# TWENTY FIFTH MEETING OF THE COUNCIL

**5 – 6 April 2017, Nuuk, Greenland**

**DOCUMENT 15** **NATIONAL PROGRESS REPORT**

**Submitted by:** **CANADA**

**Action requested:**

- For information

SC/23/NPR-Canada
4-7 November 2016
Nuuk, Greenland

# FISHERIES & OCEANS CANADA PROGRESS REPORT ON MARINE MAMMAL RESEARCH AND MANAGEMENT IN 2015

**October, 2016**

# 1.0 INTRODUCTION

This report provides an overview of the research activities, management programs, and catch statistics of marine mammals for Canada's East Coast and Arctic Archipelago in 2015. Most of the research projects in this report were conducted by the Canadian Department of Fisheries and Oceans. Many research projects involved cooperation with various universities, aboriginal organizations, and/or other research groups. Canadian universities and research groups conducted a wide variety of research on marine mammals in Canada that are not included in this report.

# 2.0 RESEARCH

## *2.1 ARCTIC*

### 2.1.1 Community-Based Monitoring Network (S. Ferguson, B. Dunn, B. Young)

Continuation of the partnership started in 2003 to develop community-based monitoring with several Nunavut communities. The focus is on tissue collections from marine mammals (walrus, ringed seals, bearded seals, harbour seals, harp seals, and beluga whales, narwhal whales, and bowhead whales). Biological samples and information continue to be gathered and has resulted in a long-term data set of marine mammal biological information. Monitoring provides trend analysis to determine how stressors such as climate warming may affect marine mammals and the Canadian Arctic communities that depend on them. The community-based monitoring network is built on existing northern expertise, provides additional training and work opportunities for Nunavummiut, and ensures a blending of scientific and traditional methods and knowledge. These partnerships are an important element in detecting changes in the ecosystem and guiding research projects specific to the needs of the local resource users. The collection network in 2015 included the following communities: Arviat, Sanikiluaq, Pangnirtung, Grise Fiord, Pond Inlet, Naujaat (Repulse Bay), Gjoa Haven, Kugaaruk, and Resolute Bay, Nunavut.

### 2.1.2 Narwhal Foraging Behaviour (C. Watt, S. Ferguson)

To investigate marine food web changes from 1982–2011, we examined diet using fatty acids, $\delta^{15}N$, and $\delta^{13}C$, in narwhals from Baffin Bay and northern Hudson Bay. Due to a significant reduction in summer ice cover in northern Hudson Bay, we predicted temporal changes would be greater there than in Baffin Bay. In northern Hudson Bay, $\delta^{15}N$ significantly increased, $\delta^{13}C$ displayed a parabolic trend, and fatty acids gradually

shifted over time. Fatty acids significantly changed over time in Baffin Bay, and $\delta^{13}C$ decreased; however, $\delta^{15}N$ was stable over time. Stable isotope mixing models indicated a dietary reduction in capelin and an increase in Greenland halibut from 1994–2000 to 2006–2011 in Baffin Bay, while capelin was an important dietary component for narwhals in northern Hudson Bay in recent years (2006–2011). These dietary changes may be attributed to changes in sea ice and narwhal migration. Seasonal dietary changes, as evidenced by changes in blubber fatty acids and skin and muscle stable isotopes, were not as apparent in the northern Hudson Bay population, which may be indicative of a reduced migratory distance for whales in this population compared to whales from Baffin Bay.

### 2.1.3 Narwhal Dive Behaviour (C. Watt, S. Ferguson, M.P. Heide-Jorgensen, J. Orr, N.H. Nielsen)

Dietary differences among narwhals (*Monodon monoceros)* from the world's three populations, East Greenland, Northern Hudson Bay, and Baffin Bay, have been detected using stable isotope analysis. We evaluated if differences in diet correspond to differences in dive behaviour among populations using satellite linked tags. Narwhals (n = 34) were equipped with transmitters in order to evaluate the total number of dives and the time they spent in pre-defined depth categories. Narwhals from East Greenland made significantly more dives and spent more time in the mid-water column compared to other populations. Northern Hudson Bay narwhals made more dives in the deep zone than the mid-water region, while Baffin Bay narwhals spent time and made most dives within the upper water column and the deep zone. Diving to the deep zone suggests deep-dwelling prey may contribute substantially to narwhal diet in both Northern Hudson Bay and Baffin Bay. We identified seasonal changes in diving for all populations and for the Baffin Bay and East Greenland populations there were sex-specific differences in time spent at depth. This was the first study to compare dive behaviour in the world's three narwhal populations and dive behaviour differences among populations paralleled differences in diet found from stable isotope analysis. Results suggest that narwhals from different populations employ specialized foraging strategies.

### 2.1.4 Narwhal Social Structure (C. Watt, S. Petersen, S. Ferguson)

Little is known about narwhal social groupings; however, it has been suggested they may display a matrilineal social structure. An ice entrapment event near the community of Pond Inlet, Nunavut, Canada captured many females and their offspring. Using genetic analyses and fatty acids as a dietary marker, we investigated whether individuals that are closely related forage together, which would support a matrilineally driven social structure where females teach their young foraging strategies, and/or travel and forage together. We found no evidence that genetic relatedness was correlated with the fatty acid biomarkers, which provides some evidence against a matrilineal social structure, and may suggest narwhals have a fission-fusion societal structure.

### 2.1.5 Arctic Killer Whales (S. Ferguson, C. Matthews)

The goal of our killer whale research, which we began in 2005, is to learn more about ECA killer whale abundance (e.g. how many are there, and are they increasing in number?), distribution (e.g. what is their seasonal distribution in Nunavut waters, where do they go during winter?) and ecological impacts (what do they eat, and how much?). We study killer whale abundance and distribution using photo identification and satellite telemetry, and we study diet using chemical analyses of biopsied skin and blubber. We also use genetic analysis to determine how killer whales in Nunavut are related to each other, and to other populations in the North Atlantic.

During August 2015, we attempted to satellite tag and biopsy killer whale in Admiralty Inlet, Nunavut, where we had encountered them in 2009 and 2010. Unfortunately, we encountered killer whales only on our last day, and were unable to get close enough to attempt tagging or biopsying. However, photo-IDs confirmed these were the same whales we had sighted in 2009. We also maintained our community-based monitoring program, equipping several communities with tagging and biopsy equipment to conduct research if killer whales arrived in their respective communities (they did not). Throughout the rest of the year, we focused on analysis of samples and data collected in previous years. Killer whale skin and blubber biopsies collected since 2009 have been analysed for stable isotopes, fatty acids, and contaminants, and currently two manuscripts about killer whale diet and foraging ecology are in preparation. We have also analysed tracking data of simultaneously tagged killer whales, narwhals, and bowhead whales, and are currently working on two separate manuscripts about killer whale impacts on prey species behavior.

### 2.1.6 Marine Mammals and Emerging Fisheries (S. Ferguson, M. Marcoux, K. Hedges, A. Fisk)

We used a combination of three different passive acoustic devices to sample marine mammal calls: C-PODs that detect and log echolocation clicks used for whale navigation and feeding, AURALs that record vocalization sounds used for whale communication, and SM2M devices that record both echolocation clicks and vocalizations. We have deployed moorings in Scott Inlet (Clyde River), offshore of central Baffin Island (Qikiqtarjuaq), and Cumberland Sound (Pangnirtung) that are designed to detect buzzes and acoustics produced by toothed whales during feeding events. Overwinter acoustic recorders deployed in Scott Inlet were used to verify seasonal selection by communicating whales in conjunction with fish acoustic tagging and receivers to correlate movements of a variety of marine predators. Plans for 2016 included returning to Cumberland Sound to retrieve Passive Acoustic Monitoring devices as well as continue to deploy devices in the Scott Inlet and offshore Baffin regions.

### 2.1.7 Ringed Seal Foraging Behaviour (S. Ferguson, B. Young, D. Yurkowski)

Almost 100 ringed seals have been tagged with satellite telemetry transmitters across the Canadian Arctic. Food habits results indicate a diet shift in the 1990s of Arctic cod to capelin and sandlance in the 2000s. Assessing seasonal feeding by Belcher Island ringed seals described a pattern of open-water pelagic feeding, followed by more benthic under-ice feeding over winter, and a diverse spring feeding prior to fasting during the molt. A spatial comparison of foraging ecology suggests dietary differences in ringed seals between eastern and western Hudson Bay, including a possible ecological divergence between east and west related to warming spring temperatures. It appears that the diet of ringed seals in western Hudson Bay consists largely of pelagic fish such as capelin and sand lance, whereas eastern Hudson Bay ringed seals rely more heavily on invertebrates. Spring temperature and timing of ice break-up were found to have a significant influence on ringed seal foraging ecology and population abundance, likely due to environmentally driven changes to prey availability. A summary of aerial seal surveys from 1995-2013 indicates a trend of declining seal abundance in western Hudson Bay and a possible die-off in 2010-11. Continued environmental and ecological change in Hudson Bay could have important consequences to the ringed seal energy budget and hence to their reproductive success and abundance. Research analysis for 2016 includes assessing movement behavior relative to sea ice condition data to understand seal population abundance patterns across Hudson Bay. Also, research continues into reproduction to assess a recent downward trend in ovulation and pregnancy rates and pups in harvest. Ringed seal spring abundance was surveyed in Eclipse Sound in 2016.

### 2.1.8 Bowhead Whale Foraging Behaviour (S. Ferguson, S. Fortune, A. Trites, M. Baumgartner)

This project will delimit summer and winter range, timing of migration, habitat use and diving behaviour of Eastern Canada-West Greenland bowhead whale population. Diving results were used to estimate a survey correction factor, in support of science advice for hunt management and habitat conservation. Bowhead tracks were added to a growing movement database and have provided insights into seasonal habitat use and timing of migration. Satellite tagging of bowhead whale took place in Foxe Basin and Cumberland Sound in July and August since 2008-2014. Tagging efforts in 2015 did not occur due to unusual sea ice conditions in Cumberland Sound. Over 200 skin/blubber biopsy samples have been obtained and were used to estimate bowhead abundance in a capture-mark-recapture genetic analysis.

This research project also examined bowhead whale diet composition across their eastern Canadian Arctic range and to understand bowhead whale habitat use in the context of foraging ecology. Bowhead whale diet was examined using several analytical tools including satellite telemetry, stomach content analysis and biochemical tracers (stable isotopes and fatty acids) in the skin and blubber of bowhead whales and of their

potential prey. Using telemetry, diet, and oceanographic results defined habitat features that characterize bowhead whale feeding (upwelling areas, sea ice cover, water masses). Research conducted in 2016 included using short-term tags to assess fine-scale foraging as well as net sampling of the water column to associate specific foraging behaviour to prey movements and deployment of long-term satellite tags and biopsy collection.

### 2.1.9 Movement Behavior and Estuary Use of Hudson Bay Belugas (S. Ferguson, M. Marcoux, M. Hammill)

Concerns have arisen over the status of the Western Hudson Bay beluga stock which has seen greater numbers being hunted in both Nunavut and Nunavik waters as well as increased predation pressure from killer whales. To better understand summer estuary site fidelity and critical habitat needs of belugas, nine whales were captured and outfitted with satellite transmitters in 2015 in the Churchill estuary. Killer whales attacked the belugas in the Seal River area in 2012 and tracking information was analyzed to assess predator avoidance behavior. The Churchill tagged beluga spent the fall in the western Hudson Bay before tags failed. These results add another key overwinter area for Hudson Bay beluga population that has recorded overwintering sites extending from the western side of Hudson Bay out to the Labrador Sea in the east. In collaboration with Quebec DFO region, past telemetry data back to the early 1990s is being analyzed to interpret inter-estuary use and movements to assess summer site fidelity and sub-population structure of the entire Hudson Bay beluga population. No tagging is planned for 2016.

### 2.1.10 Aerial Survey to Estimate Abundance of Western Hudson Bay Population (M. Marcoux, C. Matthews, S. Ferguson)

The Western Hudson Bay (WHB) beluga population was last surveyed in 2004 (Richard 2005) and corresponding telemetry tagging was performed in 2005-06. Although the WHB beluga population is considered the largest population in the world, a number of considerations make this survey a priority: (1) monitoring the demographic vigor of the world's largest beluga population by Canada is necessary to ensure successful stewardship,(2) over the past decade Nunavik has been successful in deflecting harvest away from the threatened Eastern Hudson Bay beluga population onto the WHB population, (3) harvesting of the WHB population by Nunavut has been high and possibly increasing, and (4) killer whale predation has increased with observations of predation on the WHB belugas during the past years.

The survey included both a visual observer portion of the offshore area and a photographic survey of high-density estuary regions (Seal, Churchill, Nelson, Severn, Winisk). The survey team used a twin otter with a field crew of five individuals: double platform front and back observers on each side of the plane observing through bubble windows and a camera operator in control of two continuously photographing cameras

angled out of the belly of the aircraft. The survey results will be part of a more complete Hudson Bay beluga population stock assessment that takes into consideration all jurisdictions and beluga stocks. Results were reviewed and science advice provided during the 2016 peer review that will assist with the management of all Hudson Bay stocks in combination as proposed by this aerial survey abundance estimate proposal.

### 2.1.11 Arctic Council/CAFF/Circumpolar Marine Biodiversity Program (S. Ferguson, G. Stenson)

The Arctic Marine Biodiversity Program (previously the CBMP-Marine Plan) is a circum-Arctic, long-term, integrated biodiversity monitoring plan developed by Conservation of Arctic Flora and Fauna's (CAFF) under the Arctic Council. The objectives of the CBMP-Marine Plan are to integrate existing circumpolar monitoring datasets and models to improve the detection and understanding of changes in Arctic marine biodiversity, as well as to inform policy and management responses to these changes. Of the five Expert Networks, the Marine Mammals Experts Network (MMEN) deals with the seven species of Arctic marine mammals with circumpolar or nearly circumpolar distribution: bowhead whale, narwhal, beluga, polar bear, walrus, ringed seal and bearded seal. A number of key stressors are affecting Arctic marine mammals, including climate change, harvesting, increased shipping, and emerging industrial activities, such as hydrocarbon and mineral exploration and production. To meet these challenges, Canada as a participating country, is represented by Fisheries and Oceans Canada (DFO) with S. Ferguson and G. Stenson as the Canadian leads of the MMEN. Current research is to coordinate monitoring and conducting analyses of marine mammals in the Canadian Arctic as part of Canada's international responsibility. To assist the MMEN five-year work plan we will continue community-based monitoring efforts and develop databases of relevant demographic, distribution, and condition information for all populations of marine mammals in the Canadian Arctic. This includes a summary of past abundance and harvest estimates to establish historic baselines and trends and as a reference for future monitoring. Existing data sets have been identified, aggregated and analyzed to establish indicator baselines on abundance of marine. In 2015-16 research focused on the collection and aggregation of harvest statistics for narwhal, bowhead, and walrus. Future efforts will focus on summarizing Canadian Arctic marine mammal body condition and health databases and movement/distribution, diet, genetics, contaminants.

### 2.1.12 Validation of oxygen isotopes ($\delta^{18}O$) as an approach for studying marine mammal migrations and distribution (C. Matthews, F. Longstaffe, S. Ferguson)

Stable isotope analysis of annual dentine growth layers in teeth is a relatively new approach to studying marine mammal migration and distribution. Consumer tissues such as dentine reflect the chemical composition of diet, which in turn reflects underlying biogeochemical processes. Oxygen isotope ratios ($^{18}O/^{16}O$; $\delta^{18}O$), for

example, differ between water bodies with high evaporation rates (causing relative $^{18}O$ enrichment, or higher $\delta^{18}O$ values) and those with considerable freshwater inputs, which have lower $\delta^{18}O$ values. Spatial variation in marine $\delta^{18}O$ values resulting from differential evaporation and precipitation rates is potentially useful for tracking marine mammal movements across $\delta^{18}O$ gradients, yet oxygen isotopes have rarely been used in this context. To assess dentine $\delta^{18}O$ values as a proxy for marine mammal migrations and distribution, we measured $\delta^{18}O$ values of dentine structural carbonate ($\delta^{18}Osc$) of seven odontocete species from seven regional water masses differing in baseline $\delta^{18}O$ values. Mean dentine $\delta^{18}Osc$ values were strongly correlated with water body, with lower values in high latitude regions (Arctic, eastern North Pacific) and higher values in the Gulf of Mexico and Mediterranean Sea. The correlation between dentine and environmental $\delta^{18}O$ values validates oxygen isotope measurements as a proxy for marine mammal migrations and distribution, and we suggest incremental $\delta^{18}O$ measurements along continuously growing tissues such as teeth and baleen, which archive intra- and inter-annual isotopic composition over the lifetime of the animal, will be particularly useful for characterizing movements among water bodies with strong $\delta^{18}O$ gradients. $\delta^{18}O$ measurements, for example, could be used to reconstruct high-latitude migrations of species like killer whales (*Orcinus orca*) and sperm whales (*Physeter macrocephalus*).

### 2.1.13 Individual diet specialization in Eastern Canadian Arctic beluga whales (C. Matthews, C. Wheeler, S. Ferguson)

We reconstructed longitudinal diet histories of individual eastern Canadian Arctic beluga whales (*Delphinapterus leucas*), a generalist marine consumer with a broad fish and invertebrate prey base, from profiles of stable nitrogen and carbon isotope ratios ($\delta^{15}N$ and $\delta^{13}C$) measured across annually deposited dentine growth layers. We also compared blubber fatty acid profiles to assess whether observed isotopic differences among individuals reflected diet, as opposed to habitat, differences. As expected, we found sex and age class were significant predictors of $\delta^{15}N$ values. However, there was pronounced, long-term isotopic variation among individuals of same sex and age class. Blubber fatty acid differences among individuals were consistent with isotopic differences, indicating isotopic variation was diet-based. We are currently analyzing whether the incidence of dietary specialization differs among populations and between the sexes, perhaps due to factors such as intraspecific competition (perhaps among animals from larger populations, or among females aggregated in river estuaries) and resource availability (e.g. more prey species available in southern latitudes, or in the deeper offshore habitat of males).

### 2.1.14 Abundance of beluga in eastern Hduson Bay and James Bay (J-F. Gosselin, A. Mosnier, L. Postma and M.O. Hammill)

Beluga whales are harvested for subsistence by hunters in Sanikiluaq (Nunavut) and hunters in northern Quebec (Nunavik). Aerial surveys were flown to obtain information

on beluga abundance in the eastern Hudson Bay area and in James Bay. A tissue collection program has been maintained in Nunavik since the mid-1990s. Hunters from Nunavik harvest animals belonging to an eastern Hudson Bay stock and animals from a Western Hudson Bay stock. Using mitochondrial DNA, harvested animals are allocated to the appropriate stock. Results from the survey, population modeling and genetic analyses were presented for peer-review in fall 2016.

### 2.1.15 Population modeling of Cumberland Sound beluga (M. Marcoux, M.O. Hammill)

The subsistence harvest of Pangnirtung, Nunavut, is directed towards a single stock of belugas (*Delphinapterus leucas*) in Cumberland Sound, which forms a separate stock among belugas in the Canadian Eastern Arctic. A population model incorporating updated information on harvest statistics (1920–2015) was fitted to four aerial survey estimates using Bayesian methods, resulting in a current estimated population of 1,000 (rounded to the nearest 100) animals. The management objective is to achieve a population of 5,000 animals by 2091. This could be expressed as an interim target of 1,235 animals within a decade (2026). At current reported harvest levels of 41 animals, the probability of the population declining over a 10-year period is 1. The probability that the population would increase to the interim target was 0.3, 0.25 and 0.1 for reported harvests of 0, 6, and 25 animals respectively.

### 2.1.16 Emerging Infectious Diseases in Marine Mammals (O. Nielsen)

The Department of Fisheries and Oceans in collaboration with American and international marine mammal scientists seeks to identify emerging pathogens of marine mammals. Submitted samples are tested in an effort isolate and characterize new marine mammal viral pathogens. Commencing in 2010 and continuing until the present, a never before seen seal malady was observed among ringed seals in western Hudson Bay. Affected seals were easily approachable on land, appeared sluggish, had a variety of skin lesions and had difficulty breathing. Polar bears were seen to be actively feeding on moribund seals. The syndrome spread to seals in other communities in the northern Canada and as far west as Alaska (2011) where it was reported to be affecting a number of ice seal species and walrus. Since it appeared to originate from a point source and spread out over time and space it was hypothesized that an infectious agent may be responsible. Testing samples from sick seals by an international group of marine mammal and disease specialists could not establish a primary cause for the problem. Sick seals continue to be reported in both Alaska and Canada and the investigation into the cause remains a priority for both the Canadian and US governments. Mr. Nielsen (DFO, Winnipeg) has recently developed new virus isolation methodologies and has isolated numerous virus isolates from both sick seal and walruses from Alaska. These new virus isolates are presently being identified in laboratories in the US. Once identified, their role in causing the sickness maybe come clearer. Work continues in 2016.

### 2.1.17 Incidence of beachcast Bowhead Whales in the southeast Beaufort Sea and Amundsen Gulf: update for 2015 (Harwood, L. A., Hall, P. A., Raverty, S. A., Linn, E., Lea, E. V., Postma, L. Nielsen, O)

Each spring, most Bowhead Whales (*Balaena mysticetus*) of the Bering-Chukchi-Beaufort (BCB) population migrate to the Canadian Beaufort Sea and Amundsen Gulf for summer feeding. From time to time, subsistence hunters, pilots, researchers and park staff observe beachcast (stranded) or adrift Bowhead Whale carcasses. Two beachcast bowheads were reported in 2015. From 1987 to 2015, 26 such occurrences were reported to the Department of Fisheries and Oceans (DFO. Most (65%) were found by Inuvialuit harvesters travelling on the land, and the majority (54%) from 2000 to 2006. Carcasses were found widely distributed throughout the region, with twice as many in Amundsen Gulf (65%) compared with the southeastern Beaufort Sea (35%). The mean rate of occurrence was 0.93 beachcast Bowheads/year from 1987 to 2015 (SD 1.14). Standard length was measured for 17 of the 26 specimens, and all were in one of two size groupings: provisional 'subadults' (7-9.5 m, n=10/17; 59%) or provisional 'mature adults' (13-16 m, n=7/17; 41%). The cause(s) of mortality was not determined for any of the specimens. Whales in the 'subadult' group were likely from 1 to 4 years of age, while the 'mature adult' group were likely mostly mature animals, including some potentially very old. Polar and/or grizzly bears were observed scavenging at most carcasses. It is important to continue to record the incidence of beachcast Bowhead Whales, as this is the only available means to examine their rate of occurrence, a metric that may be important when widespread mortality occurrences or unusual stranding events are reported or designated, respectively.

### 2.1.18 Long term monitoring of ringed seal body condition and reproduction in Canada's Western Arctic: an update through 2015 (Harwood, L.A., Smith, T. G., Melling, H., Alikamik, J., Kingsley, M.C.S, Lea, E. V.)

A subsistence harvest-based sample of approximately 100 ringed seals annually was obtained from 1992 to 2015, by hunters from Ulukhaktok at a traditional hunting camp located on the northwest shore of east Amundsen Gulf. Since 1970, ice conditions in east Amundsen Gulf, the main habitat used by the local seal population during all seasons, have shown a modest but significant trend toward earlier clearance (break-up) in spring (8.2 d/decade; ($p<0.05$), an extended open water season (10.2 days/decade) and a slight trend toward later freeze up in the fall (1.9 days/decade). The previously described temporal trend of declining body condition remained statistically significant considering the 24 y record ($p<0.05$), although there was an apparent although modest shift in trend since 2013. We have once again observed a failure of reproduction, in 2012 and with effects lasting through 2014, making a total of four such episodes for this population since studies of this kind were initiated in the 1970s (occurrences in 1974, 1987, 2005, 2012). What set the 2012 failure apart from all previous episodes was that

it was not associated with severe sea ice conditions in east Amundsen Gulf. Looking to other possible connections or causes, we note that similar reproductive failures occurred in Hudson Bay during the corresponding period, and also that the failures were coincident with a pinniped unidentified mortality event (UME) in 2011 to 2014 which occurred in the Nearctic.

### 2.1.19 Movements, habitat use, and inferred foraging by bowhead whales in the Canadian Beaufort Sea during August and September (Harwood, L. A., Quakenbush L. T., Small R. J., George J. C., Pokiak, J., Pokiak, C., Heide-Jørgensen M. P., Lea, E.V., and Brower H.)

Each spring, most bowhead whales of the Bering-Chukchi-Beaufort population migrate to the southeast Beaufort Sea and summer in Canadian waters. They form aggregations in August and September, mainly in the shallow, shelf waters when oceanographic conditions promote concentration of their zooplankton prey. In this study, of 20 satellite-tagged whales that could have spent some time in the southeast Canadian Beaufort Sea during late summer 2006 to 2012, 17 (85%) spent all or part of August and September there. Location data were analysed using a two-state switching correlated random walk (CRW) behavioural model for 16 whales and we classified locations in the Canadian waters as associated with lingering behaviour (inferred foraging) or directed travel. We found that these whales spent the greatest proportion of their time lingering (59%), followed by travelling 22%, and 19% transitioning between lingering and travelling. Using only lingering locations, and for all tagged whales and all study years pooled, we calculated kernel densities and defined five areas within the 75% density contour as aggregation areas. Together, the five aggregation areas we defined comprised 25,341 km2, 14.1% of the total area used by these tagged whales in Canadian waters during August and September of the deployment years. Tagged whales were observed to use one or two aggregation areas in a single season, and rarely more. The proportion of lingering time spent in each aggregation area was highly variable among individuals. Three aggregation areas were located in shallow waters of the Beaufort Sea Shelf and were used almost exclusively by immature tagged whales in our sample. Two other aggregation areas were observed; both were defined by one mature whale each, one in the Darnley Bay area slated for designation as a Marine Protected Area, and one in the deep waters of distant Viscount Melville Sound in the Canadian Arctic Archipelago.

## *2.2 ATLANTIC*

### 2.2.1 Diet of Grey Seals in the central Gulf of St Lawrence (M.O. Hammill)

Grey seal predation has been identified as a potential contributing factor to the high adult mortality observed in the southern Gulf of St. Lawrence (NAFO area 4T) Atlantic cod. Estimates of consumption indicate that significant amounts of 4T cod are being

consumed by grey seals. Sampling was initiated in the Magdalen Islands area of the central Gulf of St Lawrence in 2010. Diets are dominated by sandlance and flatfish. Overall, cod accounts for about 10% of the diet in this region, with males consuming more cod than females.

### 2.2.2 Assessing the status of grey seals in the Northwest Atlantic (M.O. Hammill, W.D. Bowen, G.B. Stenson)

Grey seals form a single genetic population that can be divided into three groups for management purposes based on the location of breeding sites. Most pups (78%) are born on Sable Island, 18% are born in the Gulf and 4% are born along the coast of Nova Scotia. This distribution has changed over time, with a decline in the fraction of the population born on the ice compared to on small islands, and an increase in the proportion of animals born on the coast of Nova Scotia, compared to the Gulf. Reproductive data from the Gulf of St Lawrence were re-analysed and indicate that there has not been any decline in reproductive rates among females aged 8 years and older. This segment of the population accounts for 70% or more of annual pup production. The last review was completed in 2010. There is little information on environmental carrying capacity and on the shape of the density-dependent relationship. Previous model runs suggested that the population was over 500,000 animals in Atlantic Canada in 2014. However, a new pup production survey was flown in 2016 and was reviewed in fall 2016.

### 2.2.3 Grey seal foraging behaviour (W.D. Bowen, D. Lidgard, S. Iverson, M.O. Hammill)

Research aimed at determining the spatial and temporal pattern of encounters between greys seals and potential prey and competitors entered its sixth year of deployments of grey seals equipped with Argos GPS tags and mobile transceivers to detect acoustically tagged Atlantic cod, salmon and tuna as part of the Ocean Tracking Network. Instrumented seals were deployed from Sable Island and in the Gulf of St. Lawrence, off Brion Island.

### 2.2.4 Developing Improved Methods of Determining Diets (G.B. Stenson)

Current methods of diet analysis in marine mammals, particularly hard part analysis (HPA), have biases that will affect the accuracy of species and frequency of prey in estimated diet. An ongoing study is examining the biases associated with all methods of diet analysis in marine mammals. The biases associated with hard part analyses, genomics, fatty acid signatures are being studies to enable us to determine the diet of seals accurately. Comparing of the diets of harp and grey seals using stomach contents and hard part remains from various portions of the intestines provides us with an understanding of the importance of retention and passage rates when determining diets.

### 2.2.5 Diet of Grey seals in Newfoundland waters (G.B. Stenson, M.O. Hammill)

The diet of grey seals inhabiting Newfoundland was determined from samples collected by hunters around the province. Sand lance were the primary prey of grey seals collected in this area. This study is a joint project between Fisheries and Oceans, Canada, Memorial University and the Fish, Food and Allied Workers Union. The study has also examined the impact of assumptions associated with hard part analysis in estimating diet composition. Additional samples were collected in 2015 and are being analysed.

### 2.2.6 Killer Whales of Atlantic Canada, Ongoing (J.W. Lawson)

To assess the status of killer whales in this region, and therefore their susceptibility to anthropogenic threats, DFO continues to collect information on their abundance, distribution, and lifestyles through a combination of photographic identification, directed and opportunistic sightings collection, and genetic and acoustic sampling.

Based on sightings and a multi-year photographic catalogue; there were almost 1,400 sighting events between 1758 and 2016, with almost half recorded in the last 10 years, and during the June-September period in the Newfoundland and Labrador Region. This temporal and spatial pattern is likely a reflection of observer effort and an increased public awareness for this species.

In Atlantic Canada, killer whales have been sighted both alone and in groups, with most groups have been comprised of 3-7 individuals. Based on the photographic records analyzed to date, there are at least 80 individual killer whales in this region, although this is an underestimate given that DFO is still reviewing its photographic collection, and given the positively-sloped discovery curve. Results of this population study were published (Lawson and Stevens 2013).

DFO is continuing to collect further imagery and biopsy sampling to examine stock structure and relationships with other north Atlantic populations such as Greenlandic killer whales. DFO will also undertake a satellite tagging programme in 2016 in an effort to track killer whale groups. A presentation describing the social cohesion and hunting behaviour of killer whale groups in the region was presented at the 2015 biennial conference; a presentation on further analyses of killer whale foraging was presented at the 2016 Ocean Sciences Meeting.

### 2.2.7 Standardized, Risk-based Framework for Assessing Cumulative Impacts of Marine Development Projects, Including Arctic Shipping and

## Seismic, on Marine Mammals and Sea Turtles in Canada, Ongoing (J.W. Lawson and V. Lesage)

This SPERA-funded project is addressing priorities on Ecosystem Impacts of Human Activities and will also provide ways for Assessing and Reporting on Ecosystems. Building on a draft framework to quantify risks of impacts on Arctic marine mammal populations from shipping noise or ship strikes (Lawson and Lesage 2013), we are expanding this approach into a national risk-based framework, which will also include seismic exploration activities, other impulsive sound sources, noise from subsea cable laying activities, and other marine predators such as marine turtles. This enhanced framework will incorporate effective thresholds for assessing impacts against population productivity in the context of population sustainability, and will account for uncertainty in input parameters, and to assess cumulative impacts from multiple activities and/or projects and on multiple ecosystem components. The end products will include: (1) a user-friendly electronic tool for evaluating MDP impacts in an objective, stepwise manner, (2) clear guidance for DFO staff and Industry as to the information required from proponents to assess MDP impacts adequately, (3) the criteria to determine probability and magnitude of such impacts, and (4) means to cumulate MDP impacts at the population and regional levels.

In association with other DFO colleagues in other regions, together with marine mammal researchers from multiple NGOs and other countries, a two-day international workshop was held in Quebec City in March 2014 to begin the expert consultation process to refine the framework. A second workshop was held in March 2015 to further develop the approach, and prepare the roll-out of the framework. To date, products of this workshop include two Research Documents (Lawson, J.W. and V. Lesage. 2016. Modelling ship strike risks for marine mammals and sea turtles. DFO Can. Sci. Advis. Sec. Res. Doc. 2016/nnn. v+22p.; Lesage, V. and J.W. Lawson. 2016. Cumulative ecological risk assessment framework (CERAF) for impacts of marine development projects on marine mammals and sea turtles. DFO Can. Sci. Advis. Sec. Res. Doc. 2016/nnn. vi + 30 p.), a Proceedings document (DFO. 2016. Proceedings of the international peer review of a risk-based framework for assessing cumulative impacts of marine development projects (MDPs) on marine mammals and sea turtles; March 3-5, 2015. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2016/nnn), and a paper (Gómez, C., Lawson, J.W., Wright, A., Buren, A., Tollit, D., and Lesaqe, V. 2016. A systematic review on the behavioural responses of wild marine mammals to noise: the disparity between science and policy. Can. J. Zool. In press). The team also began collecting the spatially- and temporally-linked information (e.g., biotic and abiotic features such as marine mammal distribution, ecosystem productivity, characteristics of the underwater soundscape) in the Atlantic and Arctic, which is needed to operationalize the framework.

## 2.2.8 Mid-Labrador Marine Megafauna and Acoustic Survey, 2013 to 2015 (J.W. Lawson, A.D. Buren, G.L. Sheppard)

The Labrador coast may be a significant source of petrochemical products in the future. Residents' concerns about the potential impacts of industrial efforts to extract oil and gas off Hopedale and other sites on the Labrador Shelf is paired with a paucity of baseline knowledge concerning the abundance and distribution of marine mammals, seabirds, and other marine fauna which might be affected by anthropogenic activities. In addition to marine mammal and seabird issues, baseline measures of natural and anthropogenic sounds on the Labrador coast are needed to assess the potential impacts of the noise from petrochemical development on marine mammals such as endangered cetaceans, and coastal ringed and harp seal populations which are important to hunters.

Environmental Studies Research Fund (ESRF) provided funding to DFO and Environment Canada (EC) to conduct aerial and boat-based surveys of a study area, in waters adjacent to the mid-Labrador coast, to estimate the distribution and abundance of marine fauna - including marine mammals and seabirds. Additional equipment and expertise was provided by DFO and EC.

Total survey effort was 1,264 nautical miles flown in October and November, 2013. In addition to sightings of cetaceans and pinnipeds, we analysed the records from the autonomous acoustic recorders (in which we have detected calling pinnipeds and cetaceans throughout the year, with some unexpected occurrences such as calling humpbacks in November). We conducted a second larger-scale, replicate aerial survey of this study area in 2014, and retrieved/re-deployed the acoustic recorders (which were retrieved in 2015).

Analyses of the visual and acoustic data revealed that white-beaked dolphins, Risso's dolphins, pilot whales, and fin whales were the most common marine mammals seen in this area in summer and fall. The acoustic data confirmed these visual results, with the addition of blue, sei, humpback, and sperm whales; many marine mammals continued to be detected throughout the winter, when sea ice would have necessitated that the cetaceans move further offshore to open waters. The primary anthropogenic contribution to the southern Labrador soundscape was vessel noise, with daily passage of three to seven vessels detected clearly, plus much more lower-level background vessel noise from more distant ships. The level of anthropogenic noise did not decline significantly in the winter, although ice movement and storms become more important contributors.

### 2.2.9 Laurentian Channel Marine Protected Area – Science Monitoring, 2012 to 2015 (J.W. Lawson, B. Stockwood, G.L. Sheppard, A.D. Buren, P. Goulet)

As part of a multi-year, multi-disciplinary project (see Lewis et al. 2015), members of the Marine Mammal Section have been conducting aerial and acoustic surveys in a large study area off the south coast of Newfoundland. The aerial data will be used to characterise the abundance and distribution of the biological components of this area

(marine mammals, sea turtles, large sharks, sunfish, and seabirds). The acoustic data will be used to characterise the underwater soundscape of this area (marine mammals, ambient sounds, shipping and seismic). Two aerial surveys, one in March and one in September, were flown in 2014 and another in August of 2015. Many cetaceans, sunfish, leatherback sea turtles and large sharks have been sighted during the visual surveys to date. Three of the four acoustic recorders were recovered in the spring of 2015 and contained much data, including northern right, blue, fin and sperm whale sounds; the greatest contributor to the anthropogenic acoustic energy budget was commercial shipping. The study is planned to continue for several more years.

### 2.2.10 Acoustic Programme in Collaboration With St. Pierre et Miquelon Off the South Coast of Newfoundland, 2011 to Now (J.W. Lawson, Association SPM Fragîles, O. Adam)

In association with Association SPM Fragîles, DFO again assisted with construction and deployment of a new mooring and deployment of AURAL acoustic recorders to the north and south of the French islands of St. Pierre et Miquelon off the south coast of Newfoundland to study the distribution and identity of marine fauna based on vocalization patterns.

The sounds made by humpback, fin, and minke whales, plus odontocetes such as pilot, sperm, and northern bottlenose whales, and dolphins have been detected. DFO researchers in Newfoundland and Quebec have developed more formal agreements with Dr. Adam (France) to facilitate a student project to analyse these data. All acoustic data collected by DFO NL on the south coast of Newfoundland for the past four years was sent to Dr. Adam to begin the process of filtering the data through automatic acoustics detectors for blue and killer whales initially.

One of the benefits of the DFO and French deployments on the Newfoundland south coast has been an opportunity to compare vocal patterns of cetaceans over a broad area of the northwest Atlantic. We developed a new stock structure model for western and central North Atlantic fin whales (*Balaenoptera physalus*) based on geographic song variations as recorded using DFO, French, and JASCO acoustic recorders (Delarue et al. 2013), and will continue to use these shared data to characterize the acoustic soundscape of these French waters, which are immediately east of the Laurentian Channel Marine Protected Area (see above).

### 2.2.11 Habitat Use by Northwest Atlantic Seals (G.B. Stenson, M.O. Hammill)

In order to determine movements and habitat use by northwest Atlantic hooded seals, a cooperative project between DFO and the Greenland Institute of Natural Resources was initiated in 2004. Papers describing habitat selection and an analysis of diving behaviour by hooded seals have been published. Many pinniped species perform a specific dive

type, referred to as a 'drift dive', where they drift passively through the water column. This dive type has been suggested to function as a resting/sleeping or food processing dive, and can be used as an indication of feeding success by calculating the daily change in vertical drift rates over time, which reflects the relative fluctuations in buoyancy of the animal as the proportion of lipids in the body change. A study of Drift diving in hooded seals was completed and published in 2014 (Andersen et al 2014). Northwest Atlantic hooded seals perform drift dives at regular intervals throughout their annual migration across the Northwest Atlantic Ocean. We found that the daily change in drift rate varied with geographic location and the time of year and that this differed between sexes. Positive changes in buoyancy (reflecting increased lipid stores) were evident throughout their migration range and although overlapping somewhat, they were not statistically associated with high use areas as indicated by First Passage Time (FPT). Differences in the seasonal fluctuations of buoyancy between males and females suggest that they experience a difference in patterns of energy gain and loss during winter and spring, associated with breeding. The fluctuations in buoyancy around the moulting period were similar between sexes.

Oceanographic data were also collected by the transmitters. Data collected by hooded seals was combined with temperature data from other marine mammals and traditional oceanographic monitors to determine the timing of the arrival of warm water on the Greenland shelf. The results of this study were published in 2014 (Grist et al 2014).

### 2.2.12 Role of Harp and Hooded seals in the Northwest Atlantic Ecosystem (G.B. Stenson, M. Koen-Alonso)

Multi-disciplinary studies on harp and hooded seal population dynamics and seal-fish interactions continued in 2015. Bioenergetic-allometric biomass dynamic models were constructed to determine if predation by seals is an important factor controlling the population dynamics of Atlantic cod or capelin in the area. Overall, the best model to fit the data to explain abundance of cod was one including capelin and fisheries catches, but without seal consumption. Based upon the results of this simple model, consumption of cod by harp seals does not appear to be an important driver of Northern cod during the study period. Instead, fisheries and availability of food appear to be the important drivers of the dynamics of this stock. Environmental factors such as ice cover appear to be more important in influencing the dynamics of capelin stocks than seal predation.

Additional samples of diets in Newfoundland have been collected and are being analyzed.

### 2.2.13 Biological Sampling of Northwest Atlantic harp, hood, ringed and grey seals (G.B. Stenson, A.D. Buren, J.W. Lawson, M.O. Hammill)

An ongoing programme of collections involving sealers and DFO personnel from Newfoundland, Labrador and the Gulf of St. Lawrence continues to provide annual biological samples of seals captured during the commercial hunt in the region. These data facilitate the long term monitoring of reproductive status, diets, and the growth and condition of seals during a period of significant ecological change.

### 2.2.14 Stock structure of harp seals (G.B. Stenson, S.Carr)

A genomic study to determine stock structure of North Atlantic harp seals was carried out using the complete gene sequence of mitochondrial DNA. Harp seals have historically been separated into three putative populations based upon their whelping locations, the White Sea Barents Sea, the Greenland Sea and the Northwest Atlantic. The latter population is considered to have two whelping locations, one being off northeast Newfoundland and southern Labrador ('The Front') and the other in the Gulf of St Lawrence. DNA sequencing on microarrays was used to obtain complete genomes of more than 50 Harp Seals. Monte Carlo simulation indicates that there is a significantly non-random distribution of families among breeding patches. The genomic analyses supports the existence of three genetically distinguishable populations of Harp Seals in the White Sea, Greenland Sea, and Northwest Atlantic. and indicated a "stepping stone" model of East ◄► West dispersion across the Atlantic. The White Sea/Barents Sea population was considered to be the oldest branch while the Greenland Sea was estimated to be the youngest. The Front and Gulf whelping areas were considered to be of intermediate age.

### 2.2.15 Changes in reproductive rates in northwest Atlantic harp seals (G.B. Stenson, A.D. Buren)

Obtaining accurate estimates of reproductive rates are critical for estimating the population dynamics of a species. Recent estimates of late term pregnancy rates, fecundity and abortion rates of Northwest Atlantic harp seals were obtained from samples collected off the coast of Newfoundland and Labrador. The declining, but highly variable, reproductive rates reported previously have continued with the pregnancy rate of mature females (2010 and 2011; <0.3) falling to the lowest level since data was first collected in the 1950s. Using a fixed-dispersion, beta regression model to explore the importance of biological and environmental conditions, we found that reproductive rates were influenced by both density dependent and independent factors. While the general decline in fecundity is a reflection of density-dependent processes associated with increased population size, including the late-term abortion rates captured much of the large inter-annual variability. Changes in the annual abortion rate could be described either by a model that incorporated ice cover in late January or a model that incorporated ice cover and capelin biomass obtained from the previous fall as a proxy for prey availability. Using these models, we predicted the 2012 fecundity rate to be 0.44 or 0.54, depending upon the model used which is lower than the

estimate (0.643) obtained from the small sample of reproductive tracts (Stenson et al 2014b).

### 2.2.16 Assessing the status of Northwest Atlantic harp seals (G.B. Stenson, M.O. Hammill, J.W. Lawson, J.F Gosselin)

The population model used to estimate total abundance of Northwest Atlantic harp seals was reviewed and published in the primary scientific literature. Harp seals require pack ice as a platform for resting, to give birth and nurse their young. They are also subject to commercial and subsistence harvesting. In the late 1990's there were concerns that the Northwest Atlantic population would decline to very low levels unless a management system using Potential Biological Removals (PBR) was adopted. Canada followed a different approach and high harvests based on an alternative management framework continued throughout the next decade. We examined the status of the Northwest Atlantic harp seal population using a three-parameter population model that incorporates information on reproductive rates, removals, and ice-related mortality acting on young of the year. By 1971, the population had declined to a minimum of 1.1 million animals and a quota was introduced, which allowed the population to increase. In 1996, the quota was raised and harvests increased substantially. Population growth continued, even as herd productivity declined. The population reached a maximum of 7.8 million animals in 2008 and has leveled off at around 7.4 million animals. Climate change is expected to result in a decline in the amount of seasonal pack ice in Atlantic Canada, which adds uncertainty to the future of this population. Although the results presented in this paper focused on how the status of this population has evolved over the last 60 years, our integrated modeling approach can also be used to examine scenarios that project into the future, to test the impacts of various management decisions in a changing environment.

### 2.2.17 The Impact of Climate Change on NWA Harp Seals (G.B. Stenson, M.O. Hammill)

Climate change associated declines in sea ice will have serious impact on species that rely on ice for reproduction and/or feeding. Little is known about the impacts on ice-dependent, sub-Arctic species or on how these species may adapt, although the ecosystem changes are likely to be most rapid along the ice edge. Harp seals (*Pagophilus groenlandicus*) require stable ice for pupping, nursing and the first weeks after weaning when the young develop the capacity to swim and feed. Although ice conditions in the Northwest Atlantic have varied over the past 40 years, in 2010 and 2011, the total extent of ice suitable for whelping harp seals was at, or near, the lowest ever recorded. These years of exceptionally poor ice provided us with an opportunity to improve our understanding about how ice-breeding seals may respond to the conditions expected in the future. Harp seals responded to poor ice conditions differently, depending on the presence or absence of ice at the beginning of the pupping period. If no ice was present, females moved away from their traditional whelping areas to find

suitable ice. If small amounts of ice were present, females gave birth even if the ice was too thin to sustain the pups, resulting in high pup mortality. There was no evidence to indicate that harp seals pupped on land even in areas where ice was absent. Young seals that drifted to shore had high levels of abandonment and mortality. If the predicted warming trends continue, ice-breeding harp seals will encounter more years with poor ice conditions and may eventually adapt by moving north. Until then, they will continue to have increased levels of mortality that could result in the disappearance of the most southern breeding component in the Gulf of St. Lawrence (Stenson and Hammill 2014).

Harp seals require stable ice as a platform for resting, pupping and rearing their young. Changes in ice cover in Atlantic Canada during the period of pupping and when the young animals or beaters are leaving the ice to forage on their own were examined between 1969 and 2013, using ice cover data from Environment Canada. The annual extent of ice cover has varied considerably, particularly in the Gulf of St Lawrence (Gulf). Overall, ice cover has declined during the pupping period, due to a decline in ice cover in the Gulf of St Lawrence. No significant trend in ice cover in southern Labrador, which includes the area known as the Front, was observed over the last 44 years. However, a decline in ice cover during April was observed at both the Front and in the Gulf. There is no direct measure of mortality in the harp seal assessment. Mortality of young of the year associated with very poor ice conditions has been identified and incorporated into the assessment since 2003. This mortality index is qualitative being based on expert opinion. An index was developed, based on the magnitude of the negative ice anomaly for the Gulf and the Front. This index suggests that ice related mortality may have been as high as 65% of the total number of pups born in 1969 and 2011 (Hammill and Stenson 2014).

### 2.1.18 Monitoring vital parameters of pinnipeds in the Newfoundland Region (G. Stenson, J. Lawson, A. Buren)

An ongoing programme of collections involving sealers and DFO personnel from Newfoundland, Labrador and the Gulf of St. Lawrence continues to provide annual biological samples of seals (Harp, Hood, Ringed, Bearded, and Grey) in the region. These data facilitate the long term monitoring of reproductive status, diets, and the growth and condition of seals during a period of significant ecological change. Multi-disciplinary studies on Harp and Hooded Seal population dynamics, seal-fisheries interactions, and the impact of climate change continued in 2015.

### 2.2.19 Passive acoustic monitoring of cetaceans and ocean noise on the Scotian Shelf (H. Moors-Murphy and N. Cochrane)

DFO-led long-term passive acoustic monitoring efforts continue on the eastern Scotian Slope, and have been expanded to other locations on the Scotian Shelf.

An initial two-year (September 2012-September 2014) near-continuous acoustic dataset using bottom-mounted autonomous multichannel acoustic recorders (AMARs; © JASCO Applied Sciences) was collected from three locations on the eastern Scotian Slope: the Gully Marine Protected Area (MPA), between the Gully and Shortland canyon, and between Shortland and Haldimand canyons (Figure 1). This dataset has been analyzed for the presence of blue, fin, sei, humpback, right, sperm, northern bottlenose, Sowerby's beaked and Cuvier's beaked whale vocalizations, as well as small the vocalizations of delphinids (e.g., pilot whales, common dolphins, Atlantic white-sided dolphins). Additionally, the received acoustic levels on these recordings have been analyzed to characterize deep-water ambient background noise levels in the Scotian Slope region. Much of this work has been completed in collaboration with JASCO Applied Sciences, and results from this analysis are currently being compiled into various reports/manuscripts.

During summer 2014 (May-September) a wide azimuth seismic survey was conducted in the mid-Scotian Shelf region. Two additional AMARs were deployed by DFO from July-September 2014 around the Gully MPA to collect additional information on received levels of seismic airgun noise within and in areas adjacent to the MPA. Analysis of this dataset is ongoing.

Starting in spring 2015, AMARs are being used to continue monitoring the Gully MPA as well as four new locations of interest for cetacean presence: Emerald Basin, the Stone Fence area at the eastern edge of the Scotian Shelf, and two locations in the St. Anns Bank Area of Interest (Figure 2). Year-long deployments are being conducted in these areas, with the goal of collecting two years of data from each site.

Information collected from these passive acoustic is essential for assessing the year-round importance of these areas off Nova Scotia to cetaceans and for gaining a better understanding of the current acoustic environment in the region. Such knowledge is vital for evaluating and mitigating the potential impacts and cumulative effects of anthropogenic activities on species at risk and in areas of enhanced biological importance.

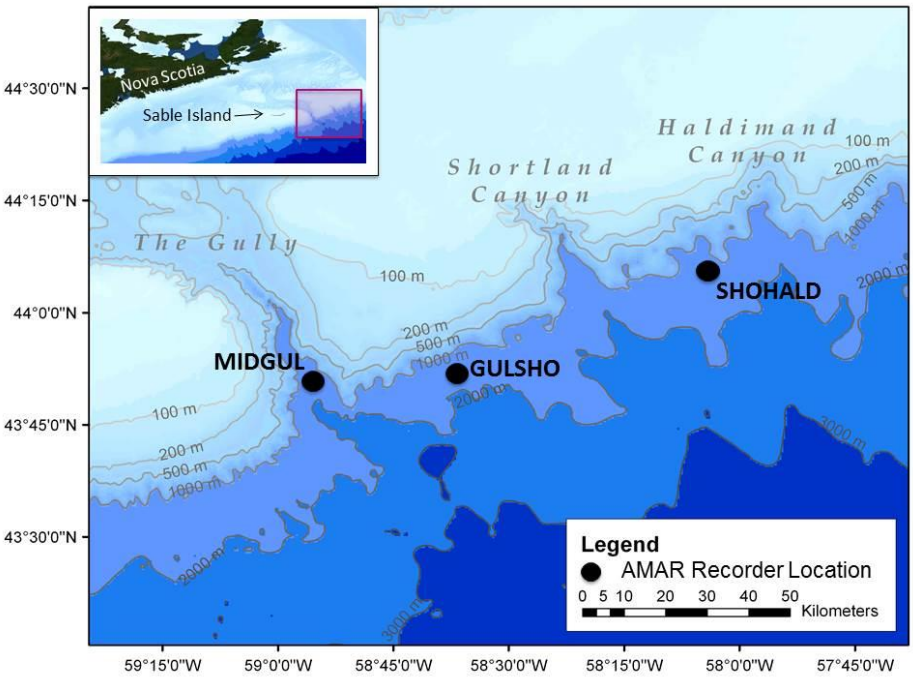


Figure 1. Locations of 2012-2014 eastern Scotian Slope AMAR deployments.

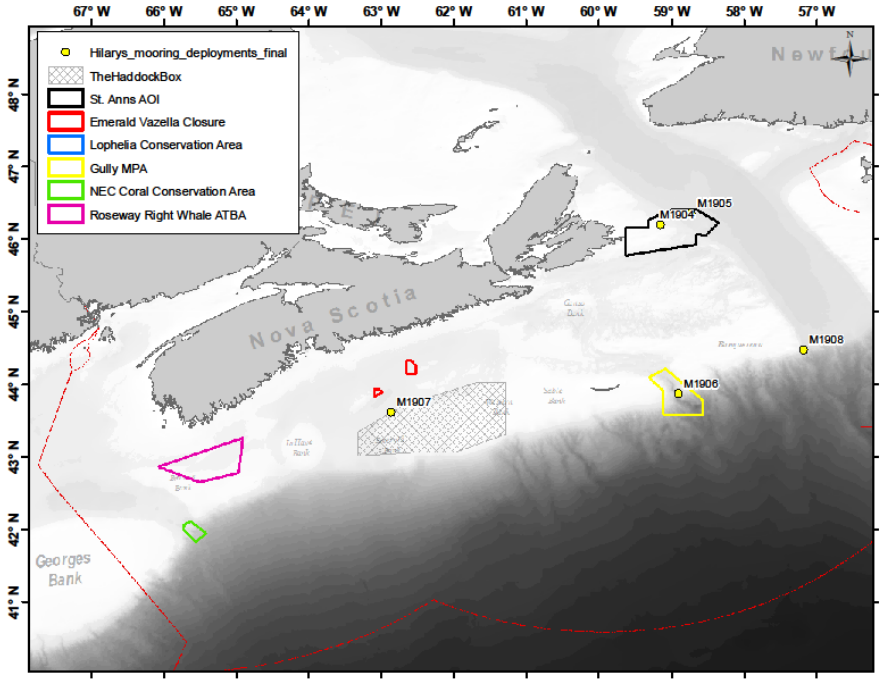


Figure 2. Locations of 2015-2017 Scotian Shelf AMAR deployments.

### 2.2.20 Investigation of species distribution modelling techniques to assess cetacean distribution on the Scotian Shelf (C. Gómez-Salazar and H. Moors-Murphy)

The majority of data available to assess cetacean occurrence in the Scotian Shelf region is opportunistic sightings data collected from various sources. As a result, only limited and general knowledge of distribution is available for most species that occur in the area. Species distribution models (SDMs) have been proposed as a potential tool to make the most of available data for assessing species distribution. A study was conducted to investigate the potential of using SDMs to examine cetacean distribution on the Scotian Shelf through a scientific literature review of SDMs used for cetaceans, compiling and evaluating cetacean sightings and environmental data available for the Scotian Shelf, and applying chosen SDMs to selected species (Gómez-Salazar and Moors-Murphy 2014). As a case study, Maximum Entropy (MaxEnt) models using five environmental variables: ocean depth, seafloor slope, seafloor aspect, sea surface temperature and chlorophyll-a concentration were performed for northern bottlenose and Sowerby's beaked whales. The potential effectiveness of SDMs to predict key areas to monitor for cetaceans within the Scotian Shelf Bioregion was highlighted through this study, though a major conclusion was that further refinement is needed before results can be more broadly applied. Subsequently, a large effort was made in 2015 to further refine these models, expand the study area to include waters off Newfoundland and Labrador and update the information being input into the models (such as the cetacean sightings data). The models were run for the 15 most commonly occurring cetacean species in eastern Canada. Results are currently being compiled into a report. Such prediction and delineation of species' distribution can be used to identify important cetacean habitat, highlighting key areas to consider for conservation.

### 2.2.21 Review of seismic mitigation measures (H. Moors-Murphy and J. Theriault)

In March 2014 a Canadian Science Advisory Secretariat (CSAS) meeting was held to review whether the mitigation measures currently outlined in the Statement of Canadian Practice with respect to the Mitigation of Seismic Sound in the Marine Environment would meet Species at Risk Act (SARA) requirements for threatened and endangered cetaceans. The objectives of this review were to: (a) examine potential sound exposure metrics and thresholds that could be used to avoid impacts (killing, "harm" and "harassment") to individuals of SARA-listed cetaceans and "destruction" of their critical habitat, as required under SARA; (b) determine efficacy of the SOCP in meeting SARA requirements for protecting individuals and their critical habitat; and, (c) identify modifications to the SOCP or additional mitigation and monitoring measures that could be used to meet SARA requirements. The outcomes of this meeting were published in 2015 (DFO 2015, Theriault and Moors-Murphy 2015).

# 3.0 CATCH DATA

a. Pinnipeds

| | Atlantic Canada (including Quebec) | Eastern Canadian Arctic |
|---|---|---|
| Harp Seal | 35,382 | no data |
| Hooded Seal | 1 | no data |
| Bearded Seal | 0 | no data |
| Grey Seal | 1151 | no data |
| Harbour Seal | 0 | no data |
| Walrus | 20 [1] | 129 [2] |
| Ringed Seal | 0 | no data |

b. Cetaceans

| | Western Canadian Arctic | Eastern Canadian Arctic | Quebec Region |
|---|---|---|---|
| Beluga | 75 | 6593 | 204 |
| Bowhead | 0 | 24 | 0 |
| Narwhal | 0 | 9125 | 26 |

1 – This number does not include all of the walrus harvested in the Nunavik Marine Region
2 – 3 communities have not reported their harvest
3 – 2 communities have not reported their harvest
4 – includes one bowhead that was struck and lost
5 – includes 246 narwhal that were landed and struck and lost during the humane harvest in Eclipse Sound
6 – two narwhal that were struck and lost

# 4.0 BYCATCH DATA

There is no systematic reporting of bycatch of marine mammals for most species in Canada. Currently, there is a dedicated analysis of certain marine mammals in Newfoundland and Labrador Region.

# 5.0 SCIENCE ADVICE PROVIDED

Canadian Science Advisory Secretariat Reports (advice provided in 2015):

- PRELIMINARY ESTIMATES OF HUMAN-INDUCED INJURY AND MORTALITY TO CETACEANS IN ATLANTIC CANADA
- ESTIMATES OF ABUNDANCE AND TOTAL ALLOWABLE REMOVALS FOR HUDSON BAY-DAVIS STRAIT ATLANTIC WALRUS (*Odobenus rosmarus rosmarus)*
- Population reduction scenarios for NORTHWEST ATLANTIC HARP SEALS, *Pagophilus groenlandicus*
- STATUS OF BELUGA WHALES (*DELPHINATERUS LEUCAS*) IN THE ST LAWRENCE RIVER ESTUARY
- ESTIMATES OF ABUNDANCE AND TOTAL ALLOWABLE REMOVALS FOR ATLANTIC WALRUS (*Odobenus rosmarus rosmarus*) IN THE CANADIAN ARCTIC
- Review of Mitigation and Monitoring Measures for Seismic Survey Activities in and near the Habitat of Cetacean Species at Risk.
- Pathways of effects for shipping: An overview.

# 6.0 PUBLICATIONS AND DOCUMENTS

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