in the form of meeting space, teleconference lines, and admin support though OTN HQ. Refer to the individual project reports for details on actual % Support from OTNC.*

**5. Public summary of report**

A continued focus of the Networking, HQP Exchange and Social Science Components project has been on increasing integration across the NSERC Network and on the sharing of research tools and program findings within and across arenas and themes. OTN Canada annual symposia bring together all Network students, PDFs, collaborators, and PIs to present projects and results, hold specialized workshops, and discuss research strategies. The 6<sup>th</sup> annual OTN Canada Symposium at Dalhousie University (1-2 June 2016) was a big success. Invited guest speakers included DFO ADM Trevor Swerdfager (and OTN Council Member), and Megan Leslie, a former Member of Parliament and now consultant to the WWF. Anna Metaxas, one of the leaders of CHONe (Canadian Healthy Oceans Network) was also invited to speak to connecting our networks. All HQP in attendance were asked to prepare either an oral or poster presentation (for abstracts see <http://oceantrackingnetwork.org/poster-and-presentation-abstracts/>).

Associated with the OTN symposium was a joint meeting of the Canadian and International Scientific Advisory Committees (SAC and ISAC, respectively). In addition to considering current research status and forecasts from the major ocean regions, these groups provided input into future developments and possible directions for the planned NCE proposal.

The eight members - Marie Auger-Methe, Melanie Beguer, Erika Eliason, Nigel Hussey, Steve Kessel, Eduardo Martins, and Vivian Nguyen, with Steve Cooke, Sara Iverson, Fred Whoriskey, and Amy Ryan as facilitators - of the **Integrate Describe Expand And Synthesize OTN (ideasOTN)** Committee, a subcommittee of existing key (senior) HQP of varying expertise selected to support the development of new ideas for synthesis and output and ensure the execution of these projects by involving individuals from across the Network, have been hard at work. Currently there are 22 projects either in progress or in preparation and seven that have been either published or submitted. Along with the eight members of ideasOTN, there are over 40 collaborators that include members of OTN (HQP and PIs) and others from academia and government. Membership of the committee is transitioning as some members (e.g., N. Hussey at U Windsor, M. Methé at UBC, E. Eliason at U California) have recently obtained faculty positions at various universities, and six new members (Amanda Barkley – U Windsor, Montana McLean – Dalhousie U, Kim Whoriskey – Dalhousie U, Franziska Broell – Dalhousie U, Robert Lennox – Carleton U, Nathan Furey - UBC, Sarah Larocque - U Windsor, and Cecila Engler - Dalhousie U) have joined the committee. The output from the ideasOTN Committee will help to inform policy and management, and depending on the materials generated, will help to educate and engage the public on ocean sciences and telemetry studies both nationally and internationally.

***Mobilizing new science for fisheries policy and management: the case of biotelemetry and Pacific salmon species in Canada (N. Young)***

All projected milestones for 2016 were met. This year, we completed 31 interviews with government employees and stakeholders of Fraser River Pacific salmon fisheries on the subject of their views of telemetry and its potential applications to fisheries policy and management. The completion of these interviews brings our total number of interviews to 98 (67 were completed in the first year of the project). Analysis of the 98 interviews was also conducted this year. This included analysis of closed-ended quantitative data from Likert-style questions using Stata 12 software, and analysis of open-ended qualitative data using Nvivo 10 software. These analyses have led or contributed to a number of articles written this year (5 published, 1 under review), and one presentation to the annual stakeholder workshop at UBC, hosted by Scott Hinch.

The research deals with processes of knowledge mobilization, knowledge exchange, and evidence-based resource management. It is therefore valuable to biotelemetry researchers, fisheries managers, and stakeholders. Results and published papers have been disseminated directly to stakeholders and representatives of the Pacific Salmon Commission and the Department of Fisheries and Oceans (Pacific Region).

**Selected HQP Conference and Research Travel**

Since October 2015 the HQP Travel Approval Committee (TAC) has processed 4 HQP travel requests to various national and international conferences, workshops and collaborative fieldwork, in addition to funding 27 (of 49) HQP to attend the annual Symposium in June 2016. Following conference attendance, HQP are required to draft a short follow-up describing their experience and its benefit to the network. The 4 completed travel reports are summarized below.

**Erika Eliason** travelled to San Marcos, Texas to present her work at the International Congress on the Biology of Fish. This meeting attracts the best fish physiologists in the world who ask questions about how fish are able to interact with their environments. The benefits of attending included the outstanding networking opportunities, potential to form new collaborations and expand her research into new areas, learn about new approaches and techniques that she will be able to integrate into future work, and help to broaden the awareness of her research program and OTN.

**Caitlin O'Neill** attended the 170th Meeting of the Acoustical Society of America held in Jacksonville, Florida from November 2 to 6, 2015. It was a conference for all branches of acoustics, with a special session on Acoustics of High Latitude Oceans. Caitlin presented her OTN research on passive acoustic monitoring and ambient noise in the High Arctic: Resolute Bay, Nunavut. This was an opportunity to get feedback on ways to further analyze her data and how best to perform quality checks to increase the reliability of results, making it more likely to get published in a peer reviewed journal. Additionally, the conference presented an opportunity to learn more about underwater acoustics in the Arctic and ways to possibly model sound propagation in Resolute Bay, which can inform studies on impact of noise on fish movement.

In February, **Mathieu Dever** attended the Ocean Sciences meeting where he made two presentations: 1) an oral presentation about the monitoring of the density front associated with the Nova Scotia Current, and 2) a poster presentation on the relationship between ocean conditions and Salmon postsmolts migration patterns. Both presentations sparked interesting discussions on the scientific reasoning, the limitations and the strengths of the analysis. Overall, the meeting was beneficial as it was an opportunity to become aware of interesting scientific products that could be useful to his work, sparked collaborations, provided valuable feedback on his research from the relevant scientific communities and advertised the work OTN have accomplished since its debut.

This summer **Marie Auger-Methe** presented at the International Statistical Ecology Conference (ISEC), an event that brings together experts (statisticians and ecologists) from around the world to discuss new statistical developments in ecology. The conference had a strong focus on topics relevant to OTN. For example, of the 33 sessions, three were devoted to movement ecology, two to marine ecosystems, and two to fisheries. Marie's presentation sparked a few new projects and collaborations (e.g. new application of my movement model to eagle data), and while there she was brought up to speed on new developments in statistical ecology, which will be highly useful to the development of new models for OTN data.

## 6. Networking, outreach, and synthesis

### *a) Interaction/Outreach to Broader Community/Public (including radio or television interviews or contribution to a programme/documentary, stakeholder workshops, etc.)*

N. Young made a presentation of findings to the annual UBC stakeholder workshop hosted by Scott Hinch. The aforementioned articles were shared directly with stakeholders via email, as well as representatives of the Pacific Salmon Commission and the Department of Fisheries and Oceans (Pacific Region). Several email updates about the research were sent to Jennifer Nener (DFO, Director of Salmon, Pacific Region).

### *b) Synthesis activities*

N. Young is a contributing author on several articles in preparation by S. Cooke and HQP V. Nguyen and R. Lennox. These articles synthesize findings across this project and those headed by S. Cooke.

Since its formation in May 2015 and an initial meeting in June 2015, the ideasOTN Committee has met monthly (and will continue to do so) via teleconference (local members meet at OTN HQ) to discuss and develop new ideas for syntheses and ensure that these get carried through by involving members from across the network. The existing projects involve a variety of OTN members including MSc and PhD students, post-docs/research associates, and PIs across five universities (e.g., Dalhousie, Carleton, Windsor, Waterloo, British Columbia). The committee also prepared a presentation of their work, which Nigel Hussey gave during a plenary session at the 6th annual OTN Canada Symposium.

## 7. Dissemination of information and results

### *a) Refereed journal articles (0 total) – accepted/published*

Refer to the Pacific arena reports for the five co-authored publications.

### *b) Refereed journal articles (1 total) – submitted*

Nathan Young, Marianne Corriveau, Vivian Nguyen, Steven J. Cooke, and Scott G. Hinch. (Submitted)  
Embracing disruptive technoscience? Biotelemetry meets fisheries management. Fisheries.

### *c) Conference/workshop/seminar presentations (1 total) – invited or contributed*

Nathan Young, Marianne Corriveau, Vivian Nguyen. (February 2016) Mobilizing Academic Science for Fisheries Management: Lessons Learned. Annual Salmon Research Workshop, UBC.

|  |              |
|--|--------------|
| <b>Ocean Tracking Network Canada</b><br><b>Progress Report Year 7 Review: 1 October 2015 – 30 September 2016</b> | <b>NSERC</b> |
|--|--------------|

**1. Project Number:** 4.17**2. Project Title:** Ocean Tracking Network Canada Secretariat

**3. Project Leaders:** S. Iverson (Scientific Director), Nikki Beauchamp (Sr. Communications Manager), Amy Ryan (Network Program Officer), Anja Samardzic (Sr. Communications Manager)

**4. Staff**

| Name            | Title                         | % Time in project | % Support from OTNC | Start Date (actual date started with OTN) | End Date (actual or anticipated) |
|-----------------|-------------------------------|-------------------|---------------------|---|----------------------------------|
| Sara Iverson    | Scientific Director           | 80                | 0                   | 01 Jan 2010                               | 31 Mar 2017                      |
| Amy Ryan        | Network Program Officer       | 100               | 100                 | 01 Oct 2014                               | 31 Mar 2017                      |
| Nikki Beauchamp | Senior Communications Manager | 100               | 100                 | 01 Jun 2012                               | 30 June 2016                     |
| Anja Samardzic  | Senior Communications Manager | 100               | 100                 | 01 Jun 2016                               | 31 Mar 2017                      |
| Tracy Rounds    | OTN Administrative Assistant  | 50                | 0                   | 01 Jan 2010                               | 31 Mar 2017                      |
| Kes Morton      | OTN Senior Project Manager    | 25                | 0                   | 01 Jun 2012                               | 31 Mar 2017                      |
| Fred Whoriskey  | OTN Executive Director        | 25                | 0                   | 01 Jan 2010                               | 31 Mar 2017                      |

**5. Public summary of report**

The Secretariat is responsible for all office operations and human resources; finances and budget re-allocation; committees; meetings, symposia, workshops, and outreach; reports and proposals; internal and external communications.

Human resources

K. Morton announced her intention to pursue long-standing entrepreneurial interests and will progressively scale back her work with the OTN during the fall, leaving by Christmas. Applications for the Sr Project Manager position closed 23 October.

At the end of June, N. Beauchamp vacated the position of OTN Sr. communications manager to pursue a work/travel opportunity. A. Samardzic was hired on full-time to fill this role. N. Beauchamp and A. Samardzic overlapped for 1.5 months and ensured a smooth transition. N. Beauchamp returned in mid-October on a two-month contract funded under CFI O&M to help the Secretariat prepare for the upcoming NCE competition and as K. Morton steps back.

Finances and budgeting

All remaining OTN NSERC funding has been released to Dalhousie and collaborating institutions with permission to spend any remaining carryover funds through December 2017.



Reprofiling. This sub-committee comprises a core of four members (currently A. Fisk (chair), S. Cooke, Tetjana Ross, and S. Hinch) to be supplemented with additional specific expertise as needed. If one of the four 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 reviews requests, make recommendations, and reports to S. Iverson, who then reports to the SAC and NSERC. Thirteen requests were made to the Reprofiling Committee (RC) in 2016:

The RC approved 10 requests to assist with publication costs totalling close to \$10K. Due to the recent and high demand on this line item, and the fact that the NSERC funding is coming to an end, we are now only permitting one ask per person and will agree to cover up to half of the cost. All requests for publication expenditures are approved on a case-by-case basis and prioritized with respect to the benefit to OTN and level of displayed synthesis with multiple projects. It is expected that individuals and their co-authors attempt to obtain additional sources of funding that can be leveraged from partial OTN support.

PI Julian Dodson made two separate requests. First, he requested to reprofile \$2K (with \$1K in DFO support) from his OTN account to send OTN HQP Melanie Beguer-Pon to France with Martin Castonguay (DFO) to meet with Dr. Sylvain Bonhommeau, Researcher at the French Institute for the Exploitation of the Sea (IFREMER), Biological and Environmental Resources Department, Sète, France, and his team to discuss a new generation of electronic satellite tags that Dr. Bonhommeau's team is developing. The RC was very supportive of Martin (non-OTN funded) and Melanie attending the meeting, who could then provide feedback to all of OTN. The second request was to invest \$2750 in carryover to help finalize the production of a film about the OTN eel track project. During the 2015 fieldwork in Cape Breton, they were accompanied by Julie Perron, a professional cineaste from Montreal who wanted to make a short film about the migration of eels. She worked with the team for 5 days, filming and interviewing all who were involved in the project, from the capture of eels in the St. Lawrence estuary to their tagging and release in Cape Breton. Approval by the RC was unanimous, particularly as it contributes to outreach and in promoting OTN during the upcoming round of grant applications.

PI Scott Hinch requested to transfer \$36K remaining in his 2016 OTN budget from the PDF/RA line item (originally to fund Dr. Erika Eliason who left UBC to take a faculty position at the University of California) to the technician salary line item (to cover additional salary costs for senior technician Andrew Lotto). Approval by the RC was unanimous, particularly since with the former PDF finishing up her synthesis work in her new faculty position, OTN will benefit from another year of data without loss of the originally budgeted synthesis activity.

### Committees

OTN Futures Committee Discussions have begun about the future of OTN post-2016. These talks are held under the auspices of a special "Futures Committee" made up of members of the NSERC Scientific Advisory Committee with the addition of two Dalhousie University social scientists in 2016. Several Futures Committee meetings have been held toward a general consensus on future OTN strategic direction. A writing workshop was held in early November to construct a mission/vision for the OTN-NCE.

Both F. Whoriskey and S. Iverson have been appointed to sit on the task force for developing the Canadian Integrated Ocean Observing System (CIOOS) convened by T. Swerdfager (DFO ADM, OTN Council), with the first meeting held November 2016.

S. Iverson has been asked to help plan the “Building a Canadian Ocean Alliance” workshop that will be held in the new year, again convened by T. Swerdfager.

### Reports and proposals

The NSERC Research Network will have minimal reporting responsibilities this year (since no new funding requires approval) and instead we will be focusing in 2017 on pulling together the comprehensive Final Report for the program (covering all years since 2010), due 30 April 2018.

CFI Cyberinfrastructure: OTN’s Secretariat helped prepare a CFI Cyberinfrastructure proposal “MERIDIAN: Marine Environmental Research Infrastructure for Data Integration and Application Network”, which was successfully awarded, March 2016 (\$5M, PI Stan Matwin, Dalhousie). As part of the work, OTN’s data expertise will assist with the creation of a data system for ocean noise, and we will co-deploy some of the noise monitoring equipment on some of the OTN moorings to maximize the value of the moorings. The program will also create an atlas of noise for Canadian oceans.

CFREF: S. Iverson was a central writer and planner (one of many) in preparing Dalhousie’s Canada First Excellence Research Fund (CFREF) proposal, The Ocean Frontier Institute, which was successfully awarded September 2016 (\$94M + substantial cash and in-kind partnership support). OTN’s Headquarters and infrastructure will underpin some of the research modules; some CFREF research funding will fund OTN tags and research.

CFI MSI: S. Iverson, F. Whoriskey, and the OTN Secretariat prepared OTN’s full proposal for OTN’s renewal and to become an official Major Science Initiative (MSI) of the CFI, which was successfully awarded (still not announced publically) in October 2016 (~\$33M, S. Iverson PI, to fund OTN’s headquarters and O&M 2017-2022).

NCE IKTP: The Networks of Centres of Excellence – International Knowledge Translation Platform proposal prepared by OTN Secretariat was not successful. There were many applications for a very small funding envelope, however, valuable experience with the NCE process was gained and feedback was provided on our application that can be used in our plans to submit a full NCE application in spring 2017.

NSERC CONNECT: S. Iverson A. Ryan and D. Lidgard prepared a successful NSERC Connect Grant: “Halibut Bio-Tracking project (HaliBT): investigating stock structure and spawning behaviour in Atlantic halibut using bio-tracking tools” (\$7.1K). The meeting was held 1 November 2016 and initiated the planning for a future Collaborative Research and Development (CRD) grant.

CFI Innovation Fund: F. Whoriskey and S. Iverson co-wrote and submitted (with D. Wallace, MEOPAR, and R. Bachmayer and B. deYoung, MUN) a full proposal to CFI’s Innovation Fund “Development of Autonomous Marine Observation Systems (DAMOS)” to fund (~\$13M, PI R. Bachmayer) more ocean gliders and receivers for open ocean deployments and which will in part support both OTN’s and CFREF’s programs. Results to be announced June 2017.

SSHRC Connections: The OTN Secretariat (especially A. Ryan) has been working to expand our social scientist connections and to further that goal, has submitted a Social Science and Humanities Research Council (SSHRC) Connections grant with Dalhousie's Megan Bailey, a Canada Research Chair in Integrated Ocean and Coastal Governance (Tier II). This grant will facilitate a three-day symposium with a focus on natural and social science knowledge exchange surrounding oceans data and information transparency. Results from the workshop will help shape the NCE application.

#### Meetings, symposia, workshops, and outreach

OTN Canada 2016 Symposium The 6<sup>th</sup> annual symposium was a big success. OTN Canada and ISAC members gathered at Dalhousie to present a synthesis of each projects' research progress and findings. Invited guest speakers included DFO ADM (and OTN Council Member) Trevor Swerdfager, and Megan Leslie, a former Member of Parliament and now consultant to the WWF. Anna Metaxas, one of the leaders of CHONe (Canadian Healthy Oceans Network) was also invited to speak to connecting our networks.

SAC/ISAC Associated with the OTN symposium was a joint meeting of the Canadian and International Scientific Advisory Committees (SAC and ISAC, respectively). In addition to considering current research status and forecasts from the major ocean regions, these groups provided input into future developments and possible directions for the planned NCE proposal.

## **6. Networking, outreach, and synthesis**

### *a) Interaction/Outreach to Broader Community/Public (including radio or television interviews or contribution to a programme/documentary, stakeholder workshops, awards, etc.)*

N. Beauchamp and J. Pye organized a "Track-a-thon" (hackathon/codefest; intensive data mining, data manipulation). This event produced visualizations from public OTN data sets (e.g., blue shark tracks, salmon migrations, global deployments/station maps) developed by graduate and undergraduate computer science students. \$1.5K (sponsored) was awarded to three winning teams.

OTN collaborated with SHAD Dalhousie (which provides month-long learning opportunities to bright high school students across the country) to host two events: a presentation given by OTN sturgeon researcher M. McLean (4.14) and a three-hour workshop featuring a seal presentation with D. Lidgard (4.7), glider talk and tour with R. Davis (4.2), labs and tour with Dal Aquatron Manager J. Batt and a closing reflection session with F. Whoriskey on the global implications of understanding ocean sciences.

In 2016, Discovery Channel's popular science broadcast, *Daily Planet*, featured OTN gliders, shark tagging, and Torpedo Ray tagging research on three separate features.

The first ever satellite tag placed on an electric fish -the Atlantic Torpedo Ray- (installed by OTN researchers), has popped up on schedule. The tagging was featured on a segment of *Daily Planet* in the fall; the media continues to follow the story.

F. Whoriskey and Program Manager of [Energy and Environmental Affairs](#) (Massachusetts), Greg Skomal interviewed on CBC Mainstreet regarding shark behaviour, migration, tagging and data collaboration.

OTN Scientific Director, Sara Iverson, and OTN Senior Project Manager, Kes Morton, were invited to attend Canada's Ocean Summit in Ottawa on June 8 hosted by WWF-Canada.

Members of the Columbian Navy were treated to a tour of Dalhousie/OTN facilities including an extensive demonstration of OTN/MEOPAR glider operations by R. Davis

Canadian Minister of Science, Kirsty Duncan, visited Dalhousie in April to tour ocean science initiatives including the OTN. Duncan met with local M. McLean, D. Lidgard, F. Broell, B. Novak, who gave brief overviews of their respective OTN work. S. Iverson presented on OTN Canadian and global operations during a private presentation. Duncan was presented with an explanation of glider operations by R. Davis and was given an opportunity to remotely pilot an OTN Slocum glider in the west coast.

Gulf of Mexico Program Partnership Gulf Guardian Award. Eight-year old Cory Diaz created a campaign to raise \$20,000 for animal tags to support the iTAG program (Utag for iTAG). OTN supported Cory in her campaign and was a co-recipient of the award.

OTN received the 2016 Conservation Achievement Award from the American Fisheries Society. F. Whoriskey accepted the award on behalf of OTN, Kansas, July 2016.

OTN was awarded the 2016 Nature Inspiration Award from the Canadian Museum of Nature. S. Iverson and F. Whoriskey accepted the award on behalf of OTN at the Nature Awards Gala in Ottawa, November 2016.

F. Whoriskey was a finalist for the Professional of Distinction award for the 14<sup>th</sup> Annual Discovery Awards, Halifax, November 2016.

OTN's Canadian "Research and Advisory Team" led by S. Iverson (including the OTN Canada SAC PIs) was nominated for the 2017 NSERC Brockhouse Prize for Interdisciplinary Research in Science and Engineering by Dal President Richard Florizone. (Decisions announced early 2017)

#### *b) Synthesis activities*

See Project 4.16 for details on the ideasOTN synthesis committee.

Publications Library Progress continues on creating an all-encompassing Publications Library, which will include all OTN-related publications accessible from the OTN website. The website is currently up-to-date with a list of all OTN publications since 2010.

## **7. Dissemination of information and results**

#### *c) Conference/workshop/seminar presentations (5 total) – invited or contributed*

Oceans 2016 S. Iverson presented at *Oceans 2016* in New Orleans (February 2016).

CNNRO F. Whoriskey attended the Canadian Network of Northern Research Operators (CNNRO), of which OTN is a founding member, held a Strategic Planning Session in Yellowknife (February 2016).

AtlantOS Annual General Meeting F. Whoriskey attended the AtlantOS Annual General Meeting,

including the European Aquatic Animal Telemetry Network next meeting, held in Kiel, Germany (June 2016).

IMCC 2016/ IUCN WCC - OTN co-hosted two international symposia in 2016 in collaboration with the Smithsonian Institution on animal tracking, the first in St. John's, NL, at the 4th Marine Conservation Conference (IMCC), and the second in Hawaii at the IUCN World Conservation Congress (June; September 2016)

3rd International Conference on Research Infrastructures S. Iverson was an invited speaker and panelist at the 2016 ICRI in South Africa, where she presented OTN as a model example in the session on "Expanding partnerships across disciplines, sectors and world regions" (October 2016)

## 8. Contributions from industrial and government partners

| Name of supporting organization:<br><b>CFI</b>                      | <b>Year 7<br/>(2016)</b> |
|---|--------------------------|
| <b>Cash contributions to direct costs of research</b>               |                          |
| <b>In-kind contributions to direct costs of research</b>            |                          |
| 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):   |                          |
| <b>In-kind contributions to indirect costs of research</b>          |                          |
| 1) Use of organization's facilities                                 |                          |
| 2) Salaries of managerial and administrative staff                  |                          |
| 3) Other (specify):   |                          |
| <b>Total of all in-kind contributions</b>                           |                          |
| <b>Is this new funding (acquired during this reporting period)?</b> | no                       |

*Indirect costs:*

1) Salaries of managerial and administrative staff that assist the Secretariat:

- Lenore Bajona, Director of Data Management
- Jon Pye, OTN Portal Manager

5) Provision of services through use of data management team and website assistance.

| Name of supporting organization:<br><b>Dalhousie University</b> | <b>Year 6<br/>(2015)</b> |
|---|--------------------------|
| <b>Cash contributions to direct costs of research</b>           | 12, 000                  |
| <b>In-kind contributions to direct costs of research</b>        |                          |
| 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):   |      |
| <b>In-kind contributions to indirect costs of research</b>          |      |
| 1) Use of organization's facilities                                 | 2850 |
| 2) Salaries of managerial and administrative staff                  | **   |
| 3) Other (specify):   |      |
| <b>Total of all in-kind contributions</b>                           |      |
| <b>Is this new funding (acquired during this reporting period)?</b> | no   |

*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 (S. Iverson, A. Ryan, and N. Beauchamp), 300 square feet at \$9.50sq/ft. \$2850;

## 2) \*\*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).