

NUNAVUT WILDLIFE RESEARCH TRUST FUND Interim Report 2010-11

1.0 Project Number: 3-10-05

2.0 Project Title:

Community-Based Monitoring of ice-breeding seals in the greater Hudson Bay and Foxe Basin regions of the Canadian Arctic

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4.0 Summary:

Since 2003, we have worked successfully with the HTO/HTAs and community members of Arviat and Sanikiluaq (and other communities secondarily – Igloolik, Repulse Bay, Chesterfield Inlet), Nunavut to develop and carry out a Community-Based Monitoring (CBM) network to collect scientific and Inuit Qaujimatuaqangit information and obtain biological samples of ice-breeding seals from greater Hudson Bay and Foxe Basin regions. The biological information and samples are being collected primarily from ringed seals, and secondarily from bearded, harp, and harbour seals to develop a long-term data set. Together we are working to better understand seal ecology, including reproduction, survival, body fat, food habits, genetics, movement, contaminants, and disease. Since 2006, another part of this CBM network has included a satellite telemetry project near Sanikiluaq, and recently Igloolik and Churchill, which has provided information on ringed and bearded seals movements, haul-out behaviour, foraging habitat, and diving behaviour. Both of these CBM programs are being conducted to determine how climate warming and increased mining, ship traffic, and other human activities may affect ice-breeding seals in the future. Our goal is to further conservation and management by maintaining sufficient seal numbers for continued subsistence hunting in northern communities in the greater Hudson Bay and Foxe Basin regions. This CMB network has proved to be highly successful to both DFO and the partnering communities.

In 2010, we were awarded funding from the NWRT to continue the CBM network and associated research in partnering communities around Hudson Bay and Foxe Basin. As a result of this funding in 2010 we achieved the following:

- 1) Community-Based Monitoring network collections of biological samples and information (scientific and IQ) from ringed, bearded, harp, and harbor seals harvested during subsistence hunts in the communities of Arviat, Sanikiluaq, and Chesterfield Inlet, NU.
- 2) Deployment of satellite transmitters on live ringed seals captured around the Belcher Islands near Sanikiluaq in August (n=9) and October (7) 2010 and Churchill Manitoba (1) in June 2010, and tracking and analysis of their movements since deployment.
- 3) Successful hands-on training and scientific knowledge transfer to locals in Sanikiluaq, so they were able to successfully conduct the field research necessary to capture and tag ringed seals with satellite tags, independently without southern involvement.
- 4) Cross-community involvement in the transfer of scientific and Inuit Knowledge of the seal capture and satellite deployment techniques, with a local Inuit hunter and guides from Sanikiluaq traveling and working hands-on with us to train Inuit in other communities such as in Igloolik.
- 5) Display of a short video documentary of local guides from Sanikiluaq conducting field research to capture and deploying satellite tags on seals at the Oslo, Norway International Polar Year conference, June 2010. The video showcase of the important role of community-based monitoring and community involvement in arctic science, and how locals from Sanikiluaq have learned to conduct their own science.
- 6) Further development of an internet website with data, maps, and movies (updated weekly) of the movements and locations of the seals tagged in Hudson Bay.
- 7) Analysis of samples and data to assess seal ecology, population dynamics, movements, haul-out and foraging behaviour, and critical habitat in the Hudson Bay and Foxe Basin regions. PhD student, Magaly Chambellant successfully defended her research.
- 8) Oral and poster presentation of the Community-Based Monitoring network research at the ArcticNet conference in Ottawa in Dec. 2010.
- 9) Developing a framework plan, in consultation with Fisheries and Oceans Canada, the Government of Nunavut, Inuit Organizations, and community HTAs/HTOs, to sustain the CBM network for the long-term, as a network run by Nunavummiut for Nunavummiut.

5.0 Introduction:

Recently, an increase in spring and summer air temperature, precipitation, and ice-free period as well as a decrease in winter snow depth, and sea-ice extent and thickness has been reported for Hudson Bay and other areas in the Canadian Arctic (Barber and Lacoza 2004; Steward and Lockhart 2005; Gagnon and Gough 2005). The evolutionary adaptations of ringed seals, and other ice-breeding seals (bearded and harbour seals) to exploit the land-fast ice habitat for reproduction and survival could expose this species to critical challenges with predicted global warming and changes in sea ice extent (Tynan and Demaster 1997). Holst et al. (1999) concluded that the ringed seal populations in western Hudson Bay are experiencing demographic difficulties. Recent studies have illustrated the negative role of early ice break-up (Harwood et al. 2000) and decreasing snow depth (Ferguson et al. 2005) on the condition and survival of ringed seals. Management concerns have increased due to lower ringed seal abundance estimates in western Hudson Bay provided from aerial surveys of hauled-out ringed seals during spring from 1995 to 2000, which show a sharp decline from 100,000 to 45,000 individuals (Lunn et al. 2000). Similar data for eastern Hudson Bay and Foxe Basin are currently unavailable.

Due to these concerns, ringed seals were declared a 'mid-priority' candidate species for assessment by COSEWIC in June 2008 as populations may need conservation help. Further the Arctic Monitoring and Assessment Program (AMAP 2002), Marine Mammal Commission, and DFOs Arctic Operational Monitoring Plan all recommended that ringed seals be used as a target (indicator) species for arctic environmental monitoring. Ringed seals are socially, numerically, nutritionally, and economically one of the most important marine mammal species to the Inuit communities of Hudson Bay and Foxe Basin, so knowledge on ringed seal ecology, and where and how seals use these regions is needed for a population assessment, with the goal of helping Inuit communities adapt to possible changes in seal distribution and abundance with climate change and increased development (i.e. mining, shipping, and other human affectivities), while preserving their cultural lifestyle, and maintaining sufficient seal numbers for continued subsistence hunting.

Since 2003 we have worked successfully with Inuit hunters, guides and community members in Arviat, Sanikiluaq and other communities in Nunavut to develop and carry out a Community-Based Monitoring (CBM) network and satellite telemetry project to study the ecology and population dynamics of seals in the greater Hudson Bay region. This CMB Network has proved to be highly successful to both DFO and the partnering communities. Thus in 2010 we were

awarded funding from the NWRT to continue the CBM network and associated research in partnering communities around Hudson Bay. The CBM network aims to (1) use an ecosystem-level Community-Based Monitoring approach with Inuit Qaujimatuaqangit (IQ or Inuit Traditional Ecological Knowledge) to study the effects of polar warming and human activities on seals, (2) develop and utilize effective methods to fully engage and involve community members in all aspects of the research, monitoring, and sample collection process from planning and coordination to communicating and applying the resultant information; and (3) develop a sustainable long-term CBM program run by Nunavummiut for Nunavummiut by empowering northerners with science skills.

6.0 Project Objectives:

To achieve the goals of the CBM network, we proposed the following objectives:

- 1) Continue and expand CBM network collections of biological samples and information (scientific and IQ) from ringed, bearded, harp, and harbor seals harvested during subsistence hunts in the communities of Arviat, Sanikiluaq, and Chesterfield Inlet (Hudson Bay).
- 2) Deploy satellite transmitters on live ringed, bearded and harbor seals captured in Sanikiluaq and Churchill, and further train local hunters/guides in capture and deployment techniques, so they will be able to conduct the field research independently, with DFO supplying the necessary equipment and supplies.
- 3) Assess seal ecology, population dynamics, movements, haul-out and foraging behaviour, and critical habitat in the Hudson Bay and Foxe Basin regions, thus providing management criteria to minimize impacts of climate warming and increased development (i.e. mining, shipping, and other human affectivities) on seal populations.
- 4) Continue to develop and implement methods to involve and engage community members (i.e. hunters, students, teachers, Elders, and others) and IQ in critical aspects of the research (i.e. training and education; community newsletters and leaflets; presentations, and internet).
- 5) Develop a framework, in consultation with Fisheries and Oceans Canada, the Government of Nunavut, Inuit Organizations, and community HTAs/HTOs, to sustain the CBM network for the long-term, as a network run by Nunavummiut for Nunavummiut.

7.0 Materials and Methods:

a. Community-Based Monitoring Kit Collections:

In March 2010 sampling kits were assembled by Fisheries and Oceans Canada (DFO) staff and sent to Hunters and Trappers Organization/Association in the communities of Arviat, Sanikiluaq, and Chesterfield Inlet, NU. One to two local dedicated hunters will be hired through the local HTO/HTA in each community to coordinate the collections of seals from hunters, and act as the community samplers.

Local Inuit hunters in these communities were hired to complete the sampling kits by providing tissues and organs from their subsistence harvest of ringed seals occurring from May 1, 2010 to February 15, 2011. The assembled kits contained equipment and information local hunters required to perform collections in the field. Biological information gathered from each seal included species, sex, date and time of kill, hunter's name, location, GPS coordinates, and habitat, as well as measurements of total length, auxiliary girth, fat depth at sternum and hips, body weight, and sculp weight. Biological sample collections include lower jaw, stomach, intestine, blood, whiskers, fur, claws and fist size pieces of muscle, kidney, blubber, and liver. Once collections are complete, the remains of the seals (complete pellet, blubber (fat), muscle, and organs) are returned to the hunters. Fisheries and Oceans researchers and students also visited the community of Sanikiluaq (October 2010) to meet with the local HTAs, and other community members, as well as aid local hunters in collection of additional biological information and samples from the seals harvested, including the collection of kidney, muscle, skin, blubber and blood samples frozen at -70°C in a cryogenic dryshipper with liquid nitrogen.

Completed sample kits are kept in local community freezers, and are sent in batches throughout the season to Fisheries and Oceans Canada in Winnipeg. Received samples are organized and sorted into the sample archived and prepared for sample analysis, including age determination, body condition, disease, genetics, Nitrogen-15 and Carbon-13 stable isotopes, and fatty acids.

For age determination teeth are from the lower jaw and submitted to Matsons Laboratory where sections will be mounted on microscope slides, stained with an aqueous solution of Toluidine blue and read under transmitted light at low magnification. Tooth cementum will determine ringed seal ages. Growth Layer Groups (GLG) in the cementum are counted in 2 to 3 blind replicates. Final ages are estimated using two identical readings or the median of 3 different readings.

Seal body condition will be estimated by calculating the volume of fat using the prolate spheroid

model (Goodyear 1999) as follows: Total fat volume (cm³) = $(4/3 * \pi * l * (r + fd)^2) - (4/3 * \pi * l * r^2)$. With $l = 1/2$ standard length cm; fd = fat depth at sternum cm; r = radius of the core calculated as $r = ((\text{axillary girth} / (2 * \pi)) - fd)$.

Carbon and Nitrogen stable isotope ratios will be obtained from seal muscle and liver, and accomplished by continuous flow ion ratio mass spectrometry (CF-IRMS) using a GV-Instruments® IsoPrime attached to a peripheral temperature controlled EuroVector® elemental analyzer (EA) (University of Winnipeg Isotope Laboratory).

Fatty acid analysis will be conducted on blubber samples, which will be prepared and analyzed at the Freshwater Institute (DFO) for fatty acid analysis using gas chromatography mass spectrometry.

For determination of diseases, such as *Brucella* spp., seal blood was centrifuged in order to separate the serum from the red blood cells. The serum was then tested for anti-*Brucella* spp. Antibodies by two competitive enzyme-linked immunosorbent assays (C-ELISA) as described in Nielsen et al. (1996).

For genetic analysis, DNA will be extracted and quantified from muscle samples. In the laboratory a small piece of tissue will be removed from the sample, and using a chemical process the DNA is separated. The mitochondrial DNA is then studied by DNA sequencing and electrophoresis. Consistent or unique differences in their DNA sequences and microsatellites are examined to distinguish between species, populations, and groups. Samples will be prepared and analyzed at the Freshwater Institute (DFO) for genetic and stock ID analysis.

b. Community-Based Monitoring Satellite Telemetry:

Community-Based Monitoring and fieldwork for the satellite telemetry project took place in Churchill, Manitoba, during July 2010, and in southeastern Hudson Bay, near the community of Sanikiluaq, Nunavut, during August and October 2010 (Figure 1).

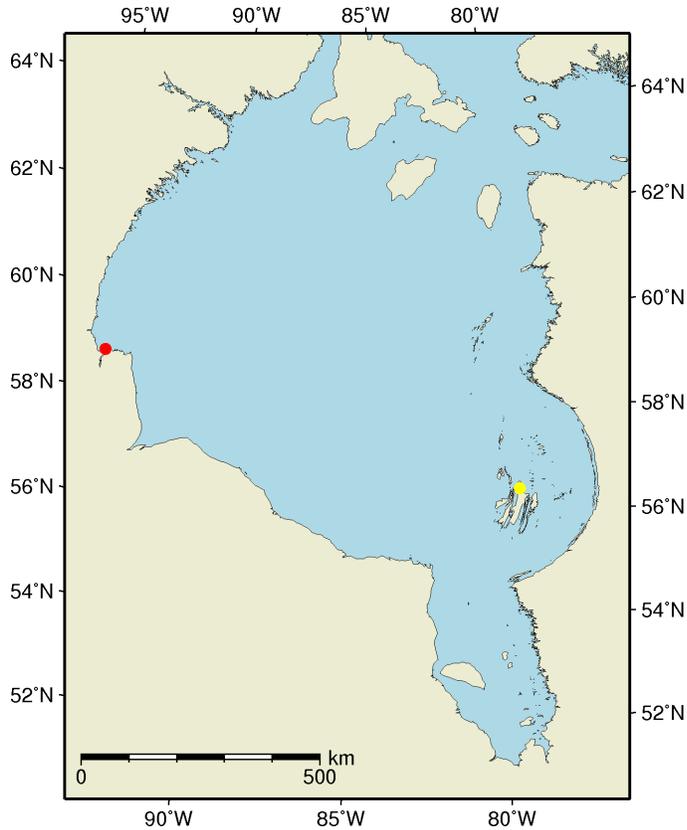


Figure 1. Location of Churchill, Manitoba (red dot), and Sanikiluaq, NU (yellow dot) in southeastern Hudson Bay.

Daily work consisted of traveling to selected sites for deploying specially designed monofilament nets (11" stretched mesh size) in relatively shallow water (up to 8 m), anchored to shore on one end and to the bottom on the other (Figure 2). These nets are light enough to allow seals to reach the surface to breathe. We monitored nets continuously for caught seals from shore and by close inspection from a boat. Whenever any seals were detected tangled in the nets they were retrieved and placed inside a bag in a boat to be transferred to shore for processing. Once captured and retrieved, seals were manually restrained and morphometric measurements taken (body mass, length, girth), and a satellite tag (SMRU 9000-X) was glued to the dorsal fur (Figure 3). The satellite tags are attached to the hair of the seals, so they will fall off with the next annual moult. Therefore, the tagging technique has no lasting effect on the seals, and no effect on the meat. A whisker, small amount of hair, blubber biopsy, and blood from the biopsy wound were also collected. Finally, seals were marked with a flipper identification tag before releasing them.



Figure 2: Examples of nets deployed for capturing live ringed seals.



Figure 3: Field team gathering biological information from restrained ringed seals including morphometric measurements (body mass, length, girth), and attaching a SPLASH PTT tag to the dorsal fur (between the shoulders) of a ringed seal using epoxy glue.

Field work in Churchill, Manitoba, was conducted from July 4 through 15, 2010, during which one adult female ringed seal was captured and equipped with a satellite telemetry tag. The field team from DFO Central & Arctic region was composed of Sebastian Luque (Postdoctoral Research Fellow at University of Manitoba), Brent Young (M.Sc. student at University of Manitoba), and Dave Yurkowski (Casual Biologist at Fisheries and Oceans Canada). As part of our commitment to foster the engagement and involve Nunavummiut in our research, and empower them with the skills to conduct field research independently, Johnnassie Ippak (local hunter and guide from Sanikiluaq, Belcher Islands) came as part of the team. Johnnassie and his brother Lucassie have actively worked with us since 2006, helping us to deploy PTTs and collect biological data from ringed and bearded seals captured for satellite telemetry research in the Belcher Islands. As a result, he has gained experience capturing, tagging, and collecting biological samples and information from seals. Therefore, they are now qualified to this work independently. Indeed, field work in Sanikiluaq, Nunavut, was carried out from August 20 through 22, and from October 15 through 20, 2010, and all activities were performed by Johnnassie and Lucassie Ippak.

Movements from satellite-derived location data from all years (2006-2010) and locations are being analyzed with GIS software and recently developed Bayesian methods to determine areas associated with movement and feeding activities, and critical habitat. Haul-out behaviour determined through the satellite tags are being used to determine whether seals return to the same haul-out sites during the year. Dive data are also being analysed, using the “dive analysis” program from Wildlife Computers and the “diveMove” program developed by Sebastian P. Luque on GNU R, to determine preferred foraging habitats for the different age/sex classes, and are providing oceanographic information on sea temperature over time (e.g. seasons), space (geographic location) and throughout the water column. The latter information constitutes a unique opportunity to record a physical variable that would be otherwise logistically impossible to obtain and that is critical to monitor the ecosystem response to climate warming and increased development.

8.0 Results, discussion and management implications:

This NWRT project was initiated to continue and build on the ice-breeding seals Community-Based Monitoring (CBM) network and associated research started in 2003 with several partnering communities around Hudson Bay and Foxe Basin. In 2010/11 we continued seal

collections of biological samples and information (scientific and IQ) from ringed, bearded, harp, and harbor seals harvested during subsistence hunts in the communities of Arviat, Sanikiluaq, and Chesterfield Inlet.

In Arviat, a local dedicated hunter, Frank Nutarasungnik, was hired through the Hunters and Trappers Organization to coordinate the collections, and act as the community coordinator and sampler of seals. Hunters from the community bring him the seals they harvest, and he collects the required samples and information from the seals and completes the kits for us. Once collections are complete, the remains of the seals (complete pelt, blubber (fat), muscle, and organs) will be returned to the hunters. In Sanikiluaq, the HTA Secretary Manager, Lucassie Arragutainaq, acted as the sampling coordinator for the community, and three local hunters were hired (Lucassie Ippak, Lucassie Takatak, and Johnny Kavik) hired to complete the samples kits with harvested seals. In Chesterfield Inlet the HTA secretary managers acted as the sampling coordinators for the community, and kit collections were available to any hunters interested in obtaining and completing the sampling kits for harvested seals. To date over 20 local hunters have participated in seal collections, and a total of 153 ringed seals, 23 bearded seals, and 8 harbour seals sample kits have been collected during the 2010-11 collection season in these partnering communities. A breakdown of the total per species and community are listed in Table 1.

Table 1. Current summary of seals samples received by Fisheries & Oceans Canada in Winnipeg (Freshwater Institute) as of 14 January 2011.

Community	Ringed seals	Bearded seals	Harbour seals	Total
Sanikiluaq	89	11	-	100
Arviat	56	12	-	68
Chesterfield Inlet	8	-	8	16
Total	153	23	8	184

Our partnering communities are still collecting biological samples and information from harvested seals until 15 March 2011, and DFO continues to receive and process samples for laboratory analysis. DFO is currently preparing samples to be analyzed for age (teeth annuli),

diet (fatty acids and stable isotopes), genetics, contaminants, and disease.

For the community-based monitoring satellite telemetry projects we successfully captured and placed satellite tags on 17 ringed seals (four males (all adults), and 13 females (seven juveniles and six adults)) in total (Table 2). Typical ringed seal movements are illustrated in Figures 4 and 5.

Table 2. Information on 17 ringed seals captured in nets and tagged with satellite transmitters in Churchill, Manitoba (IDs starting with ARCHL), and Belcher Islands, Nunavut (IDs starting with ARSQ).

Date	Sex	Age	Weight (kg)	Length (cm)	Girth (cm)	ID	Flipper Tag #	SPLASH tag
9 Jul 2010	♀	> 7	30.5	105.0	82.0	ARCHL-2010-0007	61	043848
21 Aug 2010	♀	> 3	33.0	101.0	87.0	ARSQ-2010-0973	48	043857
21 Aug 2010	♀	> 5	30.0	102.0	87.0	ARSQ-2010-0974	50	043837
21 Aug 2010	♀	> 3	36.0	103.0	85.0	ARSQ-2010-0970	51	043836
21 Aug 2010	♀	> 4	43.0	98.0	103.0	ARSQ-2010-0972	54	043838
21 Aug 2010	♀	> 4	38.0	97.5	94.0	ARSQ-2010-0971	52	043858
21 Aug 2010	♂	> 6	74.0	118.0	118.0	ARSQ-2010-0975	53	043845
22 Aug 2010	♂	> 5	46.0	106.0	101.5	ARSQ-2010-0964	55	043851
22 Aug 2010	♀	> 2	40.0	99.0	102.0	ARSQ-2010-0963	56	043853
22 Aug 2010	♀	> 6	37.0	99.5	90.5	ARSQ-2010-0969	57	043852
16 Oct 2010	♀	> 6	59.0	104.0	98.5	ARSQ-2010-0906	58	043843
16 Oct 2010	♀	> 5	55.0	112.0	107.5	ARSQ-2010-0967	59	043862
17 Oct 2010	♂	> 4	46.0	108.0	96.0	ARSQ-2010-0976		043835
18 Oct 2010	♀	> 5	51.0	112.0	102.0	ARSQ-2010-0966		043865
19 Oct 2010	♀	> 6	53.0	118.0	104.5	ARSQ-2010-0909		043842

19 Oct 2010	♀	1	27.0	74.0	80.0	ARSQ-2010-0965	043864
19 Oct 2010	♂	> 5	60.0	103.0	115.0	ARSQ-2010-0907	043847

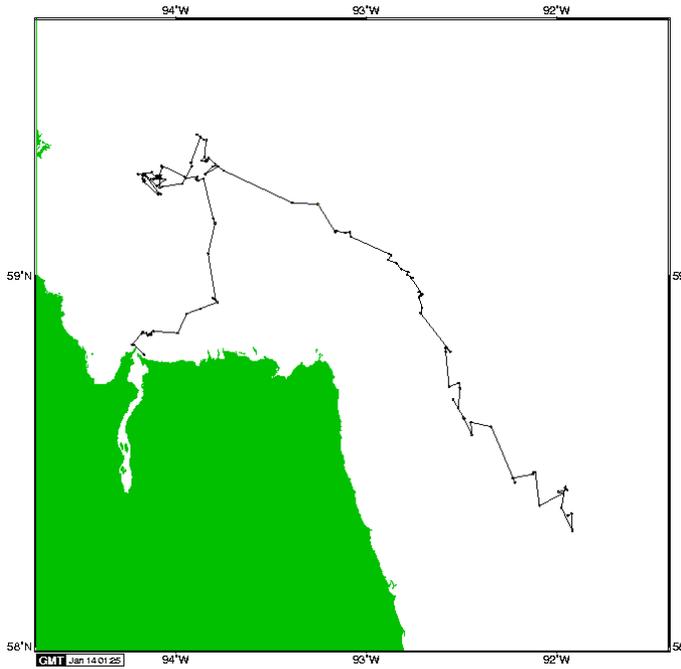


Figure 4: Movements of a ringed seal equipped in Churchill, Manitoba, during the summer of 2010. The track starts just north of Churchill.

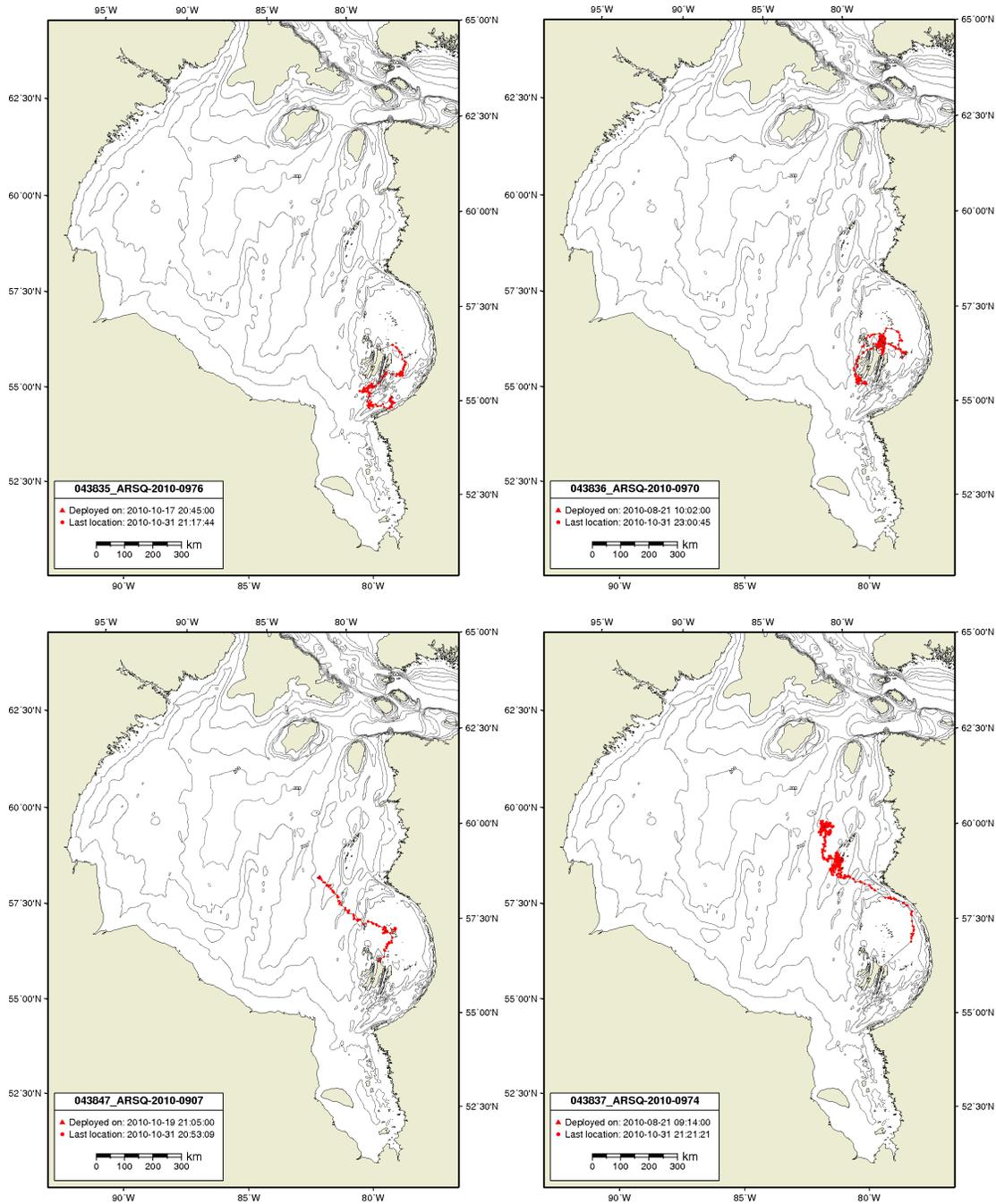


Figure 5: Four tracks of ringed seals equipped in the Belcher Islands during the summer of 2010.

The satellite tags are providing information on movements (traveling and resident behaviours), haul-out behaviour, foraging habitat and behaviour (where and when they dive, at what depth and water temperature they forage). Although much analysis is still being performed,

Preliminary results of the telemetry data indicates that south-eastern Hudson Bay ringed seals spend most of their time, and foraging activities in relatively shallow water areas between the Belcher Islands and Quebec-Nunavik (Figure 5). Two seals, both young males, traveled to the western and northern coasts of Hudson Bay. Animal movement models successfully detected travelling and resident behaviours of ringed seals in Hudson Bay, with important differences between sexes and age classes. Young seals and female seals tend to have disperse more than adults, and are likely to display resident behaviour over a wider range of ocean depths and sea ice concentrations. Diving behaviour analyses suggest that seals concentrate foraging between 40-60 m water depths in summer and increasing to approximately 80 m in winter. Movements of ringed seals became more restricted with advancing sea-ice cover during late fall and winter.

The latest information (updated weekly) on the movements of all the seals can be found on a website we have set-up with associated data and movies:

(<http://www.umanitoba.ca/faculties/science/zoology/faculty/ferguson/belchers>). This link has been given to HTO/HTAs, schools and community members in Sanikiluaq and other Nunavut communities, as well as other participating communities around Hudson Bay. Posting these results weekly on the web makes them available immediately to the scientific community, media, northern communities, the public, students, and teachers. We're also continuing to develop and implement other methods to involve and engage community members (i.e. hunters, students, teachers, Elders, and others) and IQ in all aspects of the research, including hands-on training and education; community newsletters and leaflets; video documentation; and in-person meeting and presentations. Ultimately we hope to develop a framework, in consultation with Fisheries and Oceans Canada, the Government of Nunavut, Inuit Organizations, and community HTAs/HTOs, to sustain the CBM network for the long-term, as a network run by Nunavummiut for Nunavummiut.

For the seal tagging research we also worked closely with local Government of Nunavut biologists and technicians for planning the logistics of the field research, as well as conducting the research. For the seal tagging work in Churchill, Johnassie Ippak, a local guide and hunter from Sanikiluaq who has worked with us since 2006, traveled and worked with the tagging team. Further in Sanikiluaq, with hands-on training and scientific knowledge transfer Lucassie and Johnassie Ippak, two local guides and hunters that have worked with us since 2006, were successful in independently capturing and tagging ringed seals in 2010 without southern involvement. This success demonstrates that they are now capable of conducting seal capture

tagging without southern assistance. As a result in 2010, we supplied them with the necessary supplies and equipment and contracting them to conduct the seal capture and tagging field research program in 2010 independently without our presence.

Overall, the seal Community-Based Monitoring (CBM) network collections and tagging projects were a large success in 2010, fostering strong collaborative relationships between Fisheries and Oceans Canada persons and the partnering communities. We are encouraged to continue working closely with our partnering communities, as well as continue to expand to other communities of Nunavut. Continued sampling of ringed seals for monitoring purposes is encouraged and is supported by the Circumpolar Biodiversity Monitoring Plan for which Canada (DFO) is a participant. It is important that we maintain seal populations as a food resource for polar bears, as well as a cultural and economic resource for Inuit.

9.0 Reporting to Communities/Resource Users:

During the course of this research program, we meet with the HTO/HTAs, wildlife officers, and local guides/hunters in the communities of Arviat (June 2010) and Sanikiluaq (October 2010) to discuss research plans and solicit feedback. The latest information (updated weekly) on the movements of all the seals can be found on a website we have set-up with associated data and movies: (<http://www.umanitoba.ca/faculties/science/zoology/faculty/ferguson/belchers>). This link has been given to HTO/HTAs, schools and community members in Sanikiluaq and Igloolik, as well as other participating communities around Hudson Bay. Posting these results weekly on the web makes them available immediately to the scientific community, media, northern communities, the public, students, and teachers. DFO is continuing to develop and implement methods to involve and engage community members (i.e. hunters, students, teachers, Elders, and others) and IQ in aspects of the research, including hands-on training and education, community newsletters and leaflets, video documentation, and in-person meeting and presentations

10.0 Employment and Training of Nunavut resident:

Over the past year of this study, over 20 hunters from the partnering communities have participated in the community-based monitoring sampling collection of seals. In Arviat, a local

dedicated hunter was hired through the Hunters and Trappers Organization to coordinate the collections, and act as the community coordinator and sampler of seals. Over 10 hunters from the community bring him the seals they harvest, and he collects the required samples and information from the seals and completes the kits for us. In Sanikiluaq three dedicated hunters collect and sample seal for us to complete the samples kits. In Chesterfield Inlet over 10 hunters participated in the collections. In all communities, one hunter was also hired to pack and send off the seal samples to Fisheries and Oceans in Winnipeg.

For the seal satellite tagging research program, four hunters and guides from Sanikiluaq, NU were hired to capture and tag seals from the Belcher Islands.

11.0 References:

- Barber, D.G. and Iacozza, J. (2004). Historical analysis of sea ice conditions in M'Clintock Channel and the Gulf of Boothia, Nunavut: Implications for ringed seal and polar bear habitat. *Arctic* 57: 1-14.
- Bligh, E.G. and Dyer, W.J. (1959). A rapid method of total lipid extraction and purification. *Canadian Journal of Biochemistry and Physiology* 37: 911-917.
- Bradstreet, M.S.W. and Finley, K.J. (1983). Diet of ringed seals (*Phoca hispida*) in the Canadian high Arctic. Petro-Canada Exploration Inc. Calgary, Alberta, LGL Limited, Environmental research associates, 44 Eglinton Ave. W., Toronto, Ontario, M4R 1A1: 36.
- Chambellant, M. and Ferguson, S.H. (2006). Ageing live ringed seals: which tooth to pull? *Marine Mammal Science* Submitted:
- Chambellant, M. and Ferguson, S.H. (2007). Ringed seal diet in the Canadian Arctic: inter-sites comparison using fatty acid analysis. *submitted*
- Ferguson, S.H., Stirling, I. and Mcloughlin, P. (2005). Climate change and ringed seal (*Phoca hispida*) recruitment in Hudson Bay. *Marine Mammal Science* 21: 121-135.
- Gagnon, A.S. and Gough, W.A. (2005). Climate change scenarios for the Hudson Bay region: an intermodel comparison. *Climatic Change* 69: 269-297.
- Gaston, A.J., Woo, K. and Hipfner, J.M. (2003). Trends in forage fish populations in Northern Hudson bay since 1981, as determined from the diet of nestling thick-billed Murres, *Uria lomvia*. *Arctic* 56: 227-233.
- Goodyear, M.A. (1999). Variation in growth and seasonal condition of ringed seal, *Phoca hispida*, from the Canadian Arctic. Department of Zoology. Winnipeg, MB, University of Manitoba. Master of Science: 111.
- Harwood, L.A., Smith, T.G. and Malling, H. (2000). Variation in reproduction and body condition of the ringed seal (*Phoca hispida*) in the Western Prince Albert sound, NT, Canada, as assessed through a harvest-based sampling program. *Arctic* 53: 422-431.
- Holst, M., Stirling, I. and Calvert, W. (1999). Age structure and reproductive rates of ringed seals (*Phoca hispida*) on the Northwestern coast of Hudson Bay in 1991 and 1992. *Marine Mammal Science* 15: 1357-1364.

- Kingsley, M.C.S. and Byers, T.J. (1998). Failure in reproduction of ringed seals (*Phoca hispida*) in Amundsen Gulf, Northwest Territories in 1984-1987. Ringed seals in the North Atlantic. M.P. Heide-Jorgensen and C. Lydersen. Tromso. The North Atlantic Marine Mammal Commission. 1: pp.273.
- Lunn, N.J., Stirling, I. and Davis, C. (2000). Distribution and abundance of seals in western Hudson Bay: Annual progress report 2000.
- Mclaren, I.A. (1958). The biology of the ringed seal (*Phoca hispida* Schreber) in the eastern Canadian arctic. *Fisheries Research Board of Canada Bulletin* 118:
- Nielsen, O., Nielsen, K. and Stewart, R., E.A. (1996). Serologic evidence of *Brucella* spp. exposure in Atlantic walrus (*Odobenus rosmarus rosmarus*) and ringed seals (*Phoca hispida*) of Arctic Canada. *Arctic* 49: 383-386.
- Nielsen, O., Stewart, R., E.A., Nielsen, K., Measures, L. and Duignan, P.J. (2001). Serologic survey of *Brucella* spp. antibodies in some marine mammals of North America. *Journal of Wildlife Diseases* 37: 89-100.
- Reeves, R.R. (1998). Distribution, abundance and biology of ringed seals (*Phoca hispida*): an overview. Ringed seals in the North Atlantic. M.P.H.-J.A.C. Lydersen. Tromso. NAMMCO. 1: pp.273.
- Shaw, C.N., Wilson, P.J. and White, B.N. (2003). A reliable molecular method of gender determination for mammals. *Journal of Mammalogy* 84: 123-128.
- Smith, T.G. (1973). Population dynamics of the ringed seal in the Canadian eastern arctic. *Fisheries Research Board of Canada Bulletin* 181:
- Smith, T.G. (1987). The ringed seal, *Phoca hispida*, of the Canadian western Arctic. *Canadian Bulletin of Fisheries and Aquatic Sciences* 216:
- Stewart, D.B. and Lockhart, W.L. (2005). An overview of the Hudson Bay marine ecosystem. *Canadian Technical Report of Fisheries and Aquatic Science* vi+487.
- Stirling, I. (2005). Reproductive rates of ringed seals and survival of pups in Northwestern Hudson Bay, Canada, 1991-2000. *Polar Biology* 28: 381-387.
- Stirling, I., Lunn, N.J. and Lacoza, J. (1999). Long-term trends in the population ecology of polar bears in western Hudson Bay in relation to climatic change. *Arctic* 52: 294-306.
- Tryland, M., Kleivane, L., Alfredsson, A., Kjeld, M., Arnason, A., Stuen, S. and Godfroid, J. (1999). Evidence of *Brucella* infection in marine mammals in the North Atlantic Ocean. *The Veterinary Record* 144: 588-592.
- Tynan, C.T. and Demaster, D.P. (1997). Observations and Predictions of arctic climatic change: potential effects on Marine Mammals. *Arctic* 50: 308-322.
- Wagemann, R., Innes, S. and Richard, P.R. (1996). Overview and regional and temporal differences of heavy metals in Arctic whales and ringed seals in the Canadian Arctic. *The Science of the Total Environment* 186: 41-66.