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FISHERIES & OCEANS CANADA PROGRESS REPORT ON MARINE MAMMAL RESEARCH AND MANAGEMENT IN 2017

May, 2018

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

Temporal synchrony in Atlantic walrus haul out behaviour (P. Blanchfield)

The goals of this study are to quantify temporal variation in Atlantic walrus abundance at terrestrial haul out sites, and to examine behavioral synchrony of site occupation. Both temporal variation and synchrony have implications for population estimation of walrus using aerial survey methods. We installed time-lapse cameras that monitored walrus haul out sites on Walrus Island, NU, over a month-long period that included when an aerial survey was conducted by DFO. Substantial temporal variation was observed, where number of walrus counted across sites fluctuated from 0-2039 during several haul out bouts that each lasted from 4-6 days. The number of walrus hauled out was highly correlated ($P < 0.001$) among sites, suggesting haul out synchrony, and was influenced, in part, by weather. Synchronous behaviour produces substantial temporal variability in the proportion of the walrus population hauled out at any given time, and violates a basic assumption associated with current population estimation methods. Data analyses are ongoing and future work will involve satellite telemetry tagging to examine movement patterns and habitat use.

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. Mr. Nielsen (DFO, Winnipeg) has recently developed new virus isolation methodologies and has isolated numerous virus isolates from both healthy/sick and dead stranded marine mammals. These new virus isolates are identified in laboratories in the US and their full genomes are now becoming available. New virus isolates include a beluga alphaherpesvirus isolated from both sick and healthy belugas from Arctic

Canada and Alaska. A number of gammaherpesviruses from seal species from Canada and Alaska are being analyzed with regard to their ability to cause serious disease in infected seals. A new Rotavirus species has been isolated from a dead stranded Steller Sea Lions, the full genome has been determined and a paper describing the finding is being prepared. A new species of Picornavirus has been isolated from a dead stranded Ribbon seal also from Alaska. This seal was part of the recent unusual mortality event occurring in Alaska, the role of this new virus in causing seal death is being investigated within the larger context of this unusual mortality event. A Rhabdovirus has been isolated from a dead stranded Alaskan harbor porpoise and upon sequencing it has been showed to be closely related to known fish Rhabdovirus species. A paper is being prepared detailing this new discovery. Three Reoviruses have also been isolated. One from a dead stranded sea otter and one from a dead stranded walrus both from Alaska and one from numerous dead stranded harbor seal pups along the coast of Washington State. All three have been sequenced and all three represent entirely new species. Papers describing the findings are being prepared. Work continues in 2018.

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

Develop community-based monitoring with a number of Nunavut communities to collect tissue from marine mammal subsistence hunts. The focus is on 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 (1980s to present) data set of marine mammal tissue samples and an associated metadatabase that includes morphometrics. The frozen tissue sample collection is currently stored in -30^{o}C; however efforts are underway to transition smaller subsamples to -80^{o}C freezers for longer term cryogenic storage. 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 2017 included the following Nunavut communities: Arviat, Sanikiluaq, Pangnirtung, Pond Inlet, Naujaat, Arctic Bay, Qikiqtarjuaq, Resolute, and Kugaaruk.

Narwhal Habitat and Movement Behaviour (S. Ferguson)

Climate change is reducing the Arctic sea ice concentration and extent and it has been thought that narwhal will be poorly able to adjust. Here, we analyzed narwhal year-round movement, and examined winter habitat selection in relation to sea ice and bathymetry. Narwhal from Admiralty Inlet and Eclipse Sound were equipped with satellite transmitters between 2009 and 2012. Narwhal conducted multiple late-summer movement patterns with three stocks overlapping. Compared to telemetry tagging

studies conducted a decade earlier, narwhal had a delayed fall migration and had decreased summer site fidelity. During the winter narwhal selected 1500 to 2000m depths that likely had higher prey densities, regardless of the mobile pack ice structure. They also conducted extensive movements coinciding with a delayed growth in sea ice extent, particularly in 2010. These results indicate that narwhal may be more able to adjust to habitat changes than previously believed.

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

The goal of our killer whale research, which began in 2005, was to learn more about eastern Canadian Arctic 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 summer 2017, field work out of Arctic Bay in Admiralty Inlet encountered killer whales but the field team was unable to approach for id photos, biopsy samples, or deploy satellite tags. However, numerous sightings in the Eclipse Sound, Pond Inlet area resulted in id-quality photos necessary to develop a catalogue and initiate abundance estimation methods. From northern communities, we collected 15 sightings of killer whales including the Pond Inlet area, Admiralty Inlet, Lancaster Sound, Hudson Strait, Qikiqtarjuaq, and Cumberland Sound. We continued our focus on analysis of samples and data collected in previous years. Killer whale skin and blubber biopsies collected prior to 2017 have been analysed for stable isotopes, fatty acids, contaminants, and genetics. Currently 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 to describe killer whale impacts on prey species behavior.

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 found 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. 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. In 2017 we continued aerial survey of the Eclipse Sound area in spring to count seals using visual observers, digital photographs, and infrared imagery. In addition, we surveyed the western Hudson Bay region again. Continued environmental

and ecological change in Hudson Bay has been shown to have important consequences to the ringed seal energy budget and hence to their reproductive success and abundance. Ringed seals were captured and satellite tagged out of Pond Inlet in the Eclipse Sound area in August 2017. Research continues into reproduction to assess a recent downward trend in ovulation and pregnancy rates and pups in the Hudson Bay harvest. Plans are to survey ringed seal spring abundance out of Alert in the Last Ice Area in spring 2018 as well as collect concurrent tissue samples from seals hunted in Grise Fiord, NU and Qaanaaq Greenland to compare high latitude body growth and diet patterns.

Bowhead Whale Foraging Behaviour (S. Ferguson, S. Fortune, A. Trites)

This project has delimited summer and winter range, timing of migration, habitat use and diving behaviour of Eastern Canada-West Greenland bowhead whale population. Bowhead whales were remotely tagged with long-term and short-term transmitters to detail foraging dives and seasonal movements, respectively. Results are being analyzed to understand seasonal movement, habitat use and timing of migration. Over 100 skin/blubber biopsy samples were collected in 2017 and plans are to re-analyze data to obtain an updated estimate of bowhead abundance using capture-mark-recapture genetic analysis.

This research project also examined bowhead whale diet composition across their eastern Canadian Arctic range and bowhead whale habitat use in the context of foraging ecology within Cumberland Sound. Field research is planned to be conducted out of Cumberland Sound in 2018 with further biopsy sampling and development of a photo-id catalogue.

Circumpolar Biodiversity Marine Program (S. Ferguson, G. Stenson)

The Arctic Marine Biodiversity Program 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 species of Arctic marine mammals with circumpolar or nearly circumpolar distribution. As part of the State of the Arctic Marine Biodiversity Report, the MMEN outlined 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 extraction. 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. The MMEN work plan includes efforts to develop and coalesce databases of relevant demographic, distribution, and condition information for all populations of marine mammals. Recently, we summarized past abundance and harvest estimates to establish historic baselines and trends as a reference for future monitoring. Existing data sets have been identified, aggregated and analyzed to establish indicator baselines on abundance of marine mammals. Future efforts will focus on summarizing Canadian Arctic marine mammal body condition, health databases, and telemetry movement/distribution.

Aerial survey to estimate the abundance of the Cumberland Sound beluga population (Marianne Marcoux, Cortney Watt, Steve Ferguson, Cory Matthews)

Belugas (*Delphinapterus leucas*) in Cumberland Sound are a genetically distinct population in the Canadian eastern Arctic. They have been designated as threatened by the Committee on the Status of Endangered Wildlife in Canada due to a possible decline in abundance and have been listed under the Species at Risk Act. Based on a population model that incorporates results from nine aerial surveys from 1980 to 2014, the current population size is estimated to be 1000 belugas (rounded to the nearest 100). A new aerial survey was conducted in August 2017 and was based on two components; a photographic survey of Clearwater Fiord (a small inlet in the northwest corner of Cumberland Sound), and a visual survey of the northern and western parts of Cumberland Sound. The photographic survey completely covered Clearwater Fiord five times as this is known to be an area where belugas aggregate in the summer months. The photos from this survey are currently been analysed and an updated population estimated will be computed.

Ecosystem Approach to study narwhals in Tremblay Sound (Marianne Marcoux)

Narwhals in the Canadian Arctic are harvested by Inuit communities for subsistence and are managed based on summering stocks. Narwhals spend their summers in fjords and bays where they are exposed to hunting as well as potential disturbance from economical activities. The Ecosystem Approach in Tremblay Sound project has two broad objectives: (1) to refine our understanding of narwhal summering stocks using telemetry data, and (2) to increase our understanding the summer habitat of the Eclipse Sound narwhals. This area of the Arctic is also an increasing priority for conservation and management as the area is designated as a Canadian National Marine Conservation Area. As part of the Ecosystem Approach, we use telemetry, chemical tracers and new technologies to study elements of narwhals' ecosystem including, zooplankton, fish, sharks, and seals. In the summer of 2017, we equipped 20 narwhals with satellite transmitters to provide data on the movements of narwhals and on their diving behaviour. We also equipped 145 fish with acoustic tags as well as 40 sharks

with acoustic or satellite-linked tags. Oceanographic instruments were left overwinter to characterize the physical property of the system.

Snot for science: Non-invasive tools to monitor the health of the Western Hudson Bay beluga population (Marianne Marcoux)

The Arctic is warming at double the rate of the global average, exposing marine mammals to a number of threats including increased water temperatures, shipping activity, and pollution, loss of sea-ice habitat, changes in prey distribution, and higher incidences of infectious disease. There is an urgent need for techniques to assess the impacts and implications of a changing Arctic ecosystem on the health of marine mammals. The objective of this project research is to use non-invasive techniques to develop indices of Western Hudson Bay (WHB) beluga (*Delphinapterus leucas*) health. We used a non-invasive technique to collect respiratory condensate or "blow" in order to determine baseline stress levels. We collected 233 blow samples from WHB belugas; this was the first time that this technique had been used in a wild, unrestrained beluga population. Genetic and hormone analyses will be used to determine the sex, pregnancy rates, and baseline stress levels of individuals within the population.

Role of killer whales as arctic predators (C. Matthews, S. Ferguson)

A range of studies on killer whale predation and foraging ecology are being conducted to understand the ecological role of this predator in Arctic ecosystems. In collaboration with Greg Breed (University of Alaska Fairbanks), we have analysed movements of concurrently tagged killer whales and bowhead whales, and show that ice habitat selection of the latter is completely dependent on their proximity to the former. An isotopic, fatty acid, and contaminants study of Arctic killer whale skin and blubber suggests they have dietary differences, with some killer whales potentially feeding on fish (sharks) and others on marine mammals (potentially baleen whales and seals). A separate study focusing on compound specific stable isotope analysis of amino acids (AA-CSIA) of Arctic killer whales and known ecotype killer whales from the west coast suggests similar bimodal variation in stable isotope composition of trophic and source amino acids. Generally, the variation observed in the Arctic killer whales, with unknown diets, was very similar to the west coast killer whales with diets of fish and marine mammals. Together, these isotope studies provide strong evidence of ecotypes among the Arctic killer whales.

Beluga whale foraging ecology and stock delineation using compound specific stable isotope analysis (C. Matthews, C. Watt, L. Postma, S. Ferguson)

Compound specific stable isotope analysis (CSIA) of beluga tissues from several populations in the eastern Canadian Arctic has been conducted to learn more about diet

differences among individuals, diet variation over time, and to develop trophic models based on results of a captive beluga diet study. Stable isotope values in teeth that showed long-term individual diet differences have been reanalysed using CSIA, which showed long-term isotopic differences most likely reflected spatial segregation. These results may have implications for stock and population assessment, and are being followed-up with additional genetics analyses to help understand whether observed spatial isotope differences coincide with genetic or population differences (which would provide additional support for a spatial explanation of observed isotopic differences). A comparison of amino acid specific stable isotope values among three different beluga tissues indicated values were similar irrespective of tissue type, and that tissue selection would not impact subsequent trophic position estimates. Samples collected during a three year controlled diet study of captive beluga whales have been analysed using CSIA, which will allow for calibration of amino acid-specific trophic enrichment factors between beluga tissues and their prey for application to studies of wild belugas.

Bowhead whale reproductive histories using hormone analysis of baleen (C. Matthews, S. Ferguson, N. Lysiak, K. Hunt, M.P. Heide-Jørgensen)

Analysis of hormone concentrations along bowhead whale baleen has been conducted to study bowhead whale reproduction, including calving interval and mating season. Baleen grows continuously and incorporates hormones in circulating blood in its structure, so incremental measurements of hormone concentrations along its length can be used to construct reproductive histories. Analysis of samples from baleen of ten female whales showed regular peaks in progesterone that are indicative of past pregnancies over the period of baleen growth, which is about 20 years. Progesterone peaks are currently being assessed against stable isotope concentrations, which peak annually, and concurrent patterns of corticosterone, a stress hormone, to determine calving interval and elevated stress associated with pregnancy. Testosterone analysis of male baleen showed annual cycles that are offset from stable isotope cycles by several months. Since the stable isotope cycles reflect differences in summer and winter foraging/habitat use, testosterone peaks annually and likely during early spring, which is consistent with what is currently known about bowhead reproduction. Results from this whale, along with testosterone results from two additional baleen whale species, have recently been submitted for publication (Hunt KE, Lysiak NS, Matthews CJD, Lowe C, Ajó AF, Dillon D, Willing C, Heide-Jørgensen MP, Ferguson SH, Moore MJ, Buck CL. Multi-year patterns in testosterone, cortisol and corticosterone from baleen of adult males of three whale species. *Conservation Physiology.* Submitted April 2018.).

Determination of weaning age and dietary variation in Baffin Bay narwhals (S. Zhao, and C. Watt)

Stable isotope analysis using dentine growth layer groups has become a popular technique to infer ontogenetic shifts and dietary patterns in marine mammals. Teeth are

metabolically inert and dentine is laid down in annual growth layer groups (GLGs). Once formed, dentine GLGs will not be altered, and therefore can provide a chronological archive of isotopic profiles throughout an animal's life. Isotopic nitrogen analysis of dentine GLGs can reveal $\delta^{15}N$ declines that have corresponded with weaning in several marine mammal species, while, carbon isotopes are widely used for dietary analysis, especially in terms of determining the original source of carbon in the food web.

Currently, little is known about narwhal weaning age but weaning age is an important parameter for understanding the length of the female reproductive cycle and ultimately the reproductive potential of narwhals. Embedded tusks were collected from narwhals that comprised part of the subsistence hunt in 1982 and part of a humane harvest in 2015. Tooth growth layer groups in these embedded tusks will be analyzed for $\delta^{13}C$ and $\delta^{15}N$. The objectives are i) to determine weaning age in narwhals and to evaluate whether weaning differs between sexes, among individuals of the same sex, and over time, and ii) to determine if individual narwhals specialize on different prey resources and if this specialization varies between sexes, life stages, or over time. Overall this study will contribute improved life history parameters for narwhal population modeling and promote understanding of narwhal social structure and habitat use.

Narwhal foraging habitat (C. Watt, J. Orr, and S. Ferguson)

Satellite tracking of 21 narwhals from the Baffin Bay and Northern Hudson Bay populations provided information on their diving behaviour and was used to identify foraging regions. To evaluate home ranges and define areas important for benthic foraging, we conducted kernel density analysis on narwhal locations and focused on areas where deep diving occurs, as a proxy for foraging, in the winter, spring, and migratory periods. Deep-diving was used as a proxy for foraging since previous research has indicated that narwhals from these two populations consume benthic prey. Home range analyses identified important areas for foraging for narwhals tagged in Eclipse Sound and from the Baffin Bay population on the summer grounds in Eclipse Sound, and the winter grounds in Davis Strait, as well as on the migratory pathway between the two regions. Foraging areas were also identified for the Northern Hudson Bay narwhals tagged in Repulse Bay and part of the Northern Hudson Bay narwhal population. In summer, foraging areas were identified in northwestern Hudson Bay in summer, in Northern Hudson Bay and Hudson Strait on the migration, and to the east of the entrance to Hudson Strait in the winter. Overall we found narwhal use a large portion of their range for foraging activities, including areas on the summering grounds, the wintering grounds, and on the migration.

2.2 ATLANTIC

Estimating walrus abundance in eastern Canada (A. Mosnier, M.O. Hammill, P. Blanchfield)

In September 2017, coastal aerial surveys were flown over the eastern coast of Baffin Island, the Hudson Strait, part of Southampton Island and the northern part of western Hudson Bay to estimate the abundance of walrus. These surveys combined visual observation and simultaneous digital-photography. Results are being analysed and will be compared to the 2014 survey done with the same protocol. The 2017 survey did not cover the area used by the walrus of Southern and East Hudson Bay stock, but it added new coverage of the eastern coast of Baffin Island that was not surveyed since 2008.

On Walrus Island (south of Southampton Island, Nunavut), we deployed satellite tags on several individuals concurrently with the aerial surveys with the aim of obtaining information on the proportion of time spent hauled-out or at sea.

On Nottingham Island (Hudson Strait), we also installed an autonomous tower mounted digital camera system allowing to regularly take photos of a remote haulout site where it was deployed and send them via satellite. This permitted to have, almost “live”, the numbers of walruses using the site on a daily basis and can record activity patterns on daily and seasonal haulout use. Such information could then be incorporated, among other things, in the calculation of the correction factors used in the surveys. Deployment of such system on other sites is planned for 2018.

Conservation value to assisting live-stranded neonates and entrapped juvenile beluga (Delphinapterus leucas) from the St. Lawrence Estuary population (MO Hammill and V. Lesage)

The potential benefits of relocating live stranded or entrapped beluga to recovery of the SLE beluga population was examined using a demographic model. The population is currently declining and information on reproduction rates are lacking. It is not possible to determine if the current decline is due to low reproduction or elevated mortality among neonates or both. Adult survival is already quite high and there is unlikely much room for further improvement. Efforts to improve survival of neonates and juveniles are most likely to benefit population recovery. However, considerable numbers of animals must be relocated each year to halt the decline in population trend. Reports of live-stranded neonates or entrapped juveniles are infrequent. Therefore, the benefit of relocating these few individuals to population recovery is nil, and does not meet the objectives of Conservation Translocation. The occurrences of entrapped juveniles are rare, but if in good health these animals are more likely to survive when relocated compared to abandoned neonates. From a conservation perspective, the benefit of relocating entrapped juveniles to the population as a whole is likely nil given the rarity of these events. However, relocating these individuals may be considered on other grounds. Some of the factors that need to be considered have been identified in DFO (Release and Rehabilitation Criteria).

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 continued in the Magdalen Islands area of the central Gulf of St Lawrence in 2017.

Grey seal telemetry in Gulf of St Lawrence (M.O. Hammill & T. Jeanniard du Dot)

Eight satellite transmitters deployed on grey seals in the Magdalen Islands during early July 2017. Animals remained in the Gulf, with most animals spending their time around the Magdalen Islands.

Growth and condition in harp seals: evidence of density dependent and density-independent influences (MO Hammill and C. Sauve)

Life history theory predicts that resource competition increases as a population increases, leading to changes in life history traits such as growth, survival, and reproduction. The Northwest Atlantic (NWA) harp seal population has increased from a low of 1.1 million animals in 1971 to over 7 million animals in 2014. Given this 7-fold increase in abundance, we hypothesized that density-dependent regulation might be reflected by changes in body growth. Gompertz curves fitted to size at age data for harp seals collected in the Gulf of St Lawrence over a 40 year period show a decline in female asymptotic length and mass. Body mass and condition were negatively related to reproductive rates the previous year, while a quadratic relationship (‘inverse u’) was observed between body measures and the ratio of the March:April first year ice cover, a measure of ice breakup. Condition was also negatively related to January ice cover. At high densities, reproduction is likely to be relatively more expensive for Northwest Atlantic harp seals, underlining the importance of females being able to access high energy food during the winter foraging period to build-up condition prior to pupping. A complex relationship between condition and the timing of ice-breakup likely reflects the influence of the timing of ice retreat on food resources and hence female ability to rebuild energy stores prior to moulting.

North Atlantic Right Whales

The north Atlantic Right whale population numbers around 450 animals. Twelve dead north Atlantic Right whales were located in the Gulf of St Lawrence (GSL) in 2017. Necropsies indicate that blunt trauma, likely from ship strikes and entanglement with fisheries gear were the primary cause of death in cases where mortality could be determined. The increase in documented mortalities appears to result from a shift in distribution of animals from the Bay of Fundy region, to the GSL area. A marked

increase in sightings for the GSL area was reported in 2017, but this is likely do to a combination of increased number of animals and dramatically increased survey effort to search for them. The majority of sightings in 2017 were reported in the western GSL, between Gaspe-Miscou and the Magdalen Islands and off west Anticosti Island, but this may also reflect in part search effort in these two areas. Analyses of hydrophone data suggests that right whale numbers may have increased since 2015. Animals may enter the gulf as early as April, and leave the area as late as January.

Habitat Suitability Modelling for North Atlantic right whales (Angelia S.M. Vanderlaan, Kim Davies, Katie Brennan, Catherine Johnson, Stéphane Plourde, and Hilary Moors-Murphy)

DFO continues to conduct research on species distribution models (SDMs) for cetacean species in Atlantic Canada and has expanded these efforts for the endangered North Atlantic right whale. Using long-term cetacean sightings data from government, non-governmental, academic, and industry sources, we developed SDMs using MaxEnt to predict suitable summer habitat for North Atlantic right whales on the Scotian Shelf. The initial predictor environmental variables selected included: ocean depth, compound topographic index, sea surface temperature, and near-surface chlorophyll-a concentration. These represent easily obtained environmental predictors and indirect proxies for right-whale prey. We also conducted a second set of model runs that incorporated the 1026 σ_t isopycnal, the magnitude of the tidal ellipse, and salinity at 50m depth, as they have been identified as direct proxies for the preferred right whale prey. Finally, we conducted a third set of model runs that included a direct measure of prey availability. All three SDMs were compared to test the efficacy of using indirect and direct proxies for prey to determine the suite of predictors that most highly contribute to the prediction of right whale suitable habitat. Habitat designated as “highly or moderately suitable” is interpreted as areas where North Atlantic right whale monitoring efforts should be prioritized.

North Atlantic right whale encounters with snow crab gear in the Gulf of St. Lawrence (Angelia S.M. Vanderlaan, Julie van der Hoop, and Christopher Taggart)

Given high number of mortalities and observed entanglements of North Atlantic right whales in 2017 and the known right whale entanglements in Canadian snow-crab gear, we estimated the probability of right whale encounters (potential entanglement) with crab-pot gear in the southern Gulf of St. Lawrence. Using snow crab deployment data from 2015, 2016, and 2017, and virtual right whale movements, a time-stepping model was developed to determine the number of times right whale encountered the trap lines of snow crab gear. We simulated right whale movement using an autocorrelated random walk and “swam” the whales through the gear to estimate encounter rates and the expected number of lethal entanglements. This study could inform policy decisions to reduce the impacts of the snow-crab fishery on right whales by identifying times and areas where encounter and entanglements are most likely to occur. These models

could then be used evaluate conservation initiatives implemented to protect this species at risk and estimate if mortalities and serious injuries are reduced to an acceptable level.

Grey seal tagging (GB Stenson, J Lawson, MO Hammill, L Sheppard, P Goulet)

A study of the movements of grey seals in southeast Newfoundland and the French territories of St. Pierre and Miquelon was initiated in 2017. Satellite transmitters were deployed on 15 adult seals live-captured on Miquelon. The transmitters collected data on seasonal distribution and diving behaviour of seals that summer along the south coast of Newfoundland, the Scotian Shelf, and potentially, on the Grand Banks. They also collected oceanographic data to improve climate models in this area. This study is a collaborative project between Canada and France.

Data Layers (J Lawson, P Goulet)

To assess and monitoring cetacean Species at Risk, and other marine mammals, baseline data on the occurrence and distribution of cetaceans in potential development areas are required urgently to facilitate the design of industrial monitoring programmes and impact assessments. In this final year of a three-year project we compiled and developed geo-referenced databases on human activities and environmental features in Canada that will be included as complimentary data-layers within marine mammal and sea turtle geo-referenced databases. This will facilitate DFO's efforts to operationalize the risk-based framework for assessing cumulative impacts of marine development projects on marine mammals and sea turtles in Canada (particularly SARA-listed species), and provide important support for other undertakings, such as COSEWIC and SARA assessments, requiring a comprehensive and accessible set of biological, environmental, and risk data. The geo-referenced databases and corresponding GIS maps created will be available for use with the risk framework currently being completed, and by DFO, Environment Canada, and other internal government users via a web-based interface to be developed during the project. These existing biological and physical data will be used to model the distribution, and when possible, the seasonal density of marine mammals and sea turtles in Canada's three oceans. Results will be used to delineate areas of seasonal aggregation and to visualize and to quantify the degree of geographic and seasonal overlap between human activities and areas of aggregation for marine mammals. This will highlight areas of particular conservation concern. This analysis will also be used to evaluate the performance of habitat suitability analysis to address the paucity of seasonal density data for mammals, sea turtles, and their prey; the primary focus will be on obtaining data for Species at Risk. The project has compiled data for the Atlantic, Arctic, and Pacific Canadian waters.

Sightings and survey data for marine megafauna (J Lawson, GB Stenson, A Buren, L Sheppard, Goulet, B Stockwood and colleagues from DFO Quebec and Maritimes)

To understand the distribution and abundance of cetaceans in the northwest Atlantic, DFO conducted a second large-scale aerial survey of Atlantic Canadian shelf and shelf break habitats extending from the northern tip of Labrador to the U.S border off southern Nova Scotia in August and September of 2016. Using three fixed-wing aircraft DFO achieved almost the same coverage as DFO's comparable large-scale marine megafauna survey in 2007 (TNASS); poorer weather and an extended NATO naval exercise meant that DFO completed 92.6% of their planned lines in 2016, versus 99.0% in 2007. During this 2016 Northwest Atlantic International Sightings Survey (NAISS) observers in survey aircraft collected data on the identity, group size, position, and behaviour of large and small cetaceans, plus environmental covariates. Almost twice as many cetaceans (841 sightings of 8,660 animals) were sighted in the Labrador and Newfoundland areas as in 2007 (584 sightings of 3,691 animals), although there were fewer large whales (fin, humpback, minke); white-beaked dolphins were the most encountered and numerous cetacean. Most of the additional 2016 sightings were collected on the Labrador and Newfoundland NE coasts. The two Skymaster teams amassed slightly fewer cetacean sightings in the Gulf of St. Lawrence, Scotian Shelf and Bay of Fundy (1,035 sightings of 4,449 animals) than they did in 2007 (1,217 sightings of 7,803 animals) despite greater effort in both Scotian Shelf and Bay of Fundy in 2016. Using Distance sampling approaches to estimate species abundance and derive detectability bias corrections for the common cetaceans, it appears that the abundance of cetaceans in eastern Canadian waters, particularly white-beaked dolphins, is larger than almost a decade ago.

Acoustic monitoring (J Lawson, L Sheppard)

To assess and monitoring cetacean Species at Risk, other marine mammals, and anthropogenic noise, DFO NL has been deploying long-term, autonomous underwater acoustic recorders around Newfoundland and Labrador. These recorders collect data across a broad frequency spectrum, and for periods up to one year in both nearshore and offshore locations. In addition to the data layers project and the visual survey, described above, these acoustic data will facilitate DFO's efforts to understand habitat use by marine mammals throughout the year, as well as the potential manmade stressors arising from underwater noise exposure from seismic exploration and commercial shipping.

Harp and hooded seal pup production survey (GB Stenson, J Lawson, JF Gosselin, A Buren, L Sheppard, P Goulet, MO Hammill, A Mosnier, S Lang, N den Heyer)

Visual and photographic surveys were carried out off Newfoundland and Labrador, and in the Gulf of St Lawrence, during February and March 2017 in order to assess the pup production of the Northwest Atlantic populations of hooded and harp seals. Fixed wing

and helicopter reconnaissance surveys identified the locations of multiple whelping concentrations in the southern and northern Gulf, as well as off southern Labrador (referred to as the 'Front'). Fixed-wing aircrafts carried out systematic strip-transect photographic surveys of each whelping areas. Visual survey and staging data were collected from ship and land-based helicopters. Preliminary results indicate that harp seal pup production in the southern Gulf during 2017 was much lower than previous surveys although there it appears that some of these animals may have moved to the Front. Results from this survey will be integrated with information on reproductive rates, estimates of ice related mortality and harvest information to estimate total abundance of these populations.

Ocean Productivity (A Buren, GB Stenson, J Lawson)

A project aimed at characterizing spatial and temporal variability, long-term trends, and the influence of environmental conditions (e.g., ice cover, SST, etc.) on energy content of key forage species in the northwest Atlantic was continued. In collaboration with University partners we are determining energy contents of important prey species through bomb calorimetry and proximal compositional analyses. This project is ongoing and will continue until March 2019.

A Predictive Model of the Environmental Regulation of Capelin (A Buren, K Lewis)

A project aimed at determining how environmental conditions affect the overall productivity of capelin, and at developing statistical models to provide short- and long-term forecasting models of capelin abundance. Results from this project will improve the provision of advice for the management of capelin, and predators that rely on them as an important food source (e.g. northern cod and harp seals). This project is ongoing and will continue until March 2020.

Can we detect changes in Arctic ecosystems? (GB Stenson, A Buren, S Ferguson)

This is a large scale project, funded by the Natural Environment Research Council (UK), and led by researchers from multiple British Universities. The Arctic Ocean is already being heavily impacted by climate change. It is warming faster than any other ocean region and as it absorbs fossil fuel emissions, it is gradually acidifying. To understand how Arctic ecosystems will evolve in response to multiple stressors, it is crucial to evaluate the effects of ongoing change. Often these questions are tackled by studies that focus on a specific ecosystem in one location and document the various components of the food chain. However the Arctic is diverse, with a wide range of environments that are responding to unique stressors differently. We require a new approach that can provide information on Arctic ecosystems from a pan-Arctic perspective over decadal timescales. To effectively monitor changes to pan-Arctic ecosystems requires tracers that focus on key ecosystem components and provide quantitative information on ecosystem structure, providing information for management

and conservation of ecosystem services. We will focus simultaneously on the base of the food chain, controlled by the activity of marine phytoplankton, and key Arctic predators, harp and ringed seals. Seals are excellent candidates to monitor the food web due to their pan-Arctic distribution and foraging behaviour, which means they are exposed to the changing environment. This project will provide information on past changes to Arctic ecosystems, but also put in place an approach that can be used to monitor future changes and aid in the management and conservation of ecosystem services. This project is ongoing and will continue until July 2020.

Comparative diet analysis of four sympatric ice seal species (A Buren, GB Stenson)

A comparative diet analyses of Arctic and sub-Arctic seals in the Newfoundland Region was presented at the 22nd Biennial Conference on the Biology of Marine Mammals. Overlap in resource utilization can potentially indicate the existence of interspecific competition. Several species of seals coexist in waters off Newfoundland and Labrador (Canada), including the most abundant marine mammal in the North Atlantic, the harp seal. Harp and hooded seals are migratory and move into the southern Newfoundland-Labrador Shelf during winter and spring to feed and build up energy stores for whelp and moult, while bearded, and ringed seals inhabit coastal waters year-round. Hooded seals are found primarily along the shelf edge, while the other three species occur on the shelf itself. To assess the potential for niche overlap and interspecific competition for food resources we compared the diets of these four species using data obtained since 1985. There was a distinct separation in the diet of two species; the diet of bearded seals was dominated by invertebrates and benthic organisms, while that of hooded seals was comprised mostly of flatfish, redfish, and other prey species associated with deep water. However, the diets of ringed and harp seals was composed mainly of forage fish (Arctic cod, and capelin), with important contributions of amphipods and zooplankton. Furthermore, the length frequencies distributions of fish consumed by both seal species are similar. The differential use of space may separate the niches of harp and ringed seals. However, similarity in diets suggests that they might be feeding on similar areas. Hooded and bearded seals occupy each a particular niche in the Northwest Atlantic ecosystem. Ringed and harp seals, however, share a similar niche, at least during winter and spring when the latter move into the area, and may therefore be competing for food resources. Given the large size of the harp seal herd this competitive interaction might have a significant impact on the dynamics of the ringed seal population.

Environmental influences on harp seal reproduction (GB Stenson, A Buren)

A study on environmental influences expressed via condition on harp seal reproduction was presented at the 22nd Biennial Conference on the Biology of Marine Mammals. Harp seals are the most abundant marine mammal in the north Atlantic. They are top predators, and as such, are important indicators of changes in their ecosystem. Since the 1950s, pregnancy rates of Norwest Atlantic harp seals have declined while inter-annual variability has increased. A previous study has shown that while the general

decline in fecundity is a reflection of density-dependent processes associated with increased population size, the large interannual variability is due to varying rates of late term abortions which are related to changes in capelin abundance (focal forage species of the system). We hypothesize that the impact of changing prey availability influences reproductive rates through changes in body condition and growth. To test this hypothesis we compared reproductive rates to growth rates and body condition of harp seals collected off the coast of Newfoundland Canada over the past four decades. Comparing lengths weights of seals among decades indicated that growth rates and asymptotic weights of harp seals have decline significantly since the 1980s. The average body condition of females prior to pupping varied greatly among years, although the condition of pregnant females did not change among years. Annual pregnancy rates were positively correlated with improved condition while abortion rates declined rapidly with only slight improvements in condition. Also, average blubber depth, another index of energy stores prior to pupping, was highly correlated with annual pregnancy rates. These data indicate that changes in abundance and environment influence reproductive rates in harp seals through changes in body condition and suggest that females must maintain a certain level of body condition if they are to complete their pregnancy successfully.

Biological sampling of Marine Mammals (GB Stenson, A Buren, J Lawson, P Goulet)

Multi-disciplinary studies on the population dynamics, fisheries interactions, and the impact of climate change on marine mammals were continued in 2017. The ongoing programme of collections involving sealers, fishermen 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) and stranded or by-caught cetaceans in the region. These data facilitate the long-term monitoring of distribution, reproductive status, diets, and the growth and condition of marine mammals during a period of significant ecological change.

3.0 CATCH DATA

a. Pinnipeds

	Atlantic Canada (including Quebec)*	Eastern Canadian Arctic
Harp Seal	80,935	No data
Hooded Seal	26	No data
Bearded Seal	48	No data
Grey Seal	1,600	No data
Harbour Seal	0	No data
Walrus	8	62**
Ringed Seal	353	No data

*Data is preliminary

**some communities have yet to report catches

b. Cetaceans

	Western Canadian Arctic	Eastern Canadian Arctic	Quebec Region
Beluga	68	552*	299
Bowhead	0	0	1
Narwhal	0	782*	0

*some communities have yet to report catches

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

Note that the November 2017 National Marine Mammal Peer-review Committee Meeting was delayed until February 2018, and advice from that meeting will be provided in the 2018 annual report.

6.0 PUBLICATIONS AND DOCUMENTS

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