NOAA FISHERIES

2026

ALASKA ICE SEAL RESEARCH PLAN

NOAA Fisheries | Alaska Department of Fish and Game | Alaska SeaLife Center | The Ice Seal Committee

Alaska Ice Seal Research Plan

A coordinated plan for research on ice-associated seals in Alaska,
including accomplishments and critical unfunded research

Prepared jointly by
The Ice Seal Committee
National Marine Fisheries Service
(Alaska Fisheries Science Center, Marine Mammal Laboratory)
Alaska Department of Fish and Game
(Division of Wildlife Conservation)

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Executive Summary

Four species of ice-associated seals, bearded *(Erignathus barbatus)*, ringed *(Pusa hispida)*, spotted *(Phoca largha)* and ribbon seals *(Histriophoca fasciata)*, inhabit the Bering, Chukchi, and Beaufort seas of the Alaskan Arctic. Collectively, they are often referred to as "ice seals" and despite the fact that these seals are vital resources for Alaska Native communities, as well as key ecological components of arctic marine ecosystems, relatively little is known of the seals' population status, stock structure, trends in abundance, life history, seasonal movements, diving behavior, diet or harvest rates. Ice seals are highly dependent on suitable sea ice condition and distribution, and therefore may be particularly vulnerable to climatic change, offshore oil development, or other environmental impacts that could alter their habitat. Indeed, concern about loss of sea ice habitat in the current warming climate has been the basis for petitions to the National Marine Fisheries Service (NMFS) for listing all four species as threatened or endangered under the Endangered Species Act.

The Ice Seal Research Plan is a consolidated plan for Alaskan ice seal research and monitoring that is primarily funded in whole or in part through the NMFS budget, but it also includes research projects with Alaska ice seals that have other sources of funding. Research on Alaska's ice seals is carried out principally by NMFS, Alaska Department of Fish and Game (ADF&G), and communities in the Alaska Native Regions represented by the Ice Seal Committee (North Slope Borough, Maniilaq, Kawerak, Bristol Bay Native Association, and the Association of Village Council Presidents). The combined research efforts by these groups focus on ice seal population abundance and trends, harvest, stock identification, general biology and life history, and human interactions. The principal objectives of the research plan are to:

1. Consolidate currently-funded projects into a single coordinated effort with maximum relevance to management objectives;
2. Describe additional research projects that are currently unfunded, but for which funds are critically needed, and;
3. Increase the dialogue, coordination, and collaboration among interested parties through the process of annually reviewing, evaluating and updating the research plan.

The Research Plan describes 21 current and proposed projects that identify and address specific research needs, including the identity and status of ice seal populations, the comprehensive assessment of ice seal mortality including harvest, and the impact of industrial & climatological events on ice seal habitat.

Introduction

Four species of ice-associated seals -- bearded seals *(Erignathus barbatus)*, ringed seals *(Pusa hispida)*, spotted seals *(Phoca largha)* and ribbon seals *(Histriophoca fasciata)* -- inhabit the Bering, Chukchi, and Beaufort seas (Burns 1970). These species have been important in the subsistence economy of northern Indigenous Peoples for thousands of years (Hall 1866, Murdoch 1885, Boas 1888, Rozanov 1931, Cox and Spiess 1980, Freeman 1984, Wenzel 1984), and large numbers were commercially harvested by the former Soviet Union in the 1960's (Shustov 1965, Shustov 1972, Mineev 1975, Mineev 1984). Threats to the populations include offshore oil development (Kelly 1988c, Kelly 1988a, Kelly 1988b, Quakenbush 1988) and reductions in sea ice associated with climate change. Sea ice is a key element of the habitat for ice-associated seals (Fay 1974), and changes in snow and ice cover of polar waters may have severe impacts on those species (Tynan and DeMaster 1997, Kelly 2001, Smith and Harwood 2001, Stirling and Smith 2004, Ferguson et al. 2005).

Subsistence hunters have extensive knowledge of ice-associated seals (Nelson 1969, Krupnik 1978, Huntington 2000) and have contributed traditional knowledge to scientific research and management through interviews, contributions of biological samples, and participation in scientific field projects (Allen 1880, Nelson and True 1887, Johnson et al. 1966, Lowry et al. 1980b, Lowry et al. 1980a, Whiting and Frost 2007). Despite the interests of subsistence users, scientists, and managers, ice-associated seal populations are poorly understood and documented, relative to many other living resources, and many basic questions concerning their ecology and population status remain unanswered. This Research Plan describes a coordinated effort to answer these basic questions and enhance understanding of ice-associated seals inhabiting the waters surrounding the state of Alaska.

Table A.1 Importance of research tasks identified by a working group for ice-associated seals in 1984. Tasks were rated as "critically important," "essential," or "necessary" to known or possible conservation problems (Twiss et al. 1988)

Task	 Bearded seals	 Ringed seals	 Spotted seals	 Ribbon seals
Monitor Harvest	*Essential*	*Essential*	*Essential/Critical*	*Essential/Critical*
Determine population discrepancies	*Essential*	*Essential*	*Necessary*	*Necessary*
Estimate population size	*Essential*	*Essential*	*Critical*	
Determine habitat requirements		*Essential*	*Necessary*	*Necessary*
Monitor population size	*Essential*	*Essential*	*Necessary*	*Necessary*

Management Needs

The fundamental information for reliable assessment and management of ice seal populations is largely unavailable, despite recognition of the data gaps for several decades. In 1984, the Marine Mammal Commission established working groups for marine mammals in Alaska (Twiss et al. 1988). For ice-associated seals, the working groups rated the importance of key conservation tasks as "critically important," "essential," or "necessary," (Table A.1), and they estimated annual costs for the necessary, essential, and critical tasks for the ice-associated seals at $200,000 - $537,000 (1984 dollars) for each species. Nonetheless, appropriations for research have been totally lacking in most years and have only recently begun to approach these levels, even though it is now widely recognized that the need for information has become broader and more urgent because of the rapidly changing arctic climate.

In 1994, the National Science Foundation, the National Oceanographic and Atmospheric Administration, the Office of Naval Research, Texas A & M University, the University of Alaska, the U. S. Marine Mammal Commission, the Minerals Management Service, the North Slope Borough, and the Alaska Sea Grant Program sponsored a workshop entitled "Use of Ice-associated Seals in the Bering and Chukchi Seas as Indicators of Environmental Change" (DeMaster and Davis 1996). That workshop produced five "near-term action items":

1. Update the research and management recommendations of the Marine Mammal Commission (Kelly 1988c, Kelly 1988a, Kelly 1988b, Quakenbush 1988, Twiss et al. 1988).
2. Create an ice seal database.
3. Reinitiate data collection from subsistence harvests.
4. Identify syntheses necessary to refine future research hypotheses.
5. Contrast importance of environmental factors influencing distribution and life history parameters of ringed and spotted seals.

In 2004, the Ice Seal Committee was formed to represent subsistence hunters of ice seals from five Alaska Native Regions: North Slope Borough, Maniilaq, Kawerak, Bristol Bay Native Association, and the Association of Village

Council Presidents. A working group composed of representatives from the Ice Seal Committee, the National Marine Fisheries Service, and the Alaska Department of Fish and Game identified the following research needs:

- Population status and trends
- Contaminants and their source
- Health of seal populations
- Harvest data
- Hunter education
- Climate change
- Individual animal health anomalies
- Community feedback of results

In response to those needs, the working group drafted the initial version of this Ice Seal Research Plan and recommended an overall approach that emphasizes 1) defining the identity and status of ice seal populations, 2) the comprehensive assessment of ice seal mortality including harvest, and 3) the impact of industrial & climatological events on ice seal habitat and ecology.

The following sections provide a description of ongoing projects that are currently funded, partially funded, and proposed but unfunded (Section A) and a summary of completed projects as a context for ongoing and proposed research (Section B).

Objectives of the Ice Seal Research Plan

The Research Plan plays a key role in the co-management process put in place by the Ice Seal Committee and NMFS. The Plan enhances communication between the research agencies and the Ice Seal Committee by establishing a framework that will assist in setting priorities and tracking performance of research projects. The plan is also expected to provide helpful information to the Alaska Scientific Review Group about ice seal population status and research.

A. Current and Proposed Projects

A.1 Population identity and status

A.1.1 ICE SEAL LIFE HISTORY STUDIES

Objective: Collect samples from the subsistence harvest to assess life history parameters, population status and health of ringed, bearded, spotted, and ribbon seals. Determine body condition, growth rate, reproductive rate, age at maturity, and pup survival to weaning. Identify prey remains from stomachs to determine diet. Determine concentrations of persistent organic compounds (OCs) such as PCBs, DDTs, HCLs, PBDEs, PFCs, and determine concentrations of trace elements of concern (e.g., Hg, Cd, Pb) in seal tissues by species and harvest location. Determine the prevalence of parasites, diseases, harmful algal bloom toxins, microplastics, and investigate physical anomalies of seals harvested in villages participating in the ADF&G biomonitoring program. Provide data and tissues to other researchers and graduate students for other important life history studies of ice seals, their habitat, and their predators. Collect hunter knowledge and current information on seal availability, distribution, harvest patterns, and hunter preference through hunter questionnaires.

Justification: There is little information available about abundance and population status for any species of ice seal. Body condition, growth rate, reproductive rate, age at maturity, and pup survival to weaning can be used to assess population status. Diet, parasites, disease, and contaminant loads are important in determining health. Contaminant levels can be high in the Arctic due to atmospheric transport even though the compounds are not manufactured or used there. On the other hand, the banning of pesticides and other manmade chemicals should reduce those chemicals in the environment in the future. Many of the compounds are lipophilic and concentrate in marine mammal blubber. Genetics are important for determining the structure, history, and vulnerability of the populations. Investigating physical abnormalities can help to detect health issues within the population.

Methods: Morphometric measurements (e.g., standard length and sternal blubber depth) and tissues (e.g., teeth, stomach, liver, kidney, blubber, muscle, female reproductive tracts, skin, blood) are collected from the subsistence harvest. Tissues are analyzed for age, diet, contaminants, productivity, and genetics. Hunter knowledge and preference information is collected through a questionnaire filled out by hunters.

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Wang, S.M., Springer, A.M., Budge, S.M., Horstmann-Dehn, L., Quakenbush, L., Wooller, M.J. 2016. Carbon sources and trophic relationships of ice seals during recent environmental shifts in the Bering Sea. Ecological applications: a publication of the Ecological Society of America 26:830-845

Wang, S.W., Frost, K., Whiting, A. 2015. Foraging ecology of ice seals in Kotzebue Sound, Alaska: Insights from fatty acid markers. Marine Mammal Science 32:765-776

Funding status: Funded by NOAA in 2003-2025, NOAA Section 6 in 2016-2019; partial funding by NSF 2000-2006 and NPRB in 2005-2006.

Project lead: ADF&G, Lori Quakenbush, lori.quakenbush@alaska.gov

Project partners: Ice Seal Committee, North Slope Borough, and hunters from Utqiaġvik, Wainwright, Pt. Hope, Shishmaref, Diomede, Gambell, Savoonga, and Hooper Bay.

A.1.2 GENETIC POPULATION STRUCTURE OF ICE-ASSOCIATED SEALS IN ALASKA

Objective: To assess population structure in bearded seals using genetic analysis of previously archived samples from breeding sites in the North Pacific.

Justification: The bearded seal status review noted that further investigation of population structure is needed to assess the potential for depletion due to localized threats. Bearded seals travel widely during the foraging season, but some evidence indicates that seals may show inter- and intra-annual fidelity to breeding sites. However, it is not known whether such fidelity is based on return to natal areas. To provide insight into this question, we sequenced the mitochondrial DNA (mtDNA) control region of samples (n=188) collected at breeding sites in the North Pacific between March and May. In addition, we used high throughput sequencing to identify and genotype several thousand genome-wide nuclear loci (single nucleotide polymorphisms, SNPs) in a subset of these samples (n=190 bearded seals). This latter approach can provide increased power to detect subtle, but potentially biologically significant, levels of genetic differentiation between breeding sites. It also provides data that can be used to design assays for genotyping additional samples, including museum quality specimens, in the future.

Methods: MtDNA control region sequences were generated using traditional methods (i.e., Sanger sequencing). In order to genotype nuclear loci, a high throughput sequencing approach was used to generate reduced representation 'libraries' for each sample. This approach reduces the proportion of the genome that is sequenced so that the retained fragments have high sequencing coverage and can be genotyped with high confidence. After sequencing, the resulting data was filtered to remove erroneous genotypes and retain only high-quality SNPs.

Product:

Lang, A. R., Quakenbush, L., Ziel, H., Robertson, K., Lauf, M., Taylor, B. L. and Boveng, P. 2017. Detecting population structure in bearded and ringed seals: current understanding and future challenges. Poster presented at the Alaska Marine Science Symposium, 23-27 January 2017 in Anchorage, Alaska.

The results of preliminary analyses revealed high levels of mtDNA haplotype diversity in Arctic bearded seals, with little to no differentiation between regions using either the mtDNA or nuclear (SNP) genotype datasets. These results were presented at the Alaska Marine Science Symposium in 2017 and at the NAMMCO Panarctic Bearded Seal Workshop in 2023. Further analysis of the SNP data is underway.

Funding status: The funding to complete the mtDNA control region analysis of population structure in bearded seals was provided by the National Fish and Wildlife Foundation. Funding for the project to conduct genotyping-by-sequencing on bearded seals was provided by the North Pacific Research Board. In the future, we plan to search for funding to use the genotype data produced in the latter two projects to develop genetic markers that can be used with historic samples.

Project lead: NOAA/NMFS/SWFSC, Aimee Lang, aimee.lang@noaa.gov

Project partners: Samples contributed by NMFS/NMML, ADF&G, the U.S. Geological Survey's Alaska Science Center, and the University of Alaska Fairbanks Museum of the North; additional partners may be identified in the future.

A.1.3 AUDITORY BIOLOGY OF BEARDED, RINGED, AND SPOTTED SEALS

Objective: This long-term research program seeks to improve knowledge of the acoustic sensitivity of bearded, ringed, and spotted seals. Alaskan ice seals already living in captive care are trained to cooperate in auditory research so that species hearing profiles (audiograms) can be determined, the simultaneous effects of noise on hearing (masking) can be measured, and the residual effect of noise exposures on hearing (temporary threshold shift) can be estimated. Comparative auditory research has been conducted with two spotted seals, two ringed seals, and two bearded seals at the University of California Santa Cruz. Our most recent focus has been on describing the very low-frequency hearing abilities of bearded seals and measuring auditory masking parameters in spotted seals. Results from this work improve understanding of sound reception abilities at frequencies below 100 Hz and indicate how different human-generated noise sources (including ice-breakers, offshore energy development, seismic surveys using air guns, and marine vibroseis technology) may affect hearing in ice-associated seals.

Justification: Traditional knowledge indicates that Arctic seals are highly sensitive to sound. Historically, these seals have inhabited polar seas with minimal exposure to sounds related to human presence. Extreme global climate change is altering Arctic habitats in many ways—including habitat degradation driven by increasing human activity and by human-generated noise associated with sea ice loss. Expanding human access to Arctic environments requires the assessment of risks posed to wildlife by noise pollution. Quantitative information on the hearing abilities of seals will enable more accurate estimates of zones of potential influence around specific sound sources. Noise may alter the normal hearing of marine mammals through temporary or permanent changes in their ability to hear or identify biologically important signals. Such effects may be different for different species. Reliable auditory data are needed for representative seal species to support appropriate risk assessments. The findings of these studies address data gaps for biologically and culturally important Alaskan seals and enable decision-making based on the best available science.

Methods: Research is conducted at Long Marine Laboratory in Santa Cruz, California at the University of California Santa Cruz. Seals live in specialized facilities with saltwater pools and haul-out spaces designed for acoustics research with marine mammals. The study animals are bearded, ringed, and spotted seals living in long-term human care. These seals are trained to cooperate in acoustic trials using positive (fish) reinforcement. Hearing tests may occur in air (when seals are resting out of the water on mats in a quiet acoustic chamber) or in water (while diving in an acoustically calibrated pool). The seals are presented with brief tones that vary in frequency, level, and/or duration. Hearing thresholds are determined over many trials under different conditions to assess auditory performance (1) in the absence of noise, (2) in the presence of overlapping noise, or (3) before and after exposure to noise, such as impulsive sounds representative of received seismic (air gun) signals. Different testing conditions allow relevant parameters of sound detection, masking, and temporary threshold shift to be determined. Several comprehensive hearing assessments have been completed with spotted, ringed, and bearded seals since 2010. The results of these studies have been published and shared with the Ice Seal Committee.

In addition to learning about their auditory adaptations, we conduct research to better understand how ice seals produce and use sounds to communicate. For example, we have documented the spontaneous underwater calls of spotted seals throughout development. We found

that mature males produce at least eight distinct call types, mostly during winter and spring. Seasonal calling behavior is correlated to reproductive status. Detailed knowledge of vocalizations and associated behavior can support passive acoustic monitoring efforts to identify habitats important to breeding seals.

This long-term research includes individual seals studied in human care over many years. Most of the seals involved in the program have been rehabilitated following stranding events in Alaska. At the request of the Ice Seal Committee, these seals will not be reintroduced to wild populations. Instead, when this research program is completed, the seals will participate in other relevant research activities or be transferred to permanent zoological display facilities, in coordination with the National Marine Fisheries Service and the Ice Seal Committee.

Publications:

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Sills, J. M., Southall, B. L., and Reichmuth, C. (2020). Auditory biology of bearded seals (Erignathus barbatus). Polar Biology 43(11): 1681-1691.

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Sills, J. M., Southall, B. L., and Reichmuth, C. (2017). The influence of temporally varying noise from seismic air guns on the detection of underwater sounds by seals. Journal of the Acoustical Society of America 141: 996-1008.

Reichmuth, C., Ghoul, A., Sills, J. M., Rouse, A., and Southall, B. L. (2016). Low-frequency temporary threshold shift not observed in spotted or ringed seals exposed to single air gun impulses. Journal of the Acoustical Society of America 140: 2646-2658.

Sills, J. M., Southall, B. L., and Reichmuth, C. (2016). Psychoacoustic studies of spotted (Phoca largha) and ringed (Pusa hispida) seals. In: Effects of Noise on Aquatic Life II, A.N. Popper and A. Hawkins (Eds), Springer-Verlag, Berlin, pp. 1025-1030.

Sills, J. M., Southall, B. L., and Reichmuth, C. (2015). Amphibious hearing in ringed seals (Pusa hispida): underwater audiograms, aerial audiograms, and critical ratio measurements. The Journal of Experimental Biology, 218: 2250-2258.

Sills, J. M., Southall, B. L., and Reichmuth, C. (2014). Amphibious hearing in spotted seals (Phoca largha): underwater audiograms, aerial audiograms, and critical ratio measurements. The Journal of Experimental Biology, 217: 726-734

Funding status: Since the start of this research program, associated projects have been supported by the OGP Joint Industry Programme (JIP) on Sound and Marine Life, the Environmental Studies Program of the Bureau of Ocean Energy Management (BOEM), and the US Navy's Living Marine Resources Program. Supplemental or in-kind support has been provided by the Northwest Arctic Borough Science Program, Shell Exploration and Production Company, and the Alaska SeaLife Center.

Project leads: Colleen Reichmuth and Jillian Sills (University of California Santa Cruz, coll@ucsc.edu, jmsills@ucsc.edu)

Project partners: Brandon Southall (SEA, Inc.), Alex Whiting, John Goodwin, Pearl Goodwin (Native Village of Kotzebue), Alaska SeaLife Center.

A.1.4 THE PHOCAS PROJECT: PHYSIOLOGY AND HEALTH OF COOPERATING ARCTIC SEALS

Objective: This study provides currently unknown health and physiological parameters for bearded, ringed, and spotted seals through long-term studies of individual seals in captive care. Supportive samples may be obtained from harvested seals and/or seals handled during short-term catch-and-release efforts.

Justification: Alaskan ice seals are vulnerable to rapidly warming environmental conditions and the associated loss of seasonal sea ice. They are high-level consumers that serve as sentinels of ecosystem health. Quantitative information on the biology and physiology of bearded, ringed, and spotted seals is needed to address knowledge gaps that cannot be addressed using free-ranging or harvested animals. These data can be used to inform population and ecosystem models, and to respond to changes in health status.

Unusual mortality events involving northern seals and walruses since 2011 highlight the limited amount of information available to describe the health and physiology of ice-associated seals in good condition. By studying living seals trained to cooperate in research over multiple years, this project contributes useful new information, including the description of baseline health parameters and seasonal measures of body condition, metabolism, molt, thermoregulatory costs, and diving capacity. These longitudinal and comparative measurements obtained from individual spotted, ringed, and bearded seals allow physiological comparisons to be made within individuals throughout development, and both within and across species. The Alaskan ice seals that participate in this research program live in permanent captivity, either at Long Marine Laboratory at the University of California in Santa Cruz, CA or at the Alaska SeaLife Center in Seward, AK. Most of the seals trained for participation in research were acquired following stranding and subsequent rehabilitation in Alaska. Under an agreement with the Ice Seal Committee and the National Marine Fisheries Service, they cannot be released into the wild. Therefore, this research program maximizes what can be learned from currently captive Alaskan seals that are trained to voluntarily cooperate in various research procedures.

Methods: This multi-year project is ongoing since 2014. The project relies on husbandry and veterinary data collected as part of routine animal care practices, as well as data collected from ice seals trained to cooperate in various research procedures. The methods and goals of this program are broad and include (1) using standard veterinary sampling to report baseline hematology parameters and other species indicators of health; (2) evaluating individual animals to report patterns of food consumption, growth, tissue deposition rates, and body condition as a function of physiological, developmental, and environmental conditions; (3) using infrared thermography and direct heat flux measures to establish seasonal thermal profiles and patterns of heat flow for heathy individuals; (4) using open-flow respirometry to determine the metabolic rates of seals in order to evaluate how age, season, physiological status, and environmental parameters influence the energetic needs of each species; (5) evaluating the coat condition of individual seals to document the timing, duration, and progression of molt in healthy individuals; (6) measuring the haul-out behavior of individual seals using temperature-sensing tags or video monitoring to aid in the development of correction factors for wild ice seal population surveys; (7) determining the energetic costs of routine swimming and diving activities from seals trained to cooperate in open-flow respirometry measurements; (8) evaluating heart rate and breathing rate patterns for seals at rest and while active using non-invasive methods to improve knowledge of diving capacity; (9) determining blood, muscle, and lung oxygen storage capacities through the analysis of blood and muscle samples from archival collections and subsistence-harvested ice seals or veterinary evaluation of captive seals, and (10) evaluating dietary patterns through the evaluation of body tissues, whiskers, and fecal material. Other types of data may be gathered opportunistically. Information from different project modules can be combined to address specific research questions and to estimate physiological constraints on diving and foraging in each species.

Publications:

Meranda, M, Thometz, NM, Rosen, D, Reichmuth, C (In Review). Metabolic costs of submerged activity in three species of Arctic seals. Submitted to Conservation Physiology.

Hartwick, M., Reichmuth, C., Thometz, N. M. (In Preparation) Validating simple body condition metrics for use in field assessments of wild Arctic seals. Manuscript for submission to The Journal of Wildlife Management.

Reichmuth, C., and Klein, A.M. Bearded Seal Erignathus barbatus (Erxleben, 1777). (2025). In: Hackländer, K., Zachos, F.E. (eds) Handbook of the Mammals of Europe. Handbook of the Mammals of Europe. Springer, Cham. https://doi.org/10.1007/978-3-319-65038-8_141-1.

Cameron, M., Brady, G., Hou, B., Koslovsky, S., McClintock, B., Meranda, M. Reichmuth, C., Richmond, E., and Ziel, H. (2025). Final report for the NOAA ORTA Bridging Program Project: an Extension of 2020-05 monitoring body condition of seals in Alaska using small UAS. AFSC Processed Rep. 2025-03, 46 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle WA 98115.

Pace, C., Goertz, C. E. C., Hunter, N., Abraham, T., Goertz, J., and Reichmuth, C. (2024). Seasonal variation of blood analytes associated with skin health in Alaskan ice seals. Journal of Zoo and Wildlife Medicine 55(4): 994-1004.

Tengler, M. L., Dearolf, J., Bryan, A. L., Reichmuth, C., and Thometz, N. M. (2024). Comparative Muscle Physiology of Ringed (Pusa hispida), Bearded (Erignathus barbatus), and Spotted (Phoca largha) Seals from the Bering and Chukchi Seas. Aquatic Mammals 50(3), 181-198.

Thometz, N. M., Rosen, D. A. S., Hermann-Sorensen, H., Meranda, M., Pardini, M., and Reichmuth, C. (2023). Maintaining control: metabolism of molting Arctic seals in water and when hauled out. Journal of Experimental Biology 226: jeb244862.

Meranda, M (2023). Energetic costs of submerged behaviors in Arctic seals. [Unpublished master's thesis]. University of California Santa Cruz.

Hanenburg, M., Goertz, C., Reichmuth, C. (2023) All about the curves: Cooperative body condition measurements of Arctic seals support health assessments for wild populations. Joint Conference of the International Marine Animal Trainer's Association and the Animal Behavior Management Association, Atlanta, Georgia, 5-10 March 2023. Conference Proceedings Paper.

Sills, J. M., and Reichmuth, C. (2022). Vocal behavior in spotted seals (Phoca largha) and implications for passive acoustic monitoring. Frontiers in Remote Sensing 3: 862435.

Rosen, D.A.S., Thometz, N. M., and Reichmuth, C. (2021). Seasonal and developmental patterns of energy intake and growth in Alaskan ice seals. Aquatic Mammals 47(6): 559-573.

Thometz, N. M., Hermann-Sorensen, H., Russell, B., Rosen, D. A. S., and Reichmuth, C. (2021). Molting strategies of Arctic seals drive annual patterns in metabolism. Conservation Physiology 9: 10.1093/conphys/coaa112

Hermann-Sorensen, H., Thometz, N. M., Woodie, K., Dennison-Gibby, S., and Reichmuth, C. (2021) In vivo measurement of lung volume in ringed seals: insights from biomedical imaging. Journal of Experimental Biology 224: jeb235507

Hartwick, M (2020). Assessing seasonal changes in body condition for spotted (Phoca largha), ringed (Pusa hisipda), and bearded (Erignathus barbatus) seals. [Unpublished master's thesis]. University of San Francisco.

Tengler, M (2020). Physiological development of locomotor muscle in ringed, bearded, and spotted seals [Unpublished master's thesis]. University of San Francisco.

Hermann-Sorensen, H (2020) In vivo measurements of lung volumes in ringed seals: insights from biomedical imaging. [Unpublished master's thesis]. University of California Santa Cruz.

McHuron, E. A., Williams, T., Costa, D. P., Reichmuth, C. (2020) Contrasting whisker growth dynamics within the phocid lineage. Marine Ecology Progress Series, 634:231-236.

Goertz, C.E.C., Reichmuth, C., Thometz, N.M., Ziel, H., Boveng, P.L. (2019) Comparative Health Assessments of Alaskan Ice Seals. Frontiers in Veterinary Science: Wildlife Medicine, 6(4). Open access article: https://doi.org/10.3389/fvets.2019.00004

Kienle, S.S., Hermann-Sorensen, H., Costa, D.P., Reichmuth, C., and Mehta, R.S. (2018) Comparative feeding strategies and kinematics in phocid seals: suction without specialized skull morphology. Journal of Experimental Biology, 221: jeb179424.

Beltran, R., Peterson, S. McHuron, E., Reichmuth, C. Huckstadt, L., Costa, D. (2016) Seals and sea lions are what they eat, plus what? Determination of trophic discrimination factors for seven pinniped species. Rapid Communications in Mass Spectrometry, 30, 1115–1122.

McHuron, E.A., Walcott, S.M., Zeligs, J., Skrovan, S., Costa, D.P, Reichmuth, C. (2016). Whisker growth dynamics in two North Pacific pinnipeds: implications for determining foraging ecology from stable isotope analysis. Marine Ecological Progress Series 554:213-224.

Funding status: The PHOCAS research program was supported by NOAA through the Alaska Pinnipeds Program from 2015-2022. Additional funding is needed for the continuation of this long-term project.

Project leads: Colleen Reichmuth (University of California Santa Cruz and Alaska SeaLife Center, coll@ucsc.edu), Nicole Thometz (University of San Francisco, nthometz@

usfca.edu), and David Rosen (University of British Columbia, rosen@zoology.ubc.edu).

Project partners: The Alaska SeaLife Center and Long Marine Laboratory (captive animal research), Alaska Department of Fish and Game and cooperating subsistence hunters (biosampling), Marine Mammal Laboratory Polar Ecosystems Program (archival samples and ecosystem models), National Marine Mammal Health and Stranding Program (archival data and samples).

A.1.5 BEARDED SEAL ABUNDANCE AND DEMOGRAPHICS USING CLOSE-KIN MARK-RECAPTURE METHODS

Objective: Use DNA from subsistence harvested bearded seals and close-kin mark-recapture methods to estimate the abundance and demographics of bearded seals. The preliminary population estimate is ~409,000 (CV = 0.35; Taras et al. 2024). Continued sampling will increase the sample size and refine the population estimate.

Justification: Bearded seals are an important subsistence resource and are listed as threatened under the ESA, therefore a reliable population estimate is needed. This method combines genetics for kinship determinations with a population dynamics model to provide a population estimate independent of aerial surveys and provides previously unknown information about bearded seal life history.

Methods: A tooth and tissue sample are collected from subsistence harvested bearded seals. The tooth provides age for population dynamics modeling and the DNA, determined from the tissue sample, provides genetics for kinship determination.

Product:

Conn, P.B., B.D. Taras, M.V. Bravington, L. Quakenbush, A. Kilian, A. Lang, and A. Bryan. 2023. Using close-kin mark-recapture to estimate abundance and demography of bearded seals in Alaska. Euring Analytical Conference April 17¬–21, Montpellier, France. (abstract).

Taras, B.D., L.T. Quakenbush, P.B. Conn, J.M. Ver Hoef. 2019. Exploring close-kin mark-recapture as a method for assessing bearded seal population abundance and status. The Wildlife Society Conference, September 29–October 3, Reno, Nevada (abstract).

Taras, B.D., P.B. Conn, M.V. Bravington, L. Quakenbush, A. Kilian, A.R. Lang, and A. Bryan. 2023. Close-kin mark-recapture used to estimate bearded seal population abundance and demographics. Alaska Marine Science Symposium, January 23–27, Anchorage, Alaska (abstract and poster).

Taras, B.D., P.B. Conn, M.V. Bravington, A. Kilian, A.R. Lang, A. Bryan, R. Stimmelmayr, and L. Quakenbush. 2024. Estimating demographic parameters for bearded seals, Erignathus barbatus, in Alaska using close-kin mark-recapture methods. Evolutionary Applications 2024; 17:e70035 DOI 10.1111/eva.70035

Funding status: Funded by NOAA. 2nd phase funded by NOAA and NSB.

Project lead: ADF&G, Lori Quakenbush, lori.quakenbush@alaska.gov

Project partners: NOAA, CSIRO, Diversity Arrays Technology, NSB

A.2 Mortality and harvest

A.2.1 HARVEST MONITORING

Objective: Document the Alaska Native subsistence harvest (including number struck and lost) of ice seals by species and time of year in as many communities as possible.

Justification: Collecting harvest information is a priority of the Ice Seal Committee (ISC) and a federal mandate for NOAA Fisheries. Prior to the start of this project in 2008, ice seal harvest data had rarely and inconsistently been collected following the end of the state bounty program in 1972. Some regions conduct household subsistence surveys that include ice seals along with fish, birds, and land mammals, but many do not collect detailed information about seal species or season of harvest. Ideally, communities should be surveyed repeatedly to better understand interannual variability in the harvest. A better understanding of struck and loss rates is also critically needed to improve harvest estimates. Describing factors that influence struck and loss rates may also help hunters minimize loss in the future. The documents produced by this project will be used by the ISC in their co-management activities and by NOAA Fisheries in their Stock Assessment Reports.

Methods: Prior to conducting harvest surveys in a community, the project is discussed with the IRA council. Upon approval, local survey technicians are hired to conduct the surveys. The surveys are conducted confidentially and only harvest by community is presented (i.e., information by household or hunter is not available).

Results from individual communities are summarized and returned to the community as a report for approval. After community results are approved by the IRA council, they are added to an annual ice seal harvest report presented to the Ice Seal Committee at their annual meeting. The final report is then approved by the Ice Seal Committee before being made publicly available.

Use of harvest data: During the ten-year span of 2014-2024, only one of the 60 coastal communities that harvest ice seals has been surveyed in two consecutive years or more. Due to limited available data as well as high variability in seal harvest numbers (among years, within communities, among communities, and within regions), harvest data should not be extrapolated to other communities or regions. In addition, there is concern among hunters regarding the misuse of harvest data. Please contact the Ice Seal Committee for guidance prior to using these harvest data.

Product:

Ice Seal Committee. 2024. The subsistence harvest of ice seals in Alaska – a compilation of existing information, 1960-2022. Pages 1-87. Available at https://www.iceseals.org

Nelson, M. A. 2012a. Togiak and Twin Hills Ice Seal Harvest Report: 2007 to 2011 Summary. Report to Togiak, Twin Hills, and the Ice Seal Committee. 17 pp.

Nelson, M. A. 2012b. Yukon Kuskokwim Delta Ice Seal Harvest Project: Emmonak 2011. Report to Emmonak and the Ice Seal Committee. 5 pp.

Nelson, M. A. 2013. Scammon Bay Ice Seal Harvest Report: 2011 and 2012 Summary. Report to Scammon Bay and the Ice Seal Committee. 11 pp.

Nelson, M., and L. Church. 2015. Quinhagak ice seal harvest report 2008, 2010-2014 Summary. Report to Quinhagak and the Ice Seal Committee. 15 pp. *Reports for individual years (2008, 2010-2014) are also available.*

Nelson, M. A., R. J. Adam, J. Olnes, and A. Simon. 2018. Hooper Bay Ice Seal Harvest Report 2008 to 2017 Summary. Report to Hooper Bay and the Ice Seal Committee. 16 pp. *Reports for individual years (2008-2017) are also available*.

Nelson, M., R. J. Adam, J. Olnes, and C. Inakuk. 2018. Tununak ice seal harvest report 2008-2012 and 2016 Summary. Report to Tununak and the Ice Seal Committee. 14 pp. *Reports for individual years (2008-2012, 2016) are also available.*

Nelson, M.A., L.T. Quakenbush, B.D. Taras, and the Ice Seal Committee. 2019. Subsistence harvest of ringed, bearded, spotted, and ribbon seals in Alaska is sustainable. Endangered Species Research 40: 1–16. Doi:10.3354/esr00973

Olnes, J., M. Nelson, R. J. Adam, and A. Simon. 2020. Hooper Bay ice seal harvest report 2008 to 2018 Summary. Report to Hooper Bay and the Ice Seal Committee. 17 pp. *Reports for individual years (2008-2017) are also available*.

Olnes, J., L. Quakenbush, M. Nelson, A. Simon, J. Burns, and the Ice Seal Committee. 2022. Trends in subsistence harvests of ice seals in the Yukon-Kuskokwim Delta region, Alaska, 1962–2018. Arctic 75(4):449–461. DOI:10.14430/arctic76302

All reports are available at Ice Seal Harvest Monitoring, Alaska Department of Fish and Game

Funding status: Funded by a State Wildlife Grant, NMFS through the Ice Seal Committee, and NMFS Species Recovery Grants to States (Section 6 Program)

Project lead: ADF&G, Justin Olnes, justin.olnes@alaska.gov

Project partners: Ice Seal Committee

A.3 Habitat and climate change

A.3.1 MOVEMENTS, HABITAT USE, AND FORAGING BEHAVIOR OF RIBBON AND SPOTTED SEALS IN THE BERING SEA

Objective: To document the seasonal movements, foraging behavior and important habitats of ribbon and spotted seals in the Bering Sea and to collect baseline data about population health.

Justification: Relatively little is known of the abundances and distributions, seasonal migrations and habitat requirements, diving and foraging behaviors, population health, genetic discreteness and stock structures of ribbon and spotted seals, which breed at the southern margins of seasonal sea ice in the Bering Sea. Many of these attributes are likely to be highly sensitive to suitable habitats and sea ice conditions and may be particularly vulnerable to climatic change. Our ability to predict and manage for such impacts, however, is limited by our inadequate knowledge of ice seal ecology.

Methods: Ribbon and spotted seals are captured on the ice floes where they are hauled out, instrumented, and then released with satellite-linked biologgers. Data from instrumented animals are transmitted back to researchers via the ARGOS satellite system and analyzed to: 1) provide haul-out correction factors for past and future abundance and distribution sightings surveys, 2) assess the seasonal movements and patterns of distribution and diving/foraging behavior, 3) identify and determine the priority of importance for specific marine habitats associated with key life history events such as breeding, pup rearing, and molting, and 4) describe seal dive depths and durations. Additionally, morphometrics and biological samples are collected from captured seals and will be analyzed to provide baseline data about aspects of general population health, including genetics, disease, contaminants, body condition, foraging behavior, and several life history parameters.

In summer of 2005, 15 ribbon seals were sampled near Kamchatka in the western Bering Sea. In the eastern and central Bering Sea (i.e., U.S. waters): 12 ribbon and 9 spotted seals were sampled in 2006, 48 ribbon and 24 spotted seals were sampled in 2007, 1 ribbon seal was tagged in 2008, 31 ribbon and 37 spotted seals were sampled in 2009, 23 ribbon and 19 spotted seals were tagged in 2010, 18 ribbon, 8 spotted, and 2 bearded seals were sampled in 2014, 10 ribbon and 13 spotted seals were sampled in 2016, 2 bearded and 27 spotted seals were sampled in 2018 (mostly pups). The expedition in 2020 was cancelled due to COVID. In 2022, 1 ribbon and 4 spotted seals were sampled, and in 2024, 11 ribbon and 14 spotted seals were sampled. From 2014 to 2022, we switched our focus to capturing in the early spring. This change allowed us to capture mother-pup pairs so that we could obtain tagging data from females with pups and collect samples from mother-pup pairs. In 2024, we conducted a research trip from mid-April to the end of May, which was the latest we were out working in the ice since 2010. We will continue to use sampling methods to collect data that can be replicated in the future to evaluate whether these metrics of general population health changed over time.

Product

Ziel, H.L., London, J.M., Brady, G.M., Walcott, S.M., Lindsay, J.M. 2025. Field report: 2024 Bering Sea ice seal research cruise. AFSC Processed Rep. 2025-14, 55 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv., 7600 Sand Point Way NE, Seattle, WA 98115.

London JM, Conn PB, Koslovsky SM, Richmond EL, Ver Hoef JM, Cameron MF, Crawford JA, Von Duyke AL, Quakenbush L, Boveng PL. 2024. Spring haul-out behavior of seals in the Bering and Chukchi Seas: implications for abundance estimation. PeerJ 12:e18160 https://doi.org/10.7717/peerj.18160

London, J.M., Cameron, M.F., and Boveng, P.L. In Prep. Spatial use patterns of ribbon and spotted seals in the Bering and Chukchi Seas.

Cameron, M.F., Bengtson, J.L., Burkanov, V.N., Boveng, P.L., Stewart, B.S. In Prep. Movements, dive behavior and habitats of ribbon seals (Histriophoca fasciata) from the western Bering Sea.

Ziel, H. L., Goldstein, T., Conn, P.B., and Boveng, P.L. In revision. Serologic survey for exposure to potential pathogens in ribbon seals (Histriophoca fasciata), spotted seals (Phoca largha), and bearded seals (Erignathus barbatus) in the Bering Sea. Marine Mammal Science.

Hamilton, C. D., C. Lydersen, J. Aars, M. Acquarone, T. Atwood, A. Baylis, M. Biuw, A. N. Boltunov, E. W. Born, P. Boveng, T. M. Brown, M. Cameron, J. Citta, J. Crawford, R. Dietz, J. Elias, S. H. Ferguson, A. Fisk, L. P. Folkow, K. J. Frost, D. M. Glazov, S. M. Granquist, R. Gryba, L. Harwood, T. Haug, M. P. Heide-Jørgensen, N. E. Hussey, J. Kalinek, K. L. Laidre, D. I. Litovka, J. M. London, L. L. Loseto, S. MacPhee, M. Marcoux, C. J. D. Matthews, K. Nilssen, E. S. Nordøy, G. O'Corry-Crowe, N. Øien, M. T. Olsen, L. Quakenbush, A. Rosing-Asvid, V. Semenova, K. E. W. Shelden, O. V. Shpak, G. Stenson, L. Storrie, S. Sveegaard, J. Teilmann, F. Ugarte, A. L. Von Duyke, C. Watt, Ø. Wiig, R. R. Wilson, D. J. Yurkowski and K. M. Kovacs. 2022. Marine mammal hotspots across the circumpolar Arctic. Diversity and Distributions.

Boveng, P. L., H. L. Ziel, B. T. McClintock and M. F. Cameron. 2020. Body condition of phocid seals during a period of rapid environmental change in the Bering Sea and Aleutian Islands, Alaska. Deep Sea Research Part II: Topical Studies in Oceanography 181-182: 104904.

VanWormer, E., J. A. K. Mazet, A. Hall, V. A. Gill, P. L. Boveng, J. M. London, T. Gelatt, B. S. Fadely, M. E. Lander, J. Sterling, V. N. Burkanov, R. R. Ream, P. M. Brock, L. D. Rea, B. R. Smith, A. Jeffers, M. Henstock, M. J. Rehberg, K. A. Burek-Huntington, S. L. Cosby, J. A. Hammond and T. Goldstein. 2019. Viral emergence in marine mammals in the North Pacific may be linked to Arctic sea ice reduction." Scientific Reports 9(1): 15569.

Goertz, C. E. C., C. Reichmuth, N. M. Thometz, H. Ziel and P. Boveng. 2019. Comparative health assessments of Alaskan ice seals." Frontiers in Veterinary Science 6: 4.

Citta, J., Lowry, L., Quakenbush, L., Kelly, B., Fischbach, A., London, J., Jay, C., Frost, K., O'Corry Crowe, G., Crawford, J., Boveng, P., Cameron, M., Von Duyke, A., Nelson, M., Harwood, L., Richard, P., Suydam, R., Heide-Jorgensen, M., Hobbs, R., Litovka, D., Whiting, A., Marcoux, M., Kennedy, A., George, J., Orr, J., Gray, T. -2018. A multi-species synthesis of satellite telemetry data in the Pacific Arctic (1987–2015): Overlap of marine mammal distributions and core use areas (SOAR II). Deep Sea Research II

Cameron, M., Boveng, P. and London, J. 2014 A research cruise to study the ecology of ice-associated seals in the central Bering Sea aboard the NOAA ship Oscar Dyson in April, 2014. AFSC Quarterly Report (April-June, 2014)

Ziel, H., Cameron, M., Goldstein, T., Johnson, S., and Boveng, P. 2010. Blood oxygen capacity of ribbon, spotted, and bearded seals. AFSC Quarterly Report (Jan-Mar, 2010).

Cameron, M.F., London, J.M. Boveng, P.L. 2009. Telemetry of ice seals captured during research cruise aboard the McArthur II in the eastern Bering Sea. AFSC Quarterly Report (May-July 2009)

Boveng., P., London, J., and Cameron., M. 2007. Telemetry of ice seals captured during the Oscar Dyson and USCGC Healy research cruises in the eastern Bering Sea. AFSC Quarterly Research Reports (Apr.-Jun. 2007).

Cameron, M.F. 2006. Ice seal operations aboard the Thomas G. Thompson. AFSC Quarterly Research Reports (Apr.-Jun. 2006).

Cameron, M.F. 2005. Habitat use and seasonal movements of ribbon seals in the Bering Sea and North Pacific. AFSC Quarterly Research Reports (Apr.-Jun. 2005).

Funding status: Funded by NMFS/MML

Project lead: NMFS/MML, Michael Cameron, michael.cameron@noaa.gov

Project partners: Ice Seal Committee

A.3.2 BERING-OKHOTSK SEAL SURVEYS (BOSS)

Objective: To estimate abundances of ribbon, spotted, bearded, and ringed seals in the Bering and Okhotsk Seas.

Justification: Bearded, spotted, ribbon, and ringed seals are key components of Arctic marine ecosystems and they are important subsistence resources for northern coastal Alaska Native communities. Although these seals are protected under the Marine Mammal Protection Act and bearded and ringed seals are listed as threatened under the Endangered Species Act, no reliable, comprehensive abundance estimates are available for any of the species. Obtaining reliable abundance estimates for ice-associated seals is therefore, vital for developing sound plans for management, conservation, and responses to potential environmental impacts of changing sea ice habitat and increased vessel traffic anticipated in the Arctic.

Methods:

SURVEY EFFORT

Aerial surveys for bearded, spotted, ribbon, and ringed seals were conducted in the Bering and Okhotsk Seas in the spring of 2012 and 2013. Surveys were conducted using thermal imagers (to detect seals on the ice) paired

with digital cameras (to help identify the seal to species) mounted in the belly ports of two US and one Russian fixed-wing aircraft in the spring of 2012 and 2013. Combined, the teams flew over 47,000 nautical miles (90,000 km) of survey track. The completion of this project marks the largest survey of ice-associated seals ever conducted and will provide the first comprehensive estimates of abundance for bearded, spotted, ribbon and ringed seals in the Bering Sea and Sea of Okhotsk.

ABUNDANCE ESTIMATION

Analyzing abundances from thermal video and digital photography presents several statistical challenges due to incomplete detection, false positives, and species misidentification. Novel statistical approaches were developed to deal with these challenges as part of a hierarchical modeling framework that also includes a temporal dimension to account for changing sea ice conditions during the surveys. The coordinated US Russian analyses provide the most comprehensive estimates of abundance for bearded, spotted, ribbon and ringed seals in the Bering Sea and the Sea of Okhotsk.

Product:

Conn, P.B., Trukhanova, I.S., Boveng, P.L., and Chernook, V.I. In Prep. Abundance and distribution of ice-associated seals in the western Bering Sea and Sea of Okhotsk, 2012-2013. Polar Biology.

Boveng, P.L.,Conn, P.B., Moreland, E.M., VerHoef, J.V., McClintock, B.T., London, J.M., Cameron, M.F.. In prep. Abundance of ice-associated seals in the eastern Bering Sea in spring of 2012 and 2013: a cause for concern? Scientific Reports

Conn, P. B., & Trukhanova, I. S. (2022). Modeling vital rates and age-sex structure of Pacific Arctic phocids: influence on aerial survey correction factors. Marine Mammal Science, 1–14.

Lindsay, J.M., Lairdre, K.L., Conn, P.B., Moreland, E.E., and Boveng, P.L. 2021. Modeling ringed seal Pusa hispida habitat and lair emergence timing in the eastern Bering and Chukchi Seas. Endangered Species Research 46:1–17.

Boveng, P.L., Cameron, M.F., Conn P.B. and Moreland, E.E. 2017. Abundance Estimates of Ice-Associated Seals: Bering Sea Populations that Inhabit the Chukchi Sea during the Open-Water Period. Final Report, BOEM Report 2016-077. Bureau of Ocean Energy Management, Alaska Outer Continental Shelf Region, Anchorage, Alaska, USA.

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Conn, P.B., Johnson, D.S., and Boveng, P.L. 2015. On extrapolating past the range of observed data when making statistical predictions in ecology. PloS One 10(10).

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McClintock, B. T., Moreland, E.E., London, J.M., Dahle, S.P., Brady, G.M., Richmond, E.L., Yano, K.M. and Boveng. P.L 2015. Quantitative assessment of species identification in aerial transect surveys for ice-associated seals. Marine Mammal Science 31(3):1057-1076.

Chernook V.I., Grachev A.I., Vasiliev A.N., Trukhanova I.S. Burkanov V.N., Solovyev B.A. Results of instrumental aerial survey of ice-associated seals on the ice in the Okhotsk Sea in May 2013 // Izv. TINRO. 2014. Vol. 179. Pg. 158–176.

Conn, P.B., VerHoef, J.V., McClintock, B.T., Moreland, E.M., London, J.M., Cameron, M.F., and Boveng, P.L. 2014. Estimating multi-species abundance using thermal video and digital photography: Ice-associated seals in the eastern Bering Sea. Methods in Ecology and Evolution, DOI 10.1111/2041-210X.12127

Conn, P.B., McClintock, B.T., Cameron, M.F., Laake, J.L., Johnson, D.S., Moreland, E.E., and Boveng, P.L. 2013. Accommodating species identification errors in transect surveys. Ecology. 94: 2607-2618.

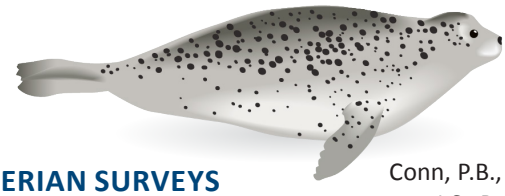
Moreland, E., Cameron, M., and Boveng, P. 2013. Bering Okhotsk Seal Surveys (BOSS): Joint US-Russian aerial surveys for ice associated seals, 2012-2013. AFSC Quarterly Report (July-Sept, 2013)

Moreland, E., Cameron, M., and Boveng, P. 2012. Bering Okhotsk Seal Surveys (BOSS): Joint US-Russian aerial surveys for ice associated seals. AFSC Quarterly Report (April-June, 2012).

Funding status: Funded by NMFS/MML and the Bureau of Ocean Energy Management (BOEM)

Project lead: NMFS/MML, Erin Moreland, erin.moreland@noaa.gov

Project partners: BOEM, State Research and Design Institute for Fishing Fleet (“Giprorybflot”), RUSSIA



A.3.3 CHUKCHI AND EAST SIBERIAN SURVEYS (CHESS)

Objective: To estimate abundances of bearded and ringed seals in the Chukchi and eastern East Siberian Seas.

Justification: Bearded and ringed seals are key components of Arctic marine ecosystems and they are important subsistence resources for northern coastal Alaska Native communities. Although these seals are protected under the Marine Mammal Protection Act and are listed as threatened under the Endangered Species Act, no reliable, comprehensive abundance estimates are available for either species in the Chukchi Sea. Obtaining reliable abundance estimates for ice-associated seals is therefore, vital for developing sound plans for management, conservation, and responses to potential environmental impacts of changing sea ice habitat and increased vessel traffic anticipated in the Arctic.

Methods: Aerial surveys for bearded and ringed seals were conducted in the Chukchi and East Siberian Seas in the spring of 2016. Similar to the 2012-2013 Bering-Okhotsk Seal Surveys (BOSS), US and Russian researchers used thermal imagers (to detect seals on the ice) paired with digital cameras (to help identify the seal to species) mounted in the belly ports of US and Russian fixed-wing aircraft. In addition to seals, these surveys were also designed to provide information on the distribution of polar bears in the Chukchi Sea; data that are critical to the U.S. Fish and Wildlife Service. Combined, the US and Russian teams flew over 16,000 nautical miles (30,000 km) of survey track.

The seal abundance estimates were calculated using a novel hierarchical modeling framework developed for the BOSS project that includes the effects of incomplete detection, false positives, species misidentification and the temporal dimension to account for changing sea ice conditions during the surveys. The data collected by our Russian collaborators has been published and integrated into a final analysis to provide the first comprehensive estimates of abundance for bearded and ringed seals in the Chukchi and eastern East Siberian Seas.

Product:

Boveng, P.L. Chernook, V.I., Moreland, E.E., Conn, P.B., Trukhanova, I.S., Cameron, M.F., Christman, C.L., Crawford, J., Koslovsky, S., HArwood, L., Hou, B.X., Lindsay, J.M., London, J.M., Platonov, N., Quakenbush, L., Richmond, E., Vasiliev, A., von Duyke, A. 2025. Abundance and distribution of bearded and ringed seals in the Chukchi Sea: a reference for future trends. Arctic Science 11:1-21.

Conn, P.B., Chernook, V.I., Moreland, E.E., Trukhanova, I.S., Regehr, E.V., Vasiliev, A.N., Wilson, R.R., Belikov, S.E., and Boveng, P.L. 2021. Aerial survey estimates of polar bears and their tracks in the eastern Chukchi Sea. PLoS ONE 16: e0251130.

Lindsay, J.M., Lairdre, K.L., Conn, P.B., Moreland, E.E., and Boveng, P.L. 2021. Modeling ringed seal Pusa hispida habitat and lair emergence timing in the eastern Bering and Chukchi Seas. Endangered Species Research 46:1–17.

Chernook V.I., Trukhanova I.S., Vasiliev A.N., Litovka D.I., Glazov D.M., Burkanov V.N. 2019. First experience of instrumental aerial survey of ringed seal (Pusa hispida) and bearded seal (Erignathus barbatus) in the Russian zone of the Chukchi and East-Siberian Seas in spring 2016 // Izv. TINRO. — Vol. 199. — P. 152–162

Conn, P.B., Moreland, E., Regeher, E.V., Richmond, E.L., Cameron, M.F. and Boveng, P. 2016. Using simulation to evaluate wildlife survey designs: polar bear and seals in the Chukchi Sea. Royal Society Open Science. http://dx.doi.org/10.1098/rsos.150561

Funding status: Funded by NMFS/MML, the Bureau of Ocean Energy Management (BOEM), and the U.S. Fish and Wildlife Service.

Project lead: NMFS/MML, Erin Moreland, erin.moreland@noaa.gov

Project partners: BOEM, State Research and Design Institute for Fishing Fleet (“Giprorybflot”), RUSSIA and the U.S. Fish and Wildlife Service.

A.3.4 JOINT BEAUFORT SEA SURVEYS (JOBSS) FOR SEALS AND POLAR BEARS

Objective: To estimate abundances of bearded and ringed seals in the Beaufort Sea.

Justification: Bearded and ringed seals are key components of Arctic marine ecosystems and they are important subsistence resources for northern coastal Alaska Native communities. Although these seals are protected under the Marine Mammal Protection Act and are listed as threatened under the Endangered Species Act, no reliable, comprehensive abundance estimates are available for either species in the Beaufort Sea. Obtaining reliable abundance estimates for ice-associated seals is therefore vital for developing sound plans for management, conservation, and responses to potential environmental impacts of changing sea ice habitat and increased vessel traffic anticipated in the Arctic.

Methods: Similar to the 2012-2013 Bering and Okhotsk Sea Seal Surveys (BOSS) and the 2016 Chukchi and East Siberian Surveys (ChESS), we used thermal imagers (to detect seals on the ice) paired with machine vision color cameras (to help identify the seal to species) and machine vision ultraviolet cameras (to help with white coat pup and polar bear detection development) mounted in the belly ports of fixed-wing aircraft. Instrument-based aerial surveys were conducted in the U.S. Beaufort Sea, extending into Canadian waters to survey the Southern Beaufort Sea polar bear sub-population boundary between April 17 – June 11 when bearded seals were hauled out on the ice to molt and the snow lairs of ringed seals were melting. In addition to seals, these surveys also provided information on the distribution of the Southern Beaufort Sea polar bear stock, which are data critical to the U.S. Fish and Wildlife Service and the Department of Fisheries and Oceans (DFO) of Canada. The survey team flew over 9,000 nautical miles (18,000 km) of survey track. A machine learning detection model was used to detect thermal signatures in the infrared imagery and identify the location of animals in the color imagery. Final animal detection and species determination was made by a biologist. A hierarchical modeling framework accounting for incomplete detection, false positives, species misidentification, and temporal aspects such as changing sea ice conditions was used to produce abundance estimates in spring 2023.

Product: Comprehensive estimates of the distributions and abundances of bearded and ringed seals in the Beaufort Sea.

Funding status: Funded by NMFS/MML; U.S. Fish and Wildlife Service

Project lead: NMFS/MML, Erin Moreland, erin.moreland@noaa.gov

Project partners: U.S. Fish and Wildlife Service, U.S. Geological Survey, Department of Fisheries and Oceans (DFO) CANADA, Government of Northwest Territories, CANADA

A.3.5 ACOUSTIC HABITAT OF ICE-LIVING SEALS IN KOTZEBUE SOUND

Objective: Measure and describe the year-round acoustic habitat of Kotzebue Sound, an area intermittently used by bearded, ringed, and spotted seals. Combine these ambient noise data with hearing data collected for these species in the laboratory to better understand hearing and auditory masking in typical environments.

Justification: This study seeks to improve understanding of the acoustic ecology of ice-living seals and typical acoustic conditions in near-shore Arctic habitats. Bearded, ringed, and spotted seals are important to trophic webs and subsistence communities in Alaska, and acoustic habitat is a fundamental but poorly understood resource for these seals. To support management decisions about anthropogenic noise in areas used by ice-living seals, more must be known about what sounds they hear, how they use sound, what types of acoustic habitat they rely on, and how human-induced changes in that habitat may affect their survival or reproductive success. To address these questions, it is necessary to evaluate natural variability in representative conditions over seasons. Combined with laboratory studies on the hearing abilities of ice seals, these measurements of acoustic habitats provide valuable perspective on the significance of acoustic information—including biological, environmental, and human-generated sounds—for seals and other marine mammals living in Arctic waters.

Methods: Two DSG-Ocean Acoustic Dataloggers (Loggerhead Instruments, Sarasota, FL, USA) were deployed in Kotzebue Sound, Alaska, in September 2014, and successfully retrieved one year later. The DSG units comprise low-power acoustic recorders designed to sample continuously or on a duty cycle. The two deployed units were programmed to record two out of every 45 minutes at a 96 kHz sampling rate, enabling the description of variations in noise up to 48 kHz within and across hours, days, months, and seasons. These instruments were deployed near Cape Blossom in Kotzebue Sound, approximately 1.5 miles offshore. The locations were selected based on a combination of local and traditional knowledge and previously published data for this region. Specifically, the sites were chosen based on the following characteristics: at least 10 m depth, known ice seal habitat, minimal ice gouging during winter, and minimal sedimentation (far enough from river mouths and past any major sandbars).

Calibrated acoustic recordings were analyzed in terms of 1/3-octave band levels – a common way to describe ambient noise conditions. We characterized average noise levels and variability in noise based on frequency, time of day and year, and prevailing weather conditions (when known). This type of 1/3-octave band analysis is also used to characterize typical ambient noise conditions in the laboratory during hearing studies, which enables us to compare directly between laboratory and field measurements. Further, this method is relevant to ongoing studies of hearing because the frequency bandwidth over which noise interferes with the detection of a target sound is often well approximated by a 1/3-octave band.

Data were collected under an existing data-sharing agreement with the Kotzebue Sound Beluga Acoustics Team—with members from the Alaska Department of Fish and Game, the National Marine Mammal Laboratory, the North Slope Borough, the University of Washington,

the Alaska Beluga Whale Committee, and the Native Village of Kotzebue. Raw data sets have been provided to the Kotzebue Sound Beluga Acoustics Team. Processed data will be shared when analysis activities are finished.

Product:

Sills, J.M., Reichmuth, C. and Whiting, A. (2018) Acoustic habitat utilized by ice-living seals: hearing and masking in natural noise environments. Journal of the Acoustical Society of America. 141(5):4002-4002.

Funding status: This project is currently unsupported. Data collection was initially funded by the Northwest Arctic Borough Science Program and the University of California Santa Cruz. Data analyses and writing are being completed opportunistically.

Project leads: Jillian Sills and Colleen Reichmuth (University of California Santa Cruz, jmsills@ucsc.edu and coll@ucsc.edu)

Project partners: Native Village of Kotzebue, Alex Whiting

A.3.6 ICE SEAL HEALTH RESEARCH

Objective: Conduct retrospective and prospective veterinary medicine based health assessment of subsistence harvested (healthy and hunter concern) and found dead ice seals.

Justification: There is little information available about natural causes of morbidity and mortality of ice seals. Hunter observations and satellite studies indicate that the Arctic is undergoing major changes in duration of seasonal sea ice extent and thickness, extreme weather patterns, more maritime traffic etc. Coupled to these environmental changes are noted changes in animal distribution, in migration routes and timing, in breeding season start, and arrival of new species to name just a few. The continuation of all these changes could negatively impact the rich marine mammal resources that are essential to Yupik and Inupiat subsistence communities. The North Slope (NSB DWM) Marine mammal health program works with hunters and communities to support the families and communities, as they, as in the past, continue to adapt to changing environmental conditions, changes in wildlife abundance and accessibility. Through our long-term harvest and health monitoring efforts we are in the position to detect early on emerging issues (i.e. novel infectious diseases; contaminants, including microplastics, harmful algae biotoxins) that are of concern to northern indigenous communities, and provide veterinary medicine based information to hunters regarding "healthy" and "hunter concern" catches, and address individual and "big picture" concerns about native food health, food safety, and food security in a rapidly changing Pacific Arctic.

Methods: Post mortem examination of ice seals by veterinarian and tissue collection for life history parameters assessment and veterinary diagnostics (e.g. histopathology; marine biotoxins; contaminants; parasitology; infectious diseases; microplastics; microbiome; genomics).

Products:

Olnes J, Quakenbush L, Bryan A, Stimmelmayr R. Trace elements in Alaska's ice seals in the 2000s and 2010s. Science of The Total Environment. 2025 Jan 1;958:178126.

Olnes J, Bryan AL, Stimmelmayr R, Quakenbush L. Organochlorine concentrations in ice seals harvested in Alaska in the 2000s and 2010s. Marine Pollution Bulletin. 2025 Jun 1;215:117843.

Funding status: NSB DWM, USFWS Prescott grant (F20AP10932-00); ECOHAB subaward agreement, & NPRA funds.

Project lead: Raphaela Stimmelmayr (NSB DWM)

Project partners: Gay Sheffield (Alaska Sea Grant), Kathi Lefevbre (NWFSC), Lori Quakenbush and Anna Bryan (ADF&G), and other NOAA partners.

A.3.7 DOCUMENTING MOVEMENTS, BEHAVIOR, AND DISTRIBUTION OF ARCTIC ICE SEALS

Objective: Capture and instrument ice seals in the NPR-A with satellite tags to monitor their movements and behavior.

Justification: Information on ice seal spatial ecology is limited and questions remain concerning which factors are important to their behavior, movements, and habitat selection. This project will build upon current understanding of ice seal ecology, supplement existing data sets, help to predict impacts from climate change, and mitigate the impacts of proposed development and increased shipping.

Given the incredible distances that ice seals can travel, this research has statewide implications, particularly for the 55+ Alaskan coastal communities that range from Kaktovik to Bristol Bay that rely upon ice seals for subsistence.

The likely increase of industrial development and shipping in response to sea-ice decline has the potential to exacerbate the influence of changes that are already occurring with the fragile and shifting Arctic ecosystem. This information will inform science based wildlife management, critical habitat designations for ringed and bearded seals (both listed under the Endangered Species Act - ESA), and is important to developing mitigation plans to minimize negative impacts to Alaska's four ice seal species, as well as the communities that rely upon them for their nutritional and cultural wellbeing.

Methods: Seals will be captured in floating nets, and will be instrumented with satellite transmitting tags (hereafter 'tags'). These tags will collect data on each seal's movements, haul-out behavior, and individual dive behavior. Though ringed seals will be targeted opportunistically, emphasis will be placed on spotted and bearded seals. All seals will be instrumented with two different tags, specifically a back mounted tag that is shed when the seal molts in the spring after it has been captured, and a flipper mounted tag that is permanently attached.

Basic morphological measurements will be taken, including: weight, length, and girth. Several biological samples will be collected for genetics and health assessment. Blood, which is collected from the holes punched in the webbing of the rear flipper, will be soaked up using blotter strips and archived. Skin samples (the hole punches) will be collected and archived for genetic, micro-histological, and disease profiling analyses. A small sample of fur and a single whisker will also be collected for use in stable isotope analysis that informs diet and chronic stress.

Location, haul-out, and dive-behavior data will be obtained as a time series using the Argos System. Data will be filtered to eliminate implausible locations and to ensure data quality. Daily locations for each seal will be estimated using a continuous-time correlated random walk model. A number of spatial, habitat, and environmental covariates will be annotated to each location estimate.

To inform our interpretation of variations in seal movements, habitat use, and haul-out behavior, we will construct a series of mixed models that to predict a variety of ecologically relevant response variables. Explanatory variables will include a variety of demographic, seasonal, spatial, and environmental factors.

Product: The data collection phase has been completed, and analyses have begun. It is anticipated that a time series of spatial and behavioral data will be produced for each seal tagged in the vicinity of Utqiagvik, AK. Factors associated with seal movements, habitat use, and haul-out and dive behavior will be analyzed within a model selection framework. A manuscript is in prep and is anticipated to be submitted for publication in the fall of 2023.

Funding status: This work has been funded through a NPR-A grant (Grant # 20-NPRA-06).

Project Lead: North Slope Borough Department of Wildlife Management, Andrew Von Duyke, andrew.vonduyke@north-slope.org

Project partners: North Slope Borough, Ice Seal Committee, ADF&G. All seal research will be conducted under NMFS permit #20466 and ADF&G Animal Care and Use Committee Protocol #0027-2017-27.

A.3.8 RINGED SEAL WINTER DENSITY

Objective: Determine the density of ringed seals within areas of oil and gas interest near Prudhoe Bay using dogs trained to find seal breathing holes and lairs. The density of seal structures and their snow depths determined during this study in 2022, 2023, and 2025 will be compared to a previous study conducted in 1982–1983.

Justification: Ringed seal winter density has not been investigated in the Beaufort Sea nearshore fast ice zone for 40 years. This area is used by the oil and gas industry for ice roads, drilling islands, and other infrastructure. In doing so, mitigation measures to minimize disturbance to ringed seals are required. Less sea ice and less snow on ice has been predicted to negatively affect ringed seals, therefore, a comparative study is necessary to determine whether the number of ringed seals using the area has changed.

Methods: Seal structures are not visible from the ice surface; therefore, trained dogs are used to find seal structures by scent. Structures are then instrumented (thermistors and cameras), geopositioned, and measured (e.g., snow and water depth, and lair dimensions when applicable).

Product:

Bryan, A., L. Quakenbush, and J. Crawford. 2023a. Using wildlife detection dogs to help determine ringed seal density. Alaska Department of Fish and Game, Brown Bag Series, October 2023. https://vimeo.com/874179206?share=copy.

Bryan, A., L. Quakenbush, and J. Crawford. 2023b. Using wildlife detection dogs to help determine ringed seal density. Winter Wildlife Series, Alaska Department of Fish and Game video https://vimeo.com/showcase/9281005

Bryan, A., L. Quakenbush, and J. Crawford. 2026. Ringed seal winter density and behavior in Prudhoe Bay, Alaska in the 2020s. Alaska Marine Science Symposium, January 26–30, Anchorage, Alaska (abstract for oral presentation).

Quakenbush, L., A. Bryan, and J. Crawford. 2022. Winter ringed seal density within Beaufort Sea oil and gas project areas. Annual Report to BOEM (AK021-01, Award No. M21AC00024). 36 pp with appendices.

Quakenbush, L., A. Bryan, and J. Crawford. 2023. Ringed seal behavior and winter density in Prudhoe Bay, Alaska, determined by wildlife detection dogs and instrumentation of subnivean lairs. Alaska Marine Science Symposium, January 23–27, Anchorage, Alaska (abstract for oral presentation).

Quakenbush, L., A. Bryan, J. Crawford. 2024. Ringed seal winter density and behavior in Prudhoe Bay, AK, using dogs and monitoring instruments. Alaska Marine Science Symposium, January 29–February 2, Anchorage, Alaska (abstract, poster).

Quakenbush, L., A. Bryan, J. Crawford. 2024. Ringed seal winter density and behavior in Prudhoe Bay, Alaska, using dogs and monitoring instruments. Biennial Conference on the Biology of Marine Mammals, November 11-15, Perth, Australia (abstract, poster).

Quakenbush, L., A. Bryan, J. Crawford. 2025. Ringed seal winter density and behavior in Prudhoe Bay, Alaska, 2022, 2023, and 2025. Alaska Marine Science Symposium, January 27-30, Anchorage, Alaska (abstract, poster).

Quakenbush, L., A. Bryan, and J. Crawford. 2025. Winter ringed seal density within Beaufort Sea oil and gas project areas. Annual Report to BOEM (AK021-01, Award No. M21AC00024). 31 pp with appendices

Woodford, R. 2023. Studying ringed seals in winter with the help of detection dogs. Alaska Fish and Wildlife News December issue. http://wildlifenews.alaska.gov

For all ADF&G products for this project see: https://www.adfg.alaska.gov/index.cfm?adfg=marinemammalprogram.winterringedseal&tab=products

Funding status: BOEM, BLM

Project lead: ADF&G, Lori Quakenbush, lori.quakenbush@alaska.gov

Project partners: North Slope Borough

A.3.9 THE TROPHIC ROLES OF ICE SEALS IN THE BERING AND ARCTIC MARINE ECOSYSTEMS OF ALASKA

Objective: Determine the seasonal and regional consumption by spotted, ringed, bearded, and ribbon seals of their dominant prey species by integrating results from spring surveys of seal abundance and distribution; satellite-tracking studies of seasonal seal movements; seal prey composition studies; controlled studies of daily energy intake and metabolic rates in captive seals; and energy assays of prey species.

Justification: Recent extreme warm periods in the Bering and Chukchi seas have led to rapid declines in sea ice with potentially profound impacts on spotted, ringed, bearded and ribbon seals. They compose a highly abundant guild of predators, whose ecological (i.e., trophic) roles in the seasonally ice-covered waters around Alaska are undoubtedly significant, yet their impact is poorly understood. In the Bering Sea alone, the numbers of seals in winter and spring exceeds 1,000,000 individuals, likely consuming several million tons annually of a diverse suite of fish and invertebrate prey. Over the past decade, progress in determining the abundance, seasonal distribution, diet, and daily energy requirements has opened broad opportunities for collaboration to clarify the trophic roles of ice seals. It has become feasible to quantify their energy intake requirements and their impacts as predators. This collaboration between NMFS and six external institutions will support syntheses that for the first time, will afford meaningful inclusion of phocid seals in Ecosystem Status Reports, integrated ecosystem models, and protected species assessments for Alaska Large Marine Ecosystems.

Methods: The overall approach consists of three main components: One component estimates the daily gross energy intake of an individual seal. A second component estimates the average diet composition in terms of the mass of each prey species making up a unit of gross energy intake for an individual seal. The third component uses the abundance and seasonal distribution of seals to scale results from the first two (individual) components to the population level.

SEAL ENERGY INTAKE

The daily energy intake of seals will be estimated by incorporating individual-based gross energy intake estimates directly measured in spotted, ringed, and bearded seals reared in captivity. These will be used as a lower bound for the expected total energy requirements of free-ranging seals.

SEAL PREY COMPOSITION

The second main component of our approach, seal prey composition, will address the taxa and quantities of prey that meet an individual seal's energetic needs. The objective of this component is to estimate the relative mass of different prey items in the seals' average diet. The primary seal diet data comprise the stomach contents from more than 3,500 ice seals sampled by ADF&G, NSB-DWM, and Alaska Native hunter collaborators between 2000 and 2020 at communities along the Bering and Chukchi coasts. For spotted and ribbon seals, the stomach contents samples will be supplemented with prey remains from seal scats collected during spring near the sea ice edge in the Bering Sea.

Prey taxa in seal stomachs and scats are summarized as the counts and measurements of identifiable prey items (e.g., fish otoliths) that we will use to reconstruct diet compositions. The weight of prey, reconstructed from the counts and sizes of identifiable parts, will be converted to caloric values using the AFSC-ABL prey-energy-content library. The key result of this component will be an estimate of the contribution of each major prey species to an individual seal's energy requirements.

SCALING PREY CONSUMPTION TO THE SEAL POPULATION LEVEL

At the final stage of estimating the annual prey consumption by a seal population, the individual energy requirements and the average prey composition will be combined into seasonal and spatial estimates of consumption by the entire seal population. This step will incorporate recent population estimates from aerial surveys and seasonal spatial use patterns obtained from seals carrying satellite-linked geolocation tags.

Products:

Fiscal Year 2022: Developed the approach using spotted seals as the case study.

Fiscal Year 2023: Completed the spotted seal analysis.

Fiscal Year 2024-2025: Prepared a draft manuscript on the spotted seal case for submission to a journal.

Fiscal Year 2026: Submit, revise, and publish the spotted seal case; develop proposal for implementing the spotted seal approach with ringed seals, pending availability of funds.

Funding status: Not currently funded; Funded 2022-2024 under NMFS-AFSC Regional Work Plan

Project lead: NMFS AFSC Marine Mammal Laboratory. Josh London (josh.london@noaa.gov).

Project partners: NMFS AFSC Age and Growth Lab; NMFS AFSC Recruitment, Energetics & Coastal Assessment; ADF&G Arctic Marine Mammals, NSB Dept. of Wildlife Management, University of California Santa Cruz, University of British Columbia, University of San Francisco, University of Alaska Fairbanks

A.3.10 COMPREHENSIVE ICE SEAL SURVEYS 2024-2025

Objective: To estimate abundances of ribbon, spotted, bearded, and ringed seals in the Bering, Chukchi, and Beaufort seas.

Justification: Bearded, spotted, ribbon, and ringed seals are key components of Arctic marine ecosystems and they are important subsistence resources for northern coastal Alaska Native communities. Although these seals are protected under the Marine Mammal Protection Act and bearded and ringed seals are listed as threatened under the Endangered Species Act, only one complete survey of their range in U.S. waters has been completed in more than a decade and each sea had to be surveyed in separate years. Obtaining reliable abundance estimates for ice-associated seals is therefore vital for developing sound plans for management, conservation, and responses to potential environmental impacts of changing sea ice habitat and increased vessel traffic anticipated in the Arctic.

Methods: Comprehensive aerial surveys for bearded, spotted, ribbon, and ringed seals were conducted in the Bering, Chukchi, and Beaufort seas between April 1 and June 9, 2025. As with previous surveys, we used thermal imagers (to detect seals on the ice) paired with high resolution color cameras (to help identify the seal to species) mounted in the belly ports of two fixed-wing aircraft. One aircraft carried additional machine vision ultraviolet cameras to help with white coat pup and polar bear detection development. The NOAA survey aircraft (Twin Otter and King Air) operated out of Dillingham, Bethel, St. Paul, Nome, Kotzebue, Utqiagvik, and Deadhorse, Alaska. The project completed 58 total survey flights covering approximately 24,645 miles (40,000 km) of survey effort. Researchers are currently reviewing results from a detection model that has processed over 500,000 images collected from one of the aircraft. Due to a detectable change in thermal camera performance, a new detection model is currently being developed to process the approximately one million remaining images from the second aircraft. Final animal detection and species determination will be made by a biologist. A hierarchical modeling framework accounting for incomplete detection, false positives, species misidentification, and temporal aspects such as changing sea ice conditions will

be used to produce abundance estimates anticipated in fall 2026. This project will provide a second round of comprehensive abundance and distribution estimates for bearded, spotted, ribbon, and ringed seals throughout their range in U.S. waters.

Product: Comprehensive estimates of the distributions and abundances of bearded and ringed seals in U.S. waters of the Bering, Chukchi, and Beaufort seas.

Funding status: Funded by NMFS/MML

Project lead: NMFS/MML, Erin Moreland, erin.moreland@noaa.gov

A.3.11 MONITORING BEARDED SEALS IN THE NPR-A THROUGH TAGGING AND ACOUSTICS

Objective: Enhance the baseline understanding of adult bearded seal spatial and acoustic ecology.

Justification: Rapid warming in the Arctic and subsequent loss of sea-ice is associated with ecological disruptions throughout marine and terrestrial ecosystems. Bearded seals *(Erignathus barbatus)* are ice-associated and, therefore, depend upon the sea-ice to fulfill important aspects of their life-history, such as: foraging, reproduction, molting, and predator avoidance. This reliance upon sea-ice ultimately led to their listing as "threatened" under the US Endangered Species Act (ESA). As a generalist benthic feeder, and one of two primary prey species for polar bears *(Ursus maritimus)*—also listed as "threatened" under the ESA—bearded seals form energetic linkages throughout the trophic web and are a vital component of the Arctic ecosystem.

Beyond their ecological importance, bearded seals are valued by indigenous communities in Alaska such as the Iñupiat on Alaska's North Slope, who have very strong cultural, nutritional, and economic connections to the subsistence harvest of marine mammals. For example, bearded seals are highly valued for their meat and oil, and for the raw materials (i.e., skins) they provide for the construction of umiaqs (Iñupiat: open boats) that are used to hunt bowhead whales *(Balaena mysticetus)*—an activity that is central to both Iñupiat and Yupik culture and economy. Protecting opportunities for subsistence has economic benefits and helps to maintain the social and cultural fabric of the Inuit, for whom the harvest, gathering, and sharing of food are of paramount importance.

Despite their ecological importance and subsistence value, relatively little is known about bearded seals in the Alaskan Arctic; largely because this population is hunted, very cautious, and quite difficult to capture. As such, there is much about bearded seal ecology and behavior that remains to be learned. Because bearded seals are a highly vocal species—relying on vocalizations to attract mates, defend territories, and in other social interactions—passive acoustic survey techniques can be highly effective for investigating both basic ecology of this aquatic mammal, as well as how bearded seals respond to anthropogenic perturbations. Despite the importance of acoustic communication to bearded seals, a baseline understanding of this species' relationship with anthropogenic noise is severely lacking. As arctic sea-ice continues to decline, opportunities for industrial activities in the region continue to increase. Unmitigated anthropogenic noise associated with these activities (e.g., boat traffic, aircraft, seismic survey equipment, and industry infrastructure) may disrupt mating or other social behavior and/or the use of preferred habitat for foraging and molting, which could result in negative fitness costs for the population. Because bearded seals travel great distances annually, these impacts may impact subsistence-based communities in Alaska from the Canadian border to Bristol Bay.

Further underscoring the need for better data on bearded seals and their resilience to human activities, are plans for oil and gas development, which have the potential for negative impacts and, in turn, negatively impact subsistence. Potential impacts associated with industrial development, a lack of data to inform mitigation plans, and statutory requirements associated with managing/conserving an ESA listed species all suggest an acute need for improved knowledge about bearded seal ecology (particularly their acoustic behavior) and how they interact with their environment, including the underwater soundscape. This is key information, without which the long-term implications of chronic human activities on bearded seal ecology and behavior can neither be mitigated nor effectively managed.

This information is applicable to assessing impacts from oil and gas exploration, informing mitigation plans, and

evaluating conservation efforts to ensure minimal negative effects to bearded seals, their ecosystem, and the subsistence communities that rely upon this species for their nutritional, cultural, and economic well-being.

Methods: Beginning in the early spring (Mar) and continuing into the fall (Sep), bearded seal vocalizations will be recorded at two different locations. In the Chukchi Sea, a 4-element hydrophone array will be deployed at a location in proximity to previously deployed hydrophone arrays (i.e., near Point Barrow) to allow for a comparative analysis of contemporary and historical acoustic data collected by the North Slope Borough between 1990 and 2012. Recordings will use a 50% duty cycle, sampling rate of 48 kHz with 16-bit resolution, and a functional recording bandwidth of 20 – 23,000 Hz, thereby covering the entire frequency range of bearded seal calls. The hydrophone array will be time-aligned post deployment, thereby enabling the calls to be acoustically localized using the near-beamforming method integrated into Raven 2.0.

Acoustic recordings will be manually reviewed in Raven Pro 2.031 to annotate any bearded seal calls. Georeferenced seal calls will be recorded in a time series to establish the phenology of bearded seal acoustic repertoire that can be assessed with respect to a suite of behavioral, environmental, and physical co-variates (including ambient sound levels). Seasonal shifts in the soundscape and identification of contributors to bearded seal underwater acoustic environment will be documented by calculating broadband RMS ambient noise values in 5-minute intervals for the entirety of each deployment using the Raven-X Toolbox. Interannual variation will be assessed by comparing contemporary and historic acoustic array data (NSB unpublished data) to assess whether, to what extent, and under what conditions bearded seal vocalizations and associated behaviors have shifted.

Product: The data collection phase has not yet begun. Historical data are being analyzed.

Funding status: This work has been funded through a NPR-A grant (Grant # 22-NPRA-06).

Project lead: North Slope Borough Department of Wildlife Management, Andrew Von Duyke, andrew.vonduyke@north-slope.org

Project partners: North Slope Borough, Ice Seal Committee, Michelle Fournet (University of New Hampshire). All seal research will be conducted under NMFS permit #20466 and ADF&G Animal Care and Use Committee Protocol #0027-2017-27.

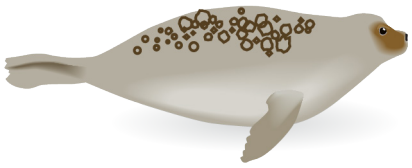
A.3.12 JOINT POLAR BEAR — RINGED SEAL POPULATION MODELING

Objective: Construct a combined demographic model for ringed seals and polar bears to explore demographic responses and predator-prey dynamics under future climate conditions.

Justification: Ringed seal demographic models have projected substantial population declines under future environmental conditions, driven by assumed increases in pup mortality when snow depths are insufficient for lair construction. Polar bears, which are also listed as threatened under the ESA, have been projected to decline due to a lengthening open-water period, during which the bears have reduced access to ringed seals for prey. The interconnected population dynamics of ringed seals and polar bears have received little research attention despite the fact that predation represents a primary source of mortality for ringed seals and the anticipated impacts of climate change on the two species are inherently linked by their predator-prey relationship. Declining snow depth will make seal pups increasingly vulnerable to predation and other sources of mortality (e.g., hypothermia), but earlier sea-ice breakup will also reduce the period over which bears can access pups (the "predation window") and possibly offset some opportunities for predation. Conversely, a shorter predation window and longer fasting period are expected to lower polar bear cub recruitment, but this may be partially offset by the ability to hunt ringed seals in thinner snow lairs more efficiently.

With the challenges of collecting data for even single-species forecasts in the Arctic, it is likely that detailed information on predator-prey relationship for polar bears and ringed seals may not be attainable in the near future. It is therefore prudent to move forward with conducting exploratory analysis that investigate potential outcomes of linked polar bear and ringed seal population models, and this can serve as a building block for the field with the potential to be updated as more information on either species or their predator-prey relationship comes to light.

Methods: We plan to address this knowledge gap by integrating recent single-species demographic models of ringed seals and polar bears into a joint model to explore dependencies between the species, including the ramifications of predator-prey dynamics on population projections for ringed seals and polar bears under changing environmental conditions such as snow depth, sea-ice extent, and sea-ice breakup date. Integrating existing single-species models into one joint model will require identifying and implementing behavioral, energetic, and demographic linkages between the bear and seal populations. Given the existing uncertainty, we will perform sensitivity analyses to identify which vital rates, relationships



between vital rates and the environment, mechanistic relationships, and structural elements of the model are most important to joint ringed seal and polar bear population dynamics. We will perform retrospective projections ("hindcasts") under historical snow depth and breakup conditions from the satellite record to ensure that our model of the bear-seal relationship and the effects of environmental conditions is reasonable. We will then use the calibrated model to project both species' populations forward under future climate conditions, and explore the impact of different model assumptions on population outcomes.

Products (planned):
Fiscal year 2026: Continue developing the joint population model and perform analyses.

Fiscal Year 2027: Submit journal article for publication

Funding status: Funded by NMFS/MML.

Project lead: NMFS/MML, Jessie Lindsay, jessica.lindsay@noaa.gov

Project partners: UW APL's Polar Science Center

A.3.13 ICE SEAL DIET DNA

Objective: To examine ringed and bearded seal diet using both traditional stomach contents and dietary DNA.

Justification: ADF&G has been analyzing the diets of ringed (Pusa hispida), bearded (Erignathus barbatus), and spotted (Phoca largha) seals since the 1960s using hard parts found in stomachs of subsistence-harvested seals. This dataset provides more than 40 years of dietary information for these species, which is of great value given current environmental changes. However, seal stomachs are often empty and therefore do not provide dietary information and prey can be either under- or over-represented when using stomach contents alone to assess diet. Stomachs can also be quite large, heavy to ship, and take up considerable freezer space. Processing stomach contents is laborious, time consuming, and experts who can identify prey items have become hard to find. A newer molecular genetic approach called dietary DNA (dDNA) has been developed for characterizing diet from prey DNA in feces or stomach contents and has been successfully used to assess diets of other marine mammal species. For this project we propose to use this new dDNA method for diet analysis of ringed and bearded seals and compare the results to those of the traditional method of prey identification from stomach contents.

Methods: Using genetic dDNA metabarcoding we will compare the species of fish and invertebrates identified in ringed seal and bearded seal stomachs using traditional diet methods to those identified from DNA. By combining two complementary methods we hope to develop a more comprehensive description of diet, including prey items that are mostly digested or difficult to identify from hard parts. We will also extract dDNA from contents in the lower colon and compare the results with stomach content fluid to see which matrix produces more dDNA information.

Product:

Bryan, A., A. Van Cise, L. Quakenbush, J. Crawford, A. Sletten, J. Phelps, and K. Parsons. 2025. Marine mammal diet: a comparison of traditional stomach contents and dietary DNA methods. Alaska Marine Science Symposium, January 27–30, Anchorage, Alaska (abstract, poster).

Sletten, A., A. Bryan, M. Ball, L. Quakenbush, J. Crawford, J. Phelps, A. Van Cise, and K. Parsons. 2026. Ice seal diet using a combination of stomach content examination and dietary DNA. Alaska Marine Science Symposium, January 26–30, Anchorage, Alaska (abstract, poster).

Funding status: USFWS

Project lead: ADF&G, Lori Quakenbush, lori.quakenbush@alaska.gov

Project partners: University of Washington and Northwest Fisheries Science Center

A.3.14 INDIGENOUS KNOWLEDGE HABITAT MODELS OF BEARDED SEALS (UGRUK; *ERIGNATHUS BARBATUS*) IN COASTAL ALASKAN WATERS

Objective: To develop Indigenous Knowledge (IK) habitat models for bearded seals in partnership with Iñupiat hunters, to better include IK in the management and conservation of bearded seals in Alaska.

Justification: To date, inferences about animal behavior and habitat use have been largely based on 'western' science, focused on methods ranging from field surveys and acoustic recordings (e.g., Stafford et al. 2016) to satellite tagging studies that document animal movement (e.g., VonDuyke et al. 2020). However, under the guidance of Indigenous knowledge-holders, IK can provide data that bypasses some of the pitfalls of 'western' science approaches. For example, IK extends beyond the

timeframes typical of 'western' science, and does not suffer from limited sample size, a common challenge with satellite tagging studies of marine mammals. Previous efforts to combine IK and 'Western' science within a statistical framework have been limited in terms of the methods applied and the number of studies (e.g., Polfus et al. 2014). A better approach to conservation and management acknowledges the wealth of information that exists within IK, values IK as its own knowledge system, and develops new methods to couple IK and 'western' science within a statistical framework (Fischer et al. 2021).

Methods: Based on methods developed by Gryba et al. (2024) seasonal IK habitat models for bearded seals, with IK as the sole data source, will be developed. To do so previously documented IK of bearded seal habitat use and behavior in regions adjacent to Utqiaġvik, Alaska (Gryba et al. 2021) will be statistically characterized in collaboration with the IK holders who provided the IK. Indigenous Knowledge holders will direct which habitat variables will be included in the IK habitat models. They will also review and provide any needed edits or corrections to the statistical characterization of the IK. This review is facilitated by the use of spatial predictions and graphical demonstrations of the statistical characterization of IK, which will not require that the IK holders have prior statistical knowledge. Indigenous Knowledge holders will also review the bearded seal IK habitat model, again providing any needed corrections or edits to the models.

We will produce seasonal IK habitat models for bearded seals that are spatially linked to the waters around Utqiaġvik. These IK habitat models can then be used to map important areas for bearded seals, including dynamic habitat types (e.g., ice concentration, currents). Such maps are directly applicable for use in species conservation and management, and are capable of fully and solely considering IK within this context.

References:

Fischer M, et al. (2021) Empowering her guardians to nurture our Ocean's future. Reviews in Fish Biology and Fisheries https://doi.org/10.1007/s11160-021-09679-3.

Gryba R, et al. (2021) Indigenous Knowledge of bearded seal (Erignathus barbatus), ringed seal (Pusa hispida), and spotted seal (Phoca largha) behaviour and habitat use near Utqiaġvik, Alaska, USA. Arctic Science. 7(4): 832-858.

Gryba R, A VonDuyke, H Huntington, B Adams, B Frantz, J Gatten, Q Harcharek, R Sarren, G Henry, M Auger-Méthé. 2024. Indigenous Knowledge as a sole data source in habitat selection functions. bioRxiv. doi: https://doi.org/10.1101/2023.09.07.556613

Polfus JL, et al. (2014) Comparing traditional ecological knowledge and western science woodland caribou habitat models. Journal of Wildlife Management 78:112–121.

Stafford KM, et al. (2016) Beluga whales in the western Beaufort Sea: Current state of knowledge on timing, distribution, habitat use and environmental drivers. Deep Sea Research Part II: Topical Studies in Oceanography 152:182-194 . https://doi.org/10.1016/j.dsr2.2016.11.017

Von Duyke AL, et al. (2020) Ringed seal (Pusa hispida) seasonal movements, diving, and haul-out behavior in the Beaufort, Chukchi, and Bering Seas (2011–2017). Ecology and Evolution 10:5595-5619.

Product: None yet

Funding status: Funded by Lenfest Ocean Program

Project Lead: Inuit Circumpolar Council Canada, Rowenna Gryba, r.gryba@gmail.com

Project partners: North Slope Borough – Department of Wildlife Management, local hunters in Utqiaġvik, AK

A.3.15 (NEW PROJECT) ADVANCING MINIMALLY-INVASIVE TECHNOLOGIES TO SUPPORT MONITORING AND CONSERVATION OF SPOTTED SEALS IN ARCTIC ALASKA

Objectives: The overarching goals of this project are to:

(1) develop and implement a comprehensive, repeatable, and minimally invasive methodology for monitoring spotted seals at remote coastal haul-out sites in the Chukchi and Beaufort Seas of Alaska and (2) characterize spotted seal health, behavior, and terrestrial ecology during the summer open-water season. Building on previous research, we will achieve these goals through the following objectives:

(1) Quantify behavioral responses to drone surveys by assessing the effects of small drone operations on spotted seal behavior at haul-out sites; (2) Develop disturbance-minimizing flight protocols by refining drone flight plans (e.g., altitude, approach, duration); (3) Establish baseline datasets on the body condition, age structure, behavior, and terrestrial habitat use of spotted seals at haul-outs along the Alaska Chukchi and Beaufort Seas coastlines; and (4) Test and refine AI image analysis tools to count seals, measure body morphometrics, and identify individuals based on unique pelage patterns in drone imagery.

Justification: Small, uncrewed aircraft systems (commonly referred to as 'drones') are becoming an increasingly popular wildlife survey tool. However, responses to

drone activity vary among species. The spotted seal is particularly sensitive to disturbance from traditional survey methods such as manned aircraft and boats, making non-invasive alternatives especially valuable. Drones offer potential future opportunities to non-invasively collect data on body condition, relative abundance, age distribution, and behavior. Determining how drones can be used as effective, non-invasive survey tools is a crucial step toward applying this technology to answer numerous questions that remain unanswered about spotted seals.

Methods: During July-September of 2024 and 2025, we surveyed haul-out sites using a small quadcopter drone deployed from a North Slope Borough Department of Wildlife Management research vessel. We conducted a total of 61 vertical flights over spotted seal haul outs in Dease Inlet, with seal counts ranging from 1 – 103 seals. We plan to conduct subsequent flights during the 2026 open-water season (~August 15 - September 15; LOC No. 29408) to test behavioral responses and horizontal flight paths. Statistical tests (e.g., GAMMs) will be used to assess disturbance response to small drones. Explanatory factors will include number of hauled out seals, flight path, wind speed and direction, cloud cover, distance from research boat to haul-out site, date, and elapsed flight time from both the survey day and the entire season to account for possible habituation. Based on model results, we will develop drone flight protocols that minimize disturbance to spotted seals. Protocols may include minimum altitude based on drone model, approach type, environmental conditions, and best practices for approaching haul outs and surveying from a research vessel.

Collected drone imagery will also be used to train machine-learning tools for rapid, efficient, and accurate data analysis of abundance and age structure. We will train selected models to detect individual spotted seals and distinguish between adults and young-of-the-year.

In addition to supporting automated counts and age classification, drone imagery will be used to quantify individual body condition. Imagery will be processed using MorphoMetriX, an open-source photogrammetry software designed to estimate body condition in pinnipeds and cetaceans.

Products:

Expected project deliverables include:

1. Electronic data files and imagery.

2. Protocol for conducting small drone surveys over spotted seals. These protocols will be disseminated to the Ice Seal Committee, NSB-DWM, and other organizations for future research and management of spotted seals.

3. Baseline dataset on age structure, habitat use, relative abundance, and body condition of spotted seals surveyed in the Beaufort Sea from 2024 – 2026.

4. At least two peer-reviewed scientific publications (e.g., Connor, Hauser, Von Duyke, Brinkman, et al. Behavioral responses and best practices for conducting small drone surveys over ice seals; Connor, Hauser, Von Duyke, Brinkman, et al. Applying drones to assess body condition and age structure of spotted seals at coastal haul-out sites).

5. We propose to present final project results at AMSS and interim updates to the Ice Seal Committee at biannual meetings.

6. Outreach will include feature stories about project updates and results in the biannual AAOKH News, which is a newsletter featuring current news and activities by AAOKH and is sent to all mailbox holders in AAOKH communities. This work will also be highlighted in the NSB-DWM newsletter and sent to all mailbox holders in North Slope communities. Websites for both the NSB-DWM and the Ice Seal Committee will also serve as venues to communicate the progress of this work. We also hope to facilitate an ice seal focused activity at the 2027 Barrow Arctic Research Center (BARC) Science & Culture Fair.

7. Training opportunities for Utqiaġvik community members and youth in drone operation and data interpretation.

Funding status: This project is currently being funded by a grant from the Alaska Sea Grant College Program from May 2024 – January 2027. The project also relies on substantial funding and support from existing projects: the Ice Seal Research Program at the North Slope Borough Department of Wildlife Management (NSB-DWM), Alaska Arctic Observatory and Knowledge Hub (AAOKH), and the International Arctic Research Center at the University of Alaska Fairbanks.

Project leads: UAF, Donna Hauser, dhauser2@alaska.edu; NSB, Andrew Von Duyke, andrew.vonduyke@north-slope.org

Graduate student: UAF, Maeghan Connor, mrconnor@alaska.edu

Project partners: University of Alaska Fairbanks, North Slope Borough, Ice Seal Committee, and Alaska Arctic Observatory and Knowledge Hub. All field activities are permitted under NMFS Letter of Confirmation No. 23546 (Years 2024 – 2025) and No. 29408 (Years 2026 – 2036), UAF IACUC #1610672-2, and UAF Animal Care Protocol 1610672-6.

A.4 Education and outreach

B. Completed projects

In response to Project Chariot, a 14-month field study of ice-associated seals was conducted near Kivalina in the mid-1960s (Johnson et al. 1966). That study elucidated food habits, age structure, reproductive patterns, and other aspects of the basic biology of ringed, ribbon, spotted, and bearded seals.

In the mid-1970s – 1980s, the Alaska Department of Fish and Game, the University of Alaska Fairbanks, and the National Marine Fisheries Service undertook a series of studies concerning ice-associated seals and offshore oil development. They investigated feeding ecology (Lowry et al. 1978, West et al. 1979, Frost and Lowry 1980, Bukhtiyarov et al. 1984, Simpkins et al. 2001a), distribution and density (Burns and Harbo 1977, Braham et al. 1984, Frost et al. 1988, Frost et al. 2002) (Kelly et al. 2000, 2003), habitat use (Burns and Eley 1978, Burns and Frost 1979, Burns et al. 1981, Burns and Kelly 1982, Kelly and Quakenbush 1990); ; Burns et al. 1981a; Kingsley et al. 1990), diving behavior (Elsner et al. 1989, Wartzok et al. 1992, Kelly 1996, Kelly and Wartzok 1996, Simpkins et al. 2001b, Simpkins et al. 2001c), and responses to industrial development (Fay et al. 1979, Burns and Kelly 1982, Kelly et al. 1986, Frost et al. 1988, Frost and Lowry 1988, Kelly et al. 1988).

Other projects, mostly completed within the past 5-10 years, are described in more detail, below.

Other projects, mostly completed within the past 5-10 years, are described in more detail, below.

B.1 Population identity and status

B.1.1 TRADITIONAL ECOLOGICAL KNOWLEDGE OF SEALS IN NORTON BAY, ALASKA

Objective: Document traditional knowledge about seals in the Norton Bay area.

Justification: Knowledge of hunters and elders, of the distribution, abundance, and natural history of seals is useful in better understanding the Norton Bay region's seal populations and any changes that have occurred. Documenting this knowledge allows local residents to express their views on the status of seal populations so that their understanding and perspective can be taken

into account in research and management. It also provides for collaboration between residents of seal hunting communities, scientists, and wildlife managers, that is an essential component of ensuring sustainability of the resource.

Methods: A workshop was held in Shaktoolik, Alaska, February 1-5, 1999 to interview participants.

Product:

Huntington, H. P. 2000. Traditional ecological knowledge of seals in Norton Bay, Alaska. Report submitted to the Elim-Shaktoolik-Koyuk Marine Mammal Commission and the National Marine Fisheries Service. Compiled and edited by Henry P. Huntington, translated by Clara Sookiayak.

Funding status: Funded by NMFS/NMML. Completed 2000.

Project lead: NMFS/NMML, John Bengtson, john.bengtson@noaa.gov

Project partners: NMFS/NMML, Elim-Shaktoolik-Koyuk Marine Mammal Commission

B.1.2 CORRECTION FACTOR FOR RINGED SEAL SURVEYS

Objective: Determine the proportion of local ringed seal populations included in aerial surveys and estimate the variance in that proportion.

Justification: Aerial surveys have been the primary method of estimating population size and have been used to compare changes in densities of ringed seals over time and space (Burns and Harbo 1972, Frost et al. 1997, Frost et al. 1998, Frost et al. 1999). Survey counts cannot generate estimates of population size with correcting for the portion of the population unseen under snow and ice. Conclusions about population status based on comparisons of densities have been based on the untested assumption that the proportion of populations that are visible is constant.

Methods: Radio telemetry was used to determine the availability of ringed seals for counting during survey periods in the spring of 1999 and 2000. Each time a radio- tagged seal came out of the water, its location and whether or not it was concealed in a subnivean lair or visible on top of the snow was recorded.

Product:

Bengtson, J. L., L.M. Hiruki-Raring, M.A. Simpkins, and P.L. Boveng. 2005. Ringed and bearded seal densities in the eastern Chukchi Sea, 1999-2000. Polar Biology 28:833-845.

Kelly, B. P. 2005. Correction factor for ringed seal surveys in Northern Alaska. OCS Study MMS 2005. Coastal Marine Institute, University of Alaska Fairbanks.

Funding status: Funded by CMI. Completed 2004, pending publication of the manuscript.

Project lead: University of Alaska Southeast, Brendan Kelly, bkelly@nsf.gov

Project partners: NMFS/NMML

B.1.3 TIMING AND RE-INTERPRETATION OF RINGED SEAL SURVEYS

Objective: Describe inter annual variation in ringed seal behavior and its implications for interpretation of aerial survey counts. Determine the environmental factors influencing the proportion of local populations available to be counted.

Justification: Aerial surveys have been the primary method of estimating population size and have been used to compare changes in densities of ringed seals over time and space (Burns and Harbo 1972, Frost et al. 1997, Frost et al. 1998, Frost et al. 1999). The fraction of the population counted in those surveys is strongly influenced by environmental factors, especially snow conditions. Interpreting past and future survey data requires accounting for those variables.

Methods: Radio telemetry was used to determine the availability of ringed seals for counting during survey periods in the spring of 1999, 2000, 2001, 2002, and 2003. Each time a radio-tagged seal came out of the water, its location and whether or not it was concealed in a subnivean lair or visible on top of the snow was recorded. Snow temperature, air temperature, wind speed and direction, time of day, and calendar date were used in models to predict the fraction of the population visible.

Product:

Kelly, B. P., O. R. Harding, and M. Kunnasranta. 2003. Timing and re-interpretation of ringed seal surveys. p. 32-37. *In* University of Alaska Coastal Marine Institute Annual Report No. 10. OCS Study MMS 2003, University of Alaska Fairbanks and USDOI, MMS, Alaska OCS Region.

Funding status: Funded by CMI. Completed 2004, pending publication of the manuscript.

Project lead: University of Alaska Southeast, Brendan Kelly, bkelly@nsf.gov

B.1.4 DENSITIES OF RINGED AND BEARDED SEALS IN THE EASTERN CHUKCHI SEA

Objective: Determine the densities and numbers of bearded and ringed seals along the eastern Chukchi Sea coast, including the coastal zone and offshore (to 100 n mi), from just north of Bering Strait to Pt. Barrow.

Justification: These two seal species have been historically important to Arctic subsistence hunters, and ringed seals are an important prey species for polar bears. Knowledge of bearded and ringed seal population dynamics, however, is limited in Alaskan waters. Although ringed seals have been surveyed recently in portions of the Bering Sea and the Beaufort Sea, seal densities in the eastern Chukchi Sea have not been assessed since 1985-87.

Methods: Aerial line-transect surveys were flown by fixed-wing aircraft from 23 May-6 June 1999 and 21-31 May 2000. To correct for seals missed because they were in the water during surveys, the haul-out behavior of some instrumented seals was recorded by satellite telemetry. Seal densities were compared in inshore/offshore and north/south strata.

Product:

Bengtson, J. L., L.M. Hiruki-Raring, M.A. Simpkins, and P.L. Boveng. 2005. Ringed and bearded seal densities in the eastern Chukchi Sea, 1999-2000. Polar Biology 28:833-845.

Funding status: Funded by NMFS/NMML. Completed 2005.

Project lead: NMFS/NMML, Peter Boveng, peter.boveng@noaa.gov

B.1.5 POPULATION STRUCTURE AND SEASONAL MOVEMENTS OF RINGED SEALS

Objective: Determine the degree of fidelity to breeding sites by ringed seals and whether site fidelity reflects philopatry.

Justification: Recent observations of tagged ringed seals indicate that they maintain small breeding home ranges (averaging 1 km^2) and that they use the same breeding sites in successive years. If the sites breeding seals return to are, in fact, their own natal sites, then the population likely consists of multiple demographically isolated units.

Methods: Satellite-linked transmitters will be used to follow the inter-annual movements of ringed seals. The transmitters will be attached to the seals using flipper tags, thereby allowing the seals to be tracked for periods longer than one annual molt cycle (the limitation imposed by gluing transmitters to the seals' hair). DNA collected as bits of molted skin from seals in their breeding sites will be analyzed and compared with samples collected at other breeding sites.

Movements of adult seals tracked telemetrically indicated fidelity to breeding sites by adult ringed seals but left open the question of natal philopatry. Mitochondrial and nuclear DNA were extracted from tissues (N = 358) collected at ringed seal breeding sites and used to examine population structure. Analyses of 9 microsatellite loci and a 359 bp sequence of the Cytochrome Oxidase I mtDNA locus region were consistent with ongoing gene flow between breeding sites. A history of large effective population sizes among ringed seals, however, prevented us from ruling out genetically isolated populations in which genetic drift has been weak.

Product:

Kelly, B. P., and P. L. Boveng. 2005. Ice Seal Movements and Stock Structure in a Changing Cryosphere. Semi-annual progress report to North Pacific Research Board. http://doc.nprb.org/web/05_prjs/515_pr_june05.pdf

Kelly, B. P., and P. L. Boveng. 2007. Ice Seal Movements and Stock Structure in a Changing Cryosphere. Semi-annual progress report to North Pacific Research Board. http://doc.nprb.org/web/05_prjs/515_pr_jul07.pdf

Kelly, B. P., M. Ponce, D. A. Tallmon, B. J. Swanson, and S. K. Sell. 2009. Genetic diversity of ringed seals sampled at breeding sites; implications for population structure and sensitivity to sea ice loss. Univeristy of Alaska Southeast, North Pacific Research Board 631 Final Report. 28 p.

Kelly, B. P., O. H. Badajos, M. Kunnasranta, J. R. Moran, M. Martinez-Bakker, D. Wartzok, and P. Boveng. 2010. Seasonal home ranges and fidelity to breeding sites among ringed seals. Polar Biology 33:1095-1109.

Funding status: Funded by North Pacific Research Board and NMFS/NMML in FY2005-2007. In final write-up phase as of 2011. Completed.

Project lead: University of Alaska Southeast, Brendan Kelly, bkelly@nsf.gov

Project partners: NMFS/NMML, Ice Seal Committee, North Slope Borough, Central Michigan University

B.1.6 POPULATION STRUCTURE OF RINGED SEALS (*PHOCA HISPIDA*) IN THE CHUKCHI AND BEAUFORT SEAS

Objective: Determine the genetic diversity of ringed seals and the scale of stock structuring in Alaska.

Justification: Recent observations of tagged ringed seals indicate that they maintain small breeding home ranges (averaging 1 km^2) and that they use the same breeding sites in successive years. If the sites breeding seals return to are, in fact, their own natal sites, then the population likely consists of multiple demographically isolated units. This work would expand the scope of B.1.5 by supporting sampling and analysis of DNA over a larger area.

Methods: DNA samples (mtDNA and microsatellites) will be collected from breeding ringed seals in three or more sites within Alaska and two or more sites outside of Alaska. If feasible, a sampling network will be established to involve community members in the research. Genetic diversity will be analyzed for each breeding site.

Product: Martinez-Bakker ME, Sell SK, Swanson BJ, Kelly BP, Tallmon DA (2013) Combined Genetic and Telemetry Data Reveal High Rates of Gene Flow, Migration, and Long-Distance Dispersal Potential in Arctic Ringed Seals (*Pusa hispida*). PLoS ONE 8(10): e77125

Funding status: Completed.

Project lead: University of Alaska Southeast, Brendan Kelly, bkelly@nsf.gov

Project partners: Ice Seal Committee, North Slope Borough, Central Michigan Univ., Dept. Fisheries and Oceans (Canada), Finnish Game and Fisheries Research Institute

B.1.7 DENSITIES AND DISTRIBUTION OF RIBBON, SPOTTED, AND BEARDED SEALS IN THE EASTERN BERING SEA

Objective: Determine the densities and numbers of ribbon, spotted, and bearded seals in the sea ice of the Bering Sea in spring time.

Justification: The Bering Sea Ecosystem Study (BEST) and the Bering Sea Integrated Ecosystem Research Program (BS-IERP) are major collaborative programs funded by NSF and NPRB, respectively, to better understand the Bering Sea ecosystem from top (humans) to bottom (climate and primary production). Because seals are important upper predators in this system that represent a direct link to the human component, it is essential to understand the trophic links that involve seals. Models used to investigate hypotheses about this system cannot be parameterized for seals without estimates of fundamental quantities such as densities, which are currently lacking.

Methods: Aerial line-transect surveys will be flown by helicopter from a U.S. Coast Guard icebreaker in spring of 2007 and 2008. The aerial survey effort will be supplemented by line-transect observations from the icebreaker and from a NOAA Fisheries research vessel. To correct for seals missed because they are in the water during surveys, the haul-out behavior of seals is being quantified in related studies using satellite telemetry.

Product:

Cameron, M.F and P.L. Boveng. 2007. Abundance and Distribution Surveys for Ice Seals Aboard the USCG Healy and the Oscar Dyson, 10 April – 18 June 2007. Alaska Fisheries Science Center Quarterly Research Reports. April – June 2007. http://www.afsc.noaa.gov/Quarterly/amj2007/divrptsNMML3.htm

Boveng, P.L., J.M. London and M.F. Cameron. 2007. Telemetry of ice seals captured during the USCG Healy and Oscar Dyson research cruises in the eastern Bering Sea. Alaska Fisheries Science Center Quarterly Research Reports. April – June 2007. http://www.afsc.noaa.gov/Quarterly/amj2007/divrptsNMML4.htm

Ver Hoef, J.M., M.F. Cameron, P.L. Boveng, J.M. London, E.E. Moreland. 2013. A spatial hierarchical model for abundance of three ice-associated seal species in the eastern Bering Sea. Statistical Methodology. 17: 46-66.

Conn, P. B., B. T. McClintock, M. F. Cameron, D. S. Johnson, E. E. Moreland, P. L. Boveng. 2013 Accommodating species identification errors in transect surveys. Ecology. 94 (11): 2607-2618.

Funding status: Funded by NMFS/NMML and NSF 2007-2011. Completed 2011.

Project lead: NMFS/NMML, Peter Boveng, peter.boveng@noaa.gov

B.1.8 BEAUFORT SEA ICE SEAL SAMPLING AND ARCHIVAL PROJECT

Objective: This Project will archive full biological sample sets from subsistence harvested ice seals in the communities of Barrow, Nuiqsut, and Kaktovik, Alaska. Samples will be analyzed in cooperation with the Alaska Department of Fish and Game Marine Mammal Program and some tissues stored at the University of Alaska Museum of the North. This is first year of the project with long-term expectations of developing an annual program to obtain future, long-term data and information on the health of ice seal populations.

Justification: Seals are a key ecological component of the Arctic and are heavily relied upon by polar bears and northern indigenous people for food. Measurable impacts from climate changes affecting ice and foraging habitat, and offshore oil and gas exploration and development affecting health and movements of seals may be attained from tissue sampling. Some past data from the 1970s and 1980s may be used for temporal health comparisons.

Methods: Seal hunting households are instructed in tissue sampling and measurements and given sample kits and data-forms. Samples are frozen and sent to Fairbanks for processing and long-term storage.

Product: Samples were collected from Kaktovik and Barrow, and data were stored in ADF&G's database.

Funding status: Completed

Project lead: ADF&G

Project partners: Alaska Nanuuq Commission, NSB Wildlife Management, Local Tribes

B.1.9 POPULATION STRUCTURE OF RINGED SEALS (*PHOCA HISPIDA*) IN THE PACIFIC ARCTIC

Objective: To assess population structure in ringed seals using genetic analysis of previously archived samples from breeding sites in the North Pacific.

Justification: Although Arctic ringed seals are currently abundant and broadly distributed, their numbers are projected to decline substantially in the future due to climate warming. While understanding population structure could provide insight into the impact of environmental changes on this subspecies, detecting demographically important levels of exchange can be difficult in taxa with high abundance. To increase power to detect low but potentially biologically significant levels of genetic differentiation, we used a next-generation sequencing approach (DArTseq) to identify and genotype several thousand single nucleotide polymorphisms (SNPs) in seals from four Pacific Arctic regions.

Methods: DNA was extracted from samples that were collected from ringed seals in four regions of the Pacific Arctic during the spring breeding season. These samples were used to produce reduced representation libraries that were then sequenced to allow the identification and genotyping of SNP loci. After sequencing, the resulting data was filtered to remove erroneous genotypes and retain only high-quality SNPs, resulting in a dataset containing 79 seals genotyped at ~5700 loci.

Product: Lang, A.R., Boveng, P., Quakenbush, L., Robertson, K., Lauf, M., Rode, K.D., Ziel, H. and Taylor, B.L., 2021. Re-examination of population structure in Arctic ringed seals using DArTseq genotyping. *Endangered Species Research*, *44*, pp.11-31.

Funding status: Funding was provided by the National Fish and Wildlife Foundation, the Marine Mammal Commission, NMFS/NMML, and NMFS/SWFSC. Completed 2021.

Project lead: NMFS/SWFSC, Aimée Lang, aimee.lang@noaa.gov

B.2 Mortality and harvest

B.2.1 BERING STRAIT SEAL HARVEST SURVEY 2002

Objective: Estimate the harvest of ice seals in the Bering Strait Region of Alaska

Justification: Ice seal harvest information has been sporadic and lacking for the Bering Strait region of Alaska.

Methods: A multi-page survey questionnaire was developed to assess ice seal harvests by age class, sex, and month of harvest. Surveyors attempted to census an entire community but generally the participation rate ranged from 10% to 64%. Results included seals harvested by species, by village, by month and struck and lost estimates. The villages included Brevig Mission, Elim, Gambell, Golovin, Shaktoolik, Saint Michael, Savoonga, Stebbins, Teller, and Wales.

Product: A currently unpublished report housed in Kawerak, Inc. has been compiled and used to assist the Kawerak, Inc., Subsistence Program to better understand ice seal subsistence harvests of Bering Strait region communities.

Funding status: Completed year?

Project lead: Kawerak, Inc., Lily Ray-Gadamus, ss.pi@kawerak.org

Project partners: NOAA/NMFS

B.2.2 NUTRIENTS AND CONTAMINANTS IN SPOTTED SEAL BASED FOODS, AND ASSESSMENT OF RISKS AND BENEFITS TO HUMAN CONSUMERS

Objective:

Justification:

Methods:

Product:

Moses, S.K., A.V. Whiting, G.R. Bratton, R.J. Taylor, T.M. O'Hara. 2009. Inorganic nutrients and contaminants in subsistence species of Alaska: linking wildlife and human health. International Journal of Circumpolar Health. Vol. 68(1):53-74.

Moses, S.K., A.V. Whiting, D.C.G. Muir, X. Wang, T.M. O'Hara. 2009. Organic nutrients and contaminants in subsistence species of Alaska: concentrations and relationship to food preparation method. International Journal of Circumpolar Health. Vol. 68(4): 354-371.

Hueffer, K., C.L. Lieske, L.M. McGilvary, R.F. Hare, D.L. Miller, T.M. O'Hara. 2011. *Streptococcus phocae* isolated from a spotted seal (*Phoca largha*) with pyometra in Alaska. Journal of Zoo and Wildlife Medicine. 42(1): 108-112.

Funding status: Project completed 2009

Project lead: Todd O'Hara

Project partners: Ice Seal Committee

B.3 Habitat and climate change

B.3.1 ICE SEAL HABITAT USE AND SELECTION NEAR ST. LAWRENCE ISLAND

Objective: Evaluate the habitat use of ice seals near St. Lawrence Island to determine whether species associate with certain ice conditions or prefer to remain near rich foraging grounds.

Justification: The design and interpretation of aerial surveys for estimating the density and abundance of ice seals, is improved by knowing the habitats (e.g., ice types and concentrations) preferred by the different species of ice seals.

Methods: Aerial line-transect surveys were conducted from helicopters supported by the U.S. Coast Guard icebreaker *Polar Star.* Seal densities were compared in

areas of differing ice concentration, floe sizes, and benthic productivity. Evidence of interactions and segregation among seal species were examined.

Product:

Simpkins, M. A., L. M. Hiruki-Raring, G. Sheffield, J. M. Grebmeier, and J. L. Bengtson. 2003. Habitat selection by ice-associated pinnipeds near St. Lawrence Island, Alaska. Polar Biology 26(9):577-586.

Funding status: Funded by the National Science Foundation and the NMML. Completed, 2003.

Project lead: NMFS/NMML, Peter Boveng, peter.boveng@noaa.gov

Project partners: ADF&G, Diomede Observatory, National Science Foundation

B.3.2 ICE SEAL CONTAMINANT LEVEL ASSESSMENT IN TISSUES CONSUMED BY HUMANS

Objective: Determine the levels of trace elements in tissues of ice seals harvested for subsistence.

Justification: Some trace elements (cadmium, lead, and mercury) are toxic to marine mammals and humans. People who rely on marine mammals are concerned about the safety of their food.

Methods: Liver, kidney, and blubber samples are collected during the subsistence harvest. Concentrations of trace elements (cadmium, silver, copper, zinc, total mercury, and methyl mercury were determined in tissues of bearded, ringed, and spotted seals from Alaska and Canada. Age and trophic level were investigated to learn more about the pathways and biomagnification of trace elements among species.

Product:

Reports to the Ice Seal Committee, Village IRAs, State of Alaska Department of Health and Social Services, and scientific publications:

Dehn, L. A., G. Sheffield, E. H. Follmann, L. K. Duffy, V. M. Woshner, and T. M. O'Hara. 2003. Age and diet related distribution of heavy metals in renal and hepatic tissue of ringed, bearded, and spotted seals harvested in Alaska. Proceedings of the 15th Conference of the Biology of Marine Mammals, 14-19 December 2003. (abstract)

Dehn, L. A., G. G. Sheffield, E. H. Follmann, L. K. Duffy, D. L. Thomas, G. R. Bratton, R. J. Taylor, and T. M. O'Hara. 2005. Trace elements in tissues of phocid seals harvested in the Alaskan and Canadian Arctic: influence of age and feeding ecology. Canadian Journal of Zoology 83: 726-746.

Funding status: Funded by Cooperative Institute for Arctic Research, NSB/DWM, IAB and Department of Wildlife and Biology UAF, USGS, BASC, and NSF. Completed.

Project lead: UAF, Todd O'Hara, fftmo@uaf.edu

Project partners: ADF&G, Village IRAs, local hunters

B.3.3 MOVEMENTS, HABITAT USE, AND FORAGING BEHAVIOR OF RINGED SEALS IN THE CHUKCHI AND BERING SEAS

Objective: To document the seasonal movements, foraging behavior, and important habitats of spotted and ringed seals in Kotzebue Sound, the Chukchi Sea, and the Bering Sea.

Justification: This work has expanded upon the existing collaboration between Kotzebue IRA, ADF&G, and NMFS by taking advantage of opportunities to study spotted and ringed seals when they are captured incidentally to the capture efforts of the bearded seal project, B.3.2.

Methods: Spotted and ringed seals are captured in large-mesh tangle nets, instrumented with satellite-linked Depth Recorders (SDRs) and then released. Information on the seal's movements and diving behavior are transmitted back to researchers via the ARGOS satellite system and analyzed for relationships with bathymetry, sea ice, and other environmental features.

Product: Crawford, J.A., K.J. Frost, L.T. Quakenbush, and A. Whiting. 2011. Different habitat use strategies by subadult and adult ringed seals (*Phoca hispida*) in the Bering and Chukchi seas. Polar Biology 35:241–255.

Funding status: Funded by USFWS Tribal grant. 2005-2011.

Project lead: Kathy Frost and Alex Whiting

Project partners: Kotzebue IRA, ADF&G, NMFS/NMML

B.3.4 YEAR-ROUND ACOUSTIC DETECTION OF BEARDED SEALS

Objective: (1) Evaluate seasonal occurrence of vocalizing bearded seals within the Bering, Chukchi and Beaufort Seas (BCB) using three years of passive acoustic monitoring data; (2) characterize and identify the implications variable sea ice conditions and changing water

temperatures have had on the distribution of vocalizing bearded seals in the BCB using vocal presence as a means to assess presence; (3) examine geographic variation by comparing call types during the spring months from all regions within the BCB.

Justification: Dramatic shifts in Arctic climate have led to changes in sea ice distribution, extent, and timing that pose substantial adaptation challenges for Arctic species. Ice obligate species like the bearded seal are inherently vulnerable to environmental change, relying on seasonal sea ice as a platform for pupping and molting. During mating season, while female bearded seals haul out on ice floes and migrate northward with the retreating ice edge, males produce underwater vocal displays to present their reproductive condition. Preliminary analysis has revealed year-round vocal presence in the Beaufort Sea, which was once believed to be a spring phenomenon. With this new insight, it is clear that passive acoustic monitoring can be employed as an effective method to examine bearded seal distribution, migration patterns, and population structure year-round. This research will help to develop a more complete understanding for bearded seal ecology through the analysis of year-round passive acoustic data and changing sea ice conditions from 2008 – 2011. By comparing call types within and between regions, we can determine population structure and seasonal movement that will address issues concerning impacts reduced sea ice will have on population dynamics. Establishing a year-round understanding for bearded seal behavior will provide baseline data to detect future changes as a consequence of climate variability.

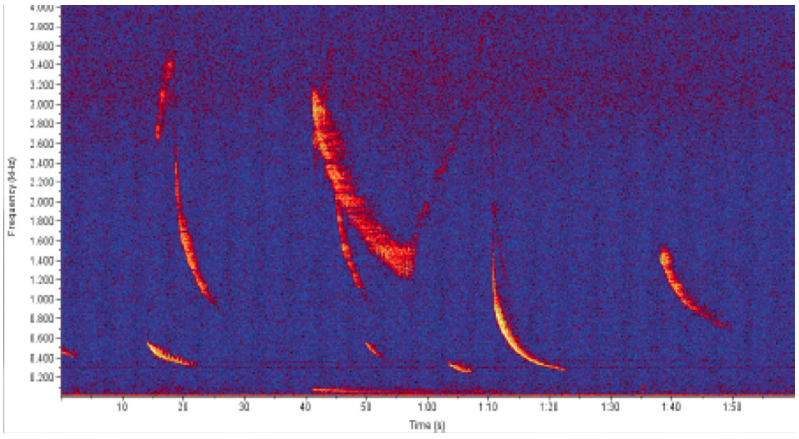
Methods: Passive acoustic data in the BCB was previously collected by the NMML NOAA and the UW APL. Hydrophones, (Multi-electronique Aural M2s), were used to make yearlong recordings of underwater sounds during a three-year period from 2008 to 2011. Instruments were deployed in 10 locations throughout the BCB: four in the Bering Sea, two in the Chukchi Sea, and four in the Beaufort Sea. The instruments were suspended 5 m above the seafloor at varying depths: the Bering Sea hydrophones were moored in ~70 m of water, the Chukchi Sea ~40 m and the Beaufort Sea hydrophones were moored at depths ranging from 60-180 m. Hydrophones in each location were set to record for one year from deployment and retrieved a year later. Each instrument recorded on a set duty cycle (e.g. 9 min on/20 min off) and at sample rates of either 8192 Hz or 16384 Hz for an entire year.

The acoustic data has been analyzed, using Ishmael, a bioacoustics software (Mellinger 2001), for the presence of sounds typically associated with bearded seals. Data was observed in the form of spectrograms, or a visual representation of sound, where frequency is plotted as a function of time. Call presence was based on daily proportions of hours per day with calls out of the total hours recorded at each site. Bearded seal vocal presence was examined and compared within and between each region of the BCB to assess distribution (based on vocal presence) between 2008 and 2011.

Bearded seal presence was then compared with mean sea ice concentration from year-round acoustic data collected between 2008 and 2011. Data to calculate mean sea ice concentration at each mooring was obtained from the National Snow and Ice Data Center (NSIDC, http://nsidc.org/data/collections.html). All mooring locations for each year (2008-2011) were surrounded by a 20 km buffer where associated sea ice concentration data within the buffer were averaged for a given day. Mean daily sea ice concentration for each day was then compared to bearded seal vocal presence to examine how variations in sea ice presence affect bearded seal distribution within and between locations in the BCB.

Geographic variation will be examined within the BCB by comparing call types observed during the spring in each region during a single year (2011). For high quality calls, key features will be extracted from each including: start frequency, duration, frequency change from start to end of the call, frequency range from the minimum to the maximum of the call, modulation, and presence or absence of harmonic bands. Mean values and standard deviations of all parameters will be calculated for each call type to facilitate comparison with previously described calls and categorization of new calls.

Following the initial classification, vocal parameters will be examined with classification trees using R (www.R-project.org). Once the call types are determined and separated out for each region, classification trees will be used to compare bearded seal vocalizations geographically between each region. The repertoire analysis will allow us to determine if distinct subpopulations exist within the study area. The presence of distinct subpopulations may have implications for independent



management strategies when considering the impacts of diminishing sea ice within the BCB and may lead to a better understanding of bearded seal ecology.

Product: One manuscript has been published in Polar Biology and a second manuscript has been drafted comparing the regional variability of bearded seal year-round vocal activity in the BCB relative to changing environmental conditions (MacIntyre et al. in prep). A third manuscript will also be produced from this research which will examine geographic variation in the BCB by comparing call types produced during the spring months.

MacIntyre, K. Q., K. M. Stafford, C. L. Berchok, P. L. Boveng. 2013. Year-round acoustic detection of bearded seals (*Erignathus barbatus*) in the Beaufort Sea relative to changing environmental conditions, 2008–2010. Polar Biology **36**: 1161-1173

Funding status: Completed

Project lead: NMFS/NMML, Kalyn MacIntyre, kalyn.macintyre@noaa.gov

Project partners: UW APL, UW SAFS

B.3.5 MOVEMENTS, HABITAT USE, AND FORAGING BEHAVIOR OF YOUNG-OF-THE-YEAR BEARDED SEALS IN THE CHUKCHI AND BERING SEAS

Objective: To document the seasonal movements, foraging behavior, and important habitats of young-of-the-year bearded seals in Kotzebue Sound, the Chukchi Sea and Bering Sea.

Justification: Bearded seals are an important subsistence resource, a key ecological component of the arctic marine ecosystem and vulnerable to climate change because of their strong association with sea ice. Their seasonal movements, habitat use, and diving behavior have never been documented in Alaskan waters.

Methods: In 2004-2006, 26 (13 female and 13 male) young bearded seals were captured in Kotzebue Sound using large-mesh tangle nets. The seals were instrumented with Satellite-linked Data Recorders (SDRs) and then released. Information on the seals' movements and diving behavior were transmitted back to researchers via the ARGOS satellite system and analyzed to: 1) provide haul-out correction factors for past and future abundance and distribution sightings surveys, 2) assess the seasonal movements and patterns of distribution and diving/foraging behavior, 3) identify and determine the priority of importance for specific marine habitats associated with key ice seal life history events such breeding, pup rearing, and foraging and molting, and 4) describe seal dive depths and durations. With the field work, data collection and analyses complete, research manuscripts are being prepared and finalized for publication in peer-reviewed journals. This project involved direct collaboration between subsistence hunters and scientists, especially in capturing and tagging seals.

Product:

Cameron, M., Frost, K., VerHoef, J., Breed, G., Whiting, A., Goodwin, J., and Boveng, P. 2018. Habitat selection and seasonal movements of young bearded seals in the Bering Sea. PLoS ONE 13(2): e0192743. https://doi.org/10.1371/journal.pone.0192743.

Breed, G., Cameron, M., VerHoef, J., Boveng, P., Whiting, A., and Frost, K., 2018. Seasonal sea ice dynamics drive movement and migration of juvenile bearded seals (Erignathus barbatus). Marine Ecology Progress Series. 600:223-237. https://doi.org/10.3354/meps12659

Citta, J., Lowry, L., Quakenbush, L., Kelly, B., Fischbach, A., London, J., Jay, C., Frost, K., O'Corry Crowe, G., Crawford, J., Boveng, P., Cameron, M., Von Duyke, A., Nelson, M., Harwood, L., Richard, P., Suydam, R., Heide-Jorgensen, M., Hobbs, R., Litovka, D., Whiting, A., Marcoux, M., Kennedy, A., George, J., Orr, J., Gray, T. -2018. A multi-species synthesis of satellite telemetry data in the Pacific Arctic (1987–2015): Overlap of marine mammal distributions and core use areas (SOAR II). Deep Sea Research II

Cameron, M. 2007. Habitat use and seasonal movements of bearded seals in Kotzebue Sound, Alaska. AFSC Quarterly Research Reports (Oct.-Dec. 2006).

Cameron, M.F. 2006. Habitat use and seasonal movements of bearded seals in Kotzebue Sound, Alaska. AFSC Quarterly Research Reports (Oct.-Dec. 2005).

Cameron, M.F. 2005. Habitat use and seasonal movements of bearded seals in Kotzebue Sound, Alaska. AFSC Quarterly Research Reports (Oct.-Dec. 2004).

Funding status: Funded by USFWS Tribal Wildlife Grant and NMFS/MML

Project lead: Alaska Marine Ecosystems Research, Kathy Frost, kjfrost@hawaii.rr.com

Project partners: Kotzebue IRA, ADF&G, NMFS/MML, Ice Seal Committee, Minerals Management Service

B.3.6 MOVEMENTS, HABITAT USE, AND FORAGING BEHAVIOR OF RINGED, BEARDED, AND SPOTTED SEALS

Objective: To document the seasonal movements, foraging behavior, and important habitats of ringed, bearded, and spotted seals in the Beaufort, Chukchi, and Bering Seas using satellite telemetry and ocean sensing technology and to collect traditional ecological knowledge regarding seals and other marine mammals.

Justification: Ringed, bearded, and spotted seals are highly valued subsistence resources for western and northern Alaska coastal communities. To better understand how shipping and oil and gas activities affect seals and how mitigation measures may be of use, more information is needed regarding seasonal movements, diving and haul-out behavior, site fidelity, and the relationship of oceanographic conditions and important habitats.

Methods: Ringed, bearded, and spotted seals are captured in large-mesh tangle nets, instrumented with satellite-linked Depth Recorders (SDRs), long-term flipper tags, or CTD tags and then released. Seal locations, hauling out behavior, diving behavior, and oceanic conditions such as salinity and temperature are transmitted back to researchers via the ARGOS satellite system and analyzed for movements, site fidelity, and relationships with bathymetry, sea ice, and other environmental features.

Product:

Huntington, H.P., L.T. Quakenbush, and M. Nelson. 2016. Effects of changing sea ice on marine mammals and subsistence hunters in northern Alaska from traditional knowledge interviews. Biology Letters http://dx.doi.org/10.1098/rsbl.2016.0198

Huntington, H.P., L.T. Quakenbush, and M. Nelson. 2017. Evaluating the effects of climate change on indigenous marine mammal hunting in northern and western Alaska using traditional knowledge. Frontiers in Marine Science 4:319. Doi:10.3389/fmars2017.00319

Crawford, J.A., Frost, K.J., Quakenbush, L.T., Whiting, A. 2012. Different habitat use strategies by subadult and adult ringed seals (*Phoca hispida*) in the Bering and Chukchi seas. Polar Biology 35:241-255

Crawford, J.A., Frost, K.J., Quakenbush, L.T., Whiting, A. 2012. Seasonal and diel differences in dive and haul-out behavior of adult and subadult ringed seals (*Pusa hispida*) in the Bering and Chukchi seas. Polar Biology 42:65-80

Quakenbush, L., Crawford J. 2019. Ice seal movements and foraging: village-based satellite tracking and collection of traditional ecological knowledge regarding ringed and bearded seals. Annual report to BOEM No. M13PC00015.

Quakenbush, L. 2020. Movements and habitat use of Pacific Arctic seals and whales via satellite telemetry and ocean sensing. Final report to the Office of Naval Research No. N00014-16-3019.

Olnes, J., J. Crawford, J.J. Citta, M.L. Druckenmiller, A.L. Von Duyke, and L. Quakenbush. 2020. Movement, diving, and haul-out behaviors of bearded seals in the Bering, Chukchi, and Beaufort seas, 2014–2018. Polar Biology doi: 10.1007/s00300-020-02710-6

Olnes, J., G.A. Breed, M.L. Druckenmiller, J.J. Citta, J.A. Crawford, A.L. Von Duyke, and L. Quakenbush. Juvenile bearded seal response to a decade of sea ice change in the Bering, Chukchi, and Beaufort seas. *In press.* Marine Ecology Progress Series.

Von Duyke, A.L., D.C. Douglas, J.K. Herreman, and J.A. Crawford. 2020. Ringed seal (*Pusa hispida*) seasonal movements, diving, and haul-out behavior in the Beaufort, Chukchi, and Bering seas. Ecology and Evolution doi:10.1002ece3.6302

Funding status: Funded by NMFS prior to 2013, BOEM 2013–2019 and ONR 2016-2019. This project has ended but publications are being finalized.

Project lead: ADF&G, Lori Quakenbush

Project partners: North Slope Borough, Ice Seal Committee, Native Village of Kotzebue, Huntington Consulting, NMFS Marine Mammal Lab.

B.3.7 FIRST DOCUMENTATION OF OIL FOULING IN SUBSISTENCE-HARVESTED RINGED (*PHOCA HISPIDA*) AND SPOTTED (*PHOCA LARGHA*) SEALS IN BERING STRAIT

Objective: Document the chemical contamination, gross necropsy, and histological findings for oiled ice seals harvested for subsistence in the Bering Strait region.

Justification: The Bering Strait is a narrow waterway that divides Alaska from Russia and forms the only maritime transportation corridor for shipping routes between the Pacific and Arctic oceans. Concurrently, reliance on marine resources harvested in this region remains essential to the human population. Decreasing ice conditions herald not only ecosystem changes but increased opportunities for industrialized maritime use in the Bering Strait.

During 2012-2014, oil spills of unknown origin were detected in the Bering Strait region by the subsistence harvest of oiled ice seals [spotted (*Phoca largha*; n=4); ringed (*Phoca hispida*; n=1)] near Shishmaref and Saint Lawrence Island.

Methods: PAH concentrations determined from various tissues of 5 seals collected in the Bering Strait region during 2012-2014 as well as an unoiled and oiled harbor seal collected during the 1989 Exxon Valdez Oil Spill (EVOS) in Prince William Sound, Alaska. All results expressed in ng/g, wet weight. Results include the sum of low molecular weight PAHs containing 2-3 ring compounds (LMWAH) and the sum of high molecular weight PAHs containing 4-5 ring compounds (HMWAH).

Product:

Stimmelmayr, R., G.M. Ylitalo, G. Sheffield, K. Beckmen, K. Burek-Huntington, V. Metcalf, and T. Rowles. 2018. Oil Fouling in Three Subsistence-Harvested Ringed (*Phoca hispida*) and Spotted seals (*Phoca largha*) from the Bering Strait region, Alaska: Polycyclic Aromatic Hydrocarbon Bile and Tissue Levels and Pathological Findings. Marine Pollution Bulletin 130 (2018):311-323. https://doi.org/10.1016/j.marpolbul.2018.02.040

Sheffield, G., R. Stimmelmayr, V. Metcalf, G. Ylitalo, K. Burek, T. Rowles, and T. Hepa. 2015. Oil fouling in subsistence harvested ringed (*Phoca hispida*) and spotted seals (*Phoca largha*) in the Bering Strait region: 2012 and 2014. Oral presentation. 2015 May 18-22: Effects of Oil on Wildlife Conference, Anchorage, Alaska.

Sheffield, G., V. Metcalf, R. Stimmelmayr, G. Ylitalo, K. Burek, K. Beckmen, and T. Rowles. 2014. First documentation of oil fouling in subsistence harvested ringed (*Phoca hispida*) and spotted seals (*Phoca largha*) in the Bering Strait region – Fall 2012. Poster presentation. 2014 Jan 20-24: Alaska Marine Science Symposium, Anchorage, Alaska.

Ice Seal Committee meeting (2013)

Funding status: Funded

Project lead: Eskimo Walrus Commission, UAF-Marine Advisory Program, and NSB Dept. of Wildlife Management

Project partners: Gay Sheffield, Vera Metcalf, Raphaela Stimmelmayr, Gina Ylitalo, Kathy Burek Huntington, Kimberlee Beckmen, Teri Rowles, Taqulik Hepa

B.3.8 MOVEMENTS, HABITAT USE, AND FORAGING BEHAVIOR OF ADULT BEARDED SEALS IN THE CHUKCHI AND BERING SEAS

Objective: To document the seasonal movements, foraging behavior, and important habitats of adult and subadult bearded seals in Kotzebue Sound, the Chukchi Sea, and Bering Sea.

Justification: Bearded seals are an important subsistence resource, a key ecological component of the arctic marine ecosystem, and vulnerable to climate change because of their strong association with sea ice. Their seasonal movements, habitat use, and diving behavior have never been documented in Alaskan waters.

Methods: In 2009-2012, seven (4 male and 3 female) adult and sub-adult bearded seals were captured in Kotzebue Sound using large-mesh tangle nets. The seals were instrumented with Satellite-linked Data Recorders (SDRs) and then released. Information on the seals' movements and diving behavior were transmitted back to researchers via the ARGOS satellite system and analyzed to: 1) provide haul-out correction factors for past and future abundance and distribution sightings surveys, 2) assess the seasonal movements and patterns of distribution and diving/foraging behavior, 3) identify and determine the priority of importance for specific marine habitats associated with key ice seal life history events such breeding, pup rearing, and foraging and molting, and 4) describe seal dive depths and durations. This project involved direct collaboration between subsistence hunters and scientists, especially in capturing and tagging seals. The initial program grew out of a 2006-2006 collaboration with the Kotzebue IRA capturing young-of-year bearded seals. The 2009 field season in Kotzebue Sound was expanded in 2010, 2011 and 2012 to include communities in the North Slope Borough; however seals were not captured in those locations. With the field work, data collection and analyses complete, research manuscripts are being prepared and finalized for publication in peer-reviewed journals.

Product:

Cameron, M., McClintock, B., Blanchard, A., Boveng, P., Crawford, J., Goodwin, J., Grebmeier, J., Jewett, S., Lauth, B., London, J., Lovvorn, J., Norcross, B., Quakenbush, L., Whiting, A. In Revision. Foraging habitat selection by bearded seals, related to benthic community composition, bathymetry and sediment in the Chukchi Sea. Ecosphere.

London JM, Conn PB, Koslovsky SM, Richmond EL, Ver Hoef JM, Cameron MF, Crawford JA, Von Duyke AL, Quakenbush L, Boveng PL. 2024. Spring haul-out behavior of seals in the Bering and Chukchi Seas: implications for abundance estimation. PeerJ 12:e18160 https://doi.org/10.7717/peerj.18160

Boveng, P.L., Cameron, M.F. Goodman, J., Johnson, S., and Whiting, A. In Prep. Winter site fidelity of bearded seals in the Bering Sea.

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Cameron, M.F. and Boveng, P.L. 2009. Habitat use and seasonal movements of adult and sub-adult bearded seals in Kotzebue Sound, Alaska. AFSC Quarterly Report (Aug-Oct 2009).

Funding Status: Funded by NMFS/MML and the Bureau of Ocean Energy Management (BOEM)

Project Lead: NMFS/MML, Michael Cameron, michael.cameron@noaa.gov

Project Partners: UAF, ADFG, Native Village of Kotzebue, University of Maryland, Southern Illinois University

B.3.9 OCEANOGRAPHIC INFLUENCES ON SPOTTED SEAL FORAGING

Objective: To use satellite telemetry oceanographic modeling and biological sampling to examine spotted seal foraging behavior.

Justification: Although spotted seals are known to be mainly fish eaters, relationships between their environment and foraging behavior are not well understood. Both sea ice and oceanographic conditions are changing in the Bering, Chukchi, and Beaufort seas, and these changes are expected to affect spotted seal distribution, available prey species, and interactions between seals and humans. Examining relationships between physical oceanography, sea ice, and seal behavior is needed to anticipate how spotted seals respond to environmental change.

Methods: Between 2016 and 2020, 23 spotted seals were equipped with Satellite Relay Data Loggers (SRDLs) with Conductivity, Temperature, and Depth (CTD) sensors capable of collecting temperature and salinity profiles as the seals dove through the water column. These instruments (referred to as CTD-SRDLs) provided animal movement and oceanographic data. Spotted seal movements, habitat use, and the dive depths targeted by seals were summarized. A state-space model was used to define seal behavioral states and explore how they related to oceanographic fields inferred from data provided by the CTD-SRDLs. The CTD-SRDLs only provided information about the oceanographic conditions seals encountered along their tracks. As such, numerical simulations from the Regional Arctic System Model were used for a broader, regional oceanographic context, and, specifically to explore the potential use of hydrographic fronts for foraging. Patterns of foraging behavior were related to prey found in seal stomachs.

Product:

Olnes, J., J. Crawford, S. Okkonen, J. Citta, L. Quakenbush, A. Von Duyke, W. Maslowski, R. Osinski, and M. Druckenmiller. 2023. Oceanographic influences on spotted seal foraging in the Pacific Arctic. Continental Shelf Research 269:105136.

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Olnes, J., J. Crawford, S. Okkonen, J. Citta, L. Quakenbush, A. Von Duyke, W. Maslowski, R. Osinski, and M. Druckenmiller. 2023. Oceanographic influences on spotted seal foraging in the Pacific Arctic. Alaska Marine Science Symposium, January 23–27, Anchorage, Alaska (abstract for oral presentation).

Funding status: NPRB

Project lead: ADF&G, Justin Olnes, justin.olnes@alaska.gov

Project partners: North Slope Borough

B.3.10 INTEGRATION OF TRADITIONAL KNOWLEDGE AND WESTERN SCIENCE USING A BAYESIAN APPROACH FOR FULLY INFORMED MODELS

Objective: Our overall goal is to combine Traditional Knowledge (TK) with satellite telemetry data of seal movements in Alaskan waters to get a better understanding of seal habitat use and behavior. To do this we are using three species as a case study: ringed, bearded, and spotted seals. Our specific objectives are to:

1. Document TK on the habitat use and behavior of ringed, bearded, and spotted seals.
1. Convert the TK into a form that can be use in Bayesian species habitat and movement models.
1. Integrate both TK and satellite telemetry data on ringed, bearded, and spotted seals in models using a Bayesian framework.

Justification: To date, inferences about animal behavior and habitat-use have been largely based on western science, with TK seen largely as a separate, albeit valuable, body of information that can help inform capture and tagging efforts (e.g., Kelly et al. 2009) or serve as corroborative/ancillary information. However, TK can provide data that extends well beyond the timeframes of western science and does not suffer from limited sample size, which can be an issue in western science, particularly in satellite telemetry studies of marine mammals. Alternatively, western science can often provide data that extends into regions (e.g., offshore waters) where TK holders may have limited knowledge. Uniting these two fields within a single analytical framework enables synergies that increase the understanding of wildlife ecology beyond what is possible using each knowledge system in isolation.

Methods: TK interviews were conducted with local hunters in Utqiaġvik, Kotzebue, and Point Hope, AK using a semi-directed format in a conversational style following Huntington (1998). The interviews focused on seal behavior (e.g., differences in diving patterns between traveling and foraging) and habitat use (e.g., are the seals predominantly associated with the ice edge or with pack ice?). Initial interviews were conducted in 2018 and 2019.

The TK collected will dictate the method of its inclusion within the Bayesian habitat models. For example, if there is TK available on the associations between species and ice-concentrations, the TK will be transformed to reflect the probability of an animal being associated with those concentrations. Once the TK has been modified, follow-up discussions with TK holders will be held to confirm that the transformation of the TK has been done in a manner that is consistent with the information provided. The TK will then be combined with satellite telemetry data for ringed, bearded, and spotted seals in Bayesian habitat and behavior models to produce more fully informed models that improve the understanding of habitat use for these species.

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Huntington HP. 1998 Observations on the utility of the semi-directive interview for documenting traditional ecological knowledge. Arctic 51: 237–242.

Product:

Gryba R, HP Huntington, AL Von Duyke, B Adams, B Frantz, J Gatten, Q Harcharek, H Olemaun, R Sarren, J Skin, G Henry, M Auger-Méthé. 2021. Indigenous Knowledge of bearded seal (Erignathus barbatus), ringed seal (Pusa hispida), and spotted seal (Phoca largha) behaviour and habitat use near Utqiaġvik, Alaska, USA. Arctic Science 7: 832–858 dx.doi.org/10.1139/as-2020-0052

Gryba R, A VonDuyke, H Huntington, B Adams, B Frantz, J Gatten, Q Harcharek, R Sarren, G Henry, M Auger-Méthé. 2024. Indigenous Knowledge as a sole data source in habitat selection functions. bioRxiv. doi: https://doi.org/10.1101/2023.09.07.556613

Funding Status: Primary funding from North Pacific Research Board from 2018-2022, with additional funds

from North Slope Borough, Marine Mammal Commission, Polar Knowledge Canada - North Scientific Training Program, Stantec Research & Development, Canadian Research Chair program, and National Sciences and Engineering Research Council of Canada

Project Lead: University of British Columbia, Rowenna Gryba, r.gryba@stat.ubc.ca

Project Partners: North Slope Borough – Department of Wildlife Management, Huntington Consulting, Kotzebue IRA, local hunters in Utqiaġvik, Kotzebue, and Point Hope, AK

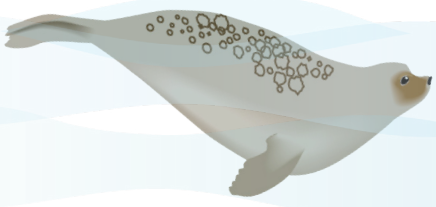
B.3.11 MONITORING BODY CONDITION OF SEALS IN ALASKA USING SMALL UAS

Objective: To develop and deploy non-invasive, low-disturbance methods for monitoring the body condition of Arctic seals as an indicator of population health and productivity.

Justification: All five phocid (or 'true') seals in Alaska, are key components of their marine ecosystems and are important subsistence resources for coastal Alaska Native communities. All are NMFS Protected Resources under the Marine Mammal Protection Act, and two are listed as Threatened under the Endangered Species Act. Body condition (e.g., the ratio of mass over length) is a key indicator of population health and productivity, but it is challenging and expensive to assess a large sample of individuals in populations by the traditional means of catching and measuring individual animals. Still, researchers have detected apparent changes in the body condition of young spotted and ribbon seals, from direct measurements, that may reflect impacts from recent warming and loss of sea ice in the Bering Sea; however the sample sizes are small and precision is poor for robust inference. Alaska Natives hunt seals for subsistence purposes and community efforts to biosample harvested animals have resulted in large and rich datasets that include information on body condition (see project A.1.1). That study produces larger sample sizes than the live-seal measurements, but may be subject to unknown biases inherent in the harvest. In addition, the timing of most seal hunting is after mothers have weaned their young, and pups were the most sensitive to changes in body condition in our data. This project seeks to complement current information about seal body condition by developing a remote-sensing method that can be applied to a broad sector of the breeding population in conjunction with large, regional aerial surveys.

Methods: Photogrammetry, using unoccupied aircraft systems (UAS) with suitable imaging and positioning capabilities has the potential for vastly increasing the numbers of seals that can be measured, compared with direct measurement of live seals. Development of UAS photogrammetry methods for ice seals may also provide a step toward a method for monitoring body condition in conjunction with image-based surveys for population abundance, thereby greatly strengthening our capability for timely, accurate, and long-term detection of changes, particularly seal-prey-related ecosystem shifts and population threats. We extended existing photogrammetry methods for marine mammals based on battery-operated multi-rotor UAS, with particular focus on conditions relevant to Alaska, such as cold operating temperatures, remoteness of operating areas, needs for operating from a variety of vessels, and conducting photogrammetry of seals on floating ice that may be in motion during overflights. Initial testing and selection of sensors and various models of UAS were conducted in 2020 and 2021. Validation studies (confirming the system's ability to accurately estimate the body condition of ice seals) were conducted in 2021, 2022, and 2023 at captive-care facilities with seals already trained for cooperation in physiological research. In April 2022, field tests of the system were conducted during an expedition aboard the NOAA Ship Oscar Dyson, where researchers collected images of ice-associated seals hauled out at the southern edge of the Bering Sea marginal ice zone. In April and May 2024, during an ice seal research cruise on the *R/V Norseman II,* we collected imagery of 44 seals (ribbon and spotted) in the Bering Sea pack ice.

The images and data collected during the lab and field efforts have been analyzed, and a model has been developed to estimate seal mass using UAS photogrammetry methods. This model is able to detect a 5% change in body mass for ringed, spotted, and bearded seals. We successfully collected UAS imagery of wild ice-associated seals in the Bering Sea in 2022 and 2024, which will be used with the model developed to evaluate and monitor body condition. These new UAS-based methods will be deployed alongside the current direct measurement approach, to take advantage of larger numbers of seals that are seen during satellite-tagging operations but are inaccessible for capture. This will enhance researchers' abilities to assess the status of Arctic seals with greater precision and efficiency. Ultimately, as a next step beyond this project, even greater gains in monitoring capability will stem from incorporation of the new methods into ongoing large-area, photo-based aerial surveys for abundance and distribution, in which thousands of seals are typically encountered.



Product:

Cameron, M., G. Brady, B. Hou, S. Koslovsky, B. McClintock, M. Meranda, C. Reichmuth, E.Richmond, and H. Ziel. In review. Monitoring the body condition of arctic seals on pack ice using small uncrewed aerial systems. Ecology and Evolution.

Cameron, M., G. Brady, B. Hou, S. Koslovsky, B. McClintock, M. Meranda, C. Reichmuth, E. Richmond, and H. Ziel. 2025. Final Report for the NOAA ORTA Bridging Program Project: An Extension of 2020-05 Monitoring Body Condition of Seals in Alaska Using Small UAS. AFSC Processed Report.

Boveng, P. L., H. L. Ziel, B. T. McClintock, and M. F. Cameron. 2020. Body condition of phocid seals during a period of rapid environmental change in the Bering Sea and Aleutian Islands, Alaska. Deep Sea Research Part II: Topical Studies in Oceanography 181-182:104904.

Ziel, H. L., S. M. Koslovsky, and G. M. Brady. 2024. Monitoring body condition of seals in Alaska: Phase III - test data collection. AFSC Processed Rep. 2024-03, 17 p. Alaska Fish. Sci. Cent., NOAA, Natl. Mar. Fish. Serv.

Funding status: Funded by NOAA's UxS Research Transition Office

Project lead: NMFS/MML, Michael Cameron, michael.cameron@noaa.gov

Project partners: Institute of Marine Sciences, University of California Santa Cruz, Long Marine Laboratory, and Alaska SeaLife Center

B.3.12 USING AERIAL SURVEYS, BIO-LOGGING, AND SATELLITE REMOTE SENSING TO CHARACTERIZE ARCTIC RINGED SEAL DENNING HABITAT

Objective: Combine data from aerial survey counts, satellite-tag bio-logging records of haul-out time, and remotely-sensed data on snow depth and melt onset to (1) understand and quantify ringed seals' habitat use, and (2) enhance capabilities to estimate abundance and trends of ringed seals.

Justification: A better understanding of ringed seals' dependence on snow cover is critical for assessing their vulnerability to future Arctic warming and for estimation of population abundance and trends. The relationships between snow depth, temperature, melt onset date, and date of ringed seal emergence from snow lairs are key to more informed projections of reproductive habitat suitability using climate model outputs. The same relationships are also fundamental for more reliable abundance estimation, due to the sensitivity of abundance estimates to the timing of emergence from lairs.

Methods:

REMOTE SENSING OF RINGED SEAL HABITAT FEATURES

We evaluated satellite-remote-sensed measures of snow depth, melt onset timing, and indices of ice roughness. The primary focus was on quantities related to common outputs of global climate models (for refining conservation risk assessments) and/or quantities available at suitable scales and resolutions for relating to aerial survey data (for abundance estimation). Specifically, the timing of snow melt onset was derived from passive microwave data using the MDSDA algorithm (Belchansky et al. 2004) and the Markus et al. (2009) algorithm. Remotely-sensed snow depths were obtained from the NASA Cryosphere database of 25-km gridded snow depths on sea ice. We evaluated these indices for their ability to explain variability in ringed seal counts from aerial surveys conducted with manned aircraft in the Bering and Chukchi seas (manuscript published in 2021) and with UAS in Kotzebue Sound (Lindsay et al. 2023).

RINGED SEAL HAUL-OUT AND EMERGENCE TIMING

Availability, or the proportion of seals visible to aircraft when flying overhead, is ultimately a function of both emergence from lairs and behavioral changes in haul-out probability related to basking. For our Chukchi and East Siberian Surveys (ChESS; see project A.3.3) we accounted for changes in haul-out behavior using data from tagged seals, and then modeled overall changes in availability using temporal trends in aerial survey counts. This allowed us to isolate the magnitude of contributions from haul-out and emergence to increases in spring seal counts, improving the accuracy of ringed seal abundance estimates. For further information, see Appendix 2 "Ringed seal availability modeling" of Boveng et al. (2025). The remote-sensing products described above, as well as weather products such as the North American Regional Reanalysis (Mesinger et al. 2006) database, were also relevant to analyses of haul-out and emergence timing.

We also used seasonal changes in the haul-out behavior of tagged ringed seals in combination with hidden Markov models (HMMs) to estimate the date at which ringed seals emerged and began basking. Specifically, we applied HMMs to a ringed seal haul-out dataset collated from previous studies in the Bering, Chukchi, and Beaufort seas during 2005–2021 where adult and subadult ringed seals were tagged with satellite-linked transmitters (projects A.3.8, B.1.3, B.3.3). For both age classes, we estimated when seals switched their haul-out behavior from hauling out in their lairs to emerging

on the sea ice, and identified environmental covariates associated with this transition. A manuscript was published in Ecology and Evolution in January 2026.

Products:

Lindsay, J. M., P. B. Conn, P. L. Boveng, J. A. Crawford, L. T. Quakenbush, A. L. Von Duyke, and K. L. Laidre. 2026. Ringed seal (*Pusa hispida*) haul-out behavior and emergence timing in the Bering, Chukchi, and Beaufort seas. Ecology and Evolution 16: e72948. https://doi.org/10.1002/ece3.72948

Boveng P. L., V. I. Chernook, E. E. Moreland, P. B. Conn, I. S. Trukhanova, M. F. Cameron, C. L. Christman, J. A. Crawford, D. M. Glazov, L. Harwood, B. X. Hou, S. M. Koslovsky, J. M. Lindsay, D. I. Litovka, J. M. London, B. T. McClintock, N. Platonov, L. Quakenbush, E. L. Richmond, A. Vasiliev, A. L. Von Duyke, and A. Willoughby. 2025. Abundance and distribution of ringed and bearded seals in the Chukchi Sea: a reference for future trends. Arctic Science 11:1–21. https://doi.org/10.1139/as-2024-0068

Lindsay, J. M., D. D. W. Hauser, A. R. Mahoney, K. L. Laidre, J. Goodwin, C. Harris, R. J. Schaeffer, R. Schaeffer Sr., A.V. Whiting, P. L. Boveng, N. J. M. Laxague, S. Betcher, A. Subramaniam, C. R. Witte, and C. J. Zappa. 2023. Characteristics of ringed seal *Pusa hispida* ('natchiq') denning habitat in Kotzebue Sound, Alaska, during a year of limited sea ice and snow. Mar Ecol Prog Ser 705:1-20. https://doi.org/10.3354/meps14252

Lindsay, J. M., K. L. Laidre, P. B. Conn, E. E. Moreland, and P. L. Boveng. 2021. Modeling ringed seal P*usa hispida* habitat and lair emergence timing in the eastern Bering and Chukchi Seas. Endangered Species Research 46:1-17. https://doi.org/10.3354/esr01140
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Markus, T., J. C. Stroeve, and J. Miller. 2009. Recent changes in Arctic sea ice melt onset, freezeup, and melt season length. Journal of Geophysical Research: Oceans 114:doi: 10.1029/2009JC005436.

Mesinger F., G. DiMego, E. Kalnay, K. Mitchell, P. C. Shafran, W. Ebisuzaki, D. Jović, J. Woollen, E. Rogers, E. H. Berbery, M. B. Ek, Y. Fan, R. Grumbine, W. Higgins, H. Li, Y. Lin, G. Manikin, D. Parrish, and W. Shi. 2006. North American Regional Reanalysis. Bulletin of the American Meteorological Society 87:343–360.

Funding status: Funded by NMFS/MML, NSF, NPRB, UW SAFS, and the Gordon and Betty Moore Foundation.

Project lead: NMFS/MML, Paul Conn, paul.conn@noaa.gov and Jessie Lindsay, jessica.lindsay@noaa.gov

Project partners: ADF&G Arctic Marine Mammals, NSB Dept. of Wildlife Management, Department of Fisheries &

Oceans Canada, University of Washington Applied Physics Laboratory and School of Aquatic and Fisheries Sciences, Native Village of Kotzebue, Columbia University, University of Alaska Fairbanks, and Farthest North Films.

B.3.13 SPOTTED SEAL COASTAL HAUL OUT BEHAVIOR IN ARCTIC ALASKA

Objectives: The goal of this study was to improve our understanding of spotted seal (Phoca largha) ecology during the summer-fall open water period. Specifically, we used remote time-lapse trail camera imagery and weather data to evaluate how spotted seal counts at terrestrial haul outs were: 1) affected by haul out area availability, and (2) environmental conditions and temporal variations (i.e., diel, seasonal, and yearly). Seasonal and interannual spotted seal count results were then (3) considered alongside local environmental observations from IK holders to provide broader ecological context.

Justification: Spotted seals are seasonally abundant throughout coastal regions of the Beaufort Sea during the summer and fall, frequently hauling out on coastal sandbars, spits, and islands. However, the influence of environmental factors on distribution, numbers, and behavior is unclear. Improving our understanding of spotted seal terrestrial ecology during the open-water season can provide insights on how this species may be impacted by ongoing ecological change.

Methods: Previously collected time-lapse camera imagery was used to evaluate coastal haul-out behavior, presence, and counts of spotted seals at study sites in the Beaufort Sea, including Oarlock Island and Topagoruk River in Dease Inlet. Two high-resolution time-lapse cameras were placed at each study site during the open water season (~mid-July to October) each year, 2020-2022. The sites were monitored for a total of 330 days (5469 hours), resulting in a total of ~300,000 photos over the three study years. Images were reviewed manually for presence, seal counts, and environmental data including substrate availability, sea state, visibility, and air temperature. Additional weather variables (wind speed and wind direction) were collected from the National Weather Service (NWS) in Utqiaġvik to complement concurrent weather and environmental observations collected by Iñupiat observers who are part of the Alaska Arctic Observatory & Knowledge Hub (AAOKH).

Generalized additive statistical models were fit for each site to examine how environmental and temporal covariates explain variation in spotted seal counts. Substrate availability was assessed by aligning wind speed and direction data with time-lapse images that showed exposed or submerged substrate. We found that temperature, day-of- year, year, wind speed, and wind direction best explained variation in seal counts, with wind effects on substrate availability varying by location. Observations from IK holders put seal monitoring results into a broader environmental context, highlighting the role of ice and weather conditions on seasonal and interannual variability in summer and fall haul out behavior.

Products:

Connor, M. 2025. Spotted seal coastal haul out behavior in Arctic Alaska. [MA Thesis, University of Alaska Fairbanks]. https://www.proquest.com/openview/40dc9fcd36552c8cf66a79a083bfe918/1.pdf?pq-origsite=gscholar&cbl=18750&diss=y

Connor, M., Von Duyke, A., Brinkman, T., Hauser, D. D. W. (in review). Applying remote monitoring, environmental conditions, and community-based observations to understand spotted seal terrestrial ecology. Arctic Science.

Funding status: This project was funded by a grant from the Alaska Sea Grant College Program. Time-lapse camera monitoring components were previously funded by a grant from the Coastal Marine Institute and the Bureau of Ocean Energy Management (#AK-19-02-5). The project also relied on funding and support from existing projects: the Alaska Arctic Observatory and Knowledge Hub (AAOKH), the International Arctic Research Center at the University of Alaska Fairbanks, and the Ice Seal Research Program at the North Slope Borough Department of Wildlife Management (NSB-DWM).

Project leads: UAF, Donna Hauser, dhauser2@alaska.edu; NSB, Andrew Von Duyke, andrew.vonduyke@north-slope.org

Graduate student: UAF, Maeghan Connor, mrconnor@alaska.edu

Project partners: University of Alaska Fairbanks, North Slope Borough, Ice Seal Committee, and Alaska Arctic Observatory and Knowledge Hub. All field activities were permitted under NMFS Letter of Confirmation No. 23546, UAF IACUC #1610672-2 and UAF Animal Care Protocol 1610672-6. Previous camera data was also collected under BLM Land Use Permit FF097621.

B.4 Education and Outreach

B.4.1 KAWERAK ICE SEAL AND WALRUS PROJECT, 2010-2014

Objective: Document traditional knowledge of ice seals and walruses in the Bering Strait Region of Alaska,

including important habitat areas, local management traditions, and cultural importance.

Justification: Bering Strait tribes have detailed knowledge of ice seals and walruses, and a long history of subsistence use.

Methods: Participatory research design. Semi-structured interviews and focus groups with a purposive sample of local experts. Interviews included mapping as well narrative traditional knowledge. Participating communities were Diomede, King Island, Savoonga, Nome, Elim, Koyuk, Shaktoolik, Saint Michael and Stebbins.

Product:

Gadamus, L. and J. Raymond-Yakoubian. 2015. Qualitative participatory mapping of seal and walrus harvest and habitat areas: documenting indigenous knowledge, preserving local values, and discouraging map misuse. International Journal of Applied Geospatial Research. 6(1): 76-93.

Gadamus, L. 2013. Linkages between human health and ocean health: a participatory climate change vulnerability assessment for marine mammal harvesters. International Journal of Circumpolar Health. 72: 20715.

A map atlas "Seal and Walrus Harvest and Habitat Areas for Nine Bering Strait Region Communities"

Two books: *Seal and Walrus Hunting Safety* and *Traditions of Respect*

A policy document: "Policy-Based recommendations from Kawerak's Ice Seal and Walrus Project"

A synthesis document in collaboration with Oceana: "Bering Strait Marine Life and Subsistence Use Data Synthesis"

Two articles have been submitted for publication. One on the use of traditional knowledge in habitat delineation, and one on local values associated with seal and walrus harvest and management.

A collaboration with Audubon Alaska to do an analysis of vessel traffic in the Bering Strait which includes spatial data from this project

http://www.kawerak.org/socialsci.html

Funding status: Completed 2014

Project lead: Kawerak Social Science Program, socsci@kawerak.org

Project partners: Ice Seal Committee, Eskimo Walrus Commission, the communities of Diomede, King Island, Savoonga, Nome, Elim, Koyuk, Shaktoolik, Saint Michael, and Stebbins

B.4.2 TRADITIONAL HUNTING WORKBOOK – ICE SEALS

Objective: A workbook on traditional ice-seal hunting in the Yukon-Kuskokwim region will be produced that can be used by teachers in the region. Printing of the workbook will require additional funds.

Justification: Young hunters need to know the traditional ways of hunting, the tools used in hunting, and the ways to prepare seals.

Methods: Produce outline and draft workbook for review by hunters and elders.

Product: Workbook is completed and being used for teaching in the Yukon-Kuskokwim and Kawerak regions and as a template for a beluga hunting book by the Alaska Beluga Whale Committee.

Funding status: Funded 2005-2006 by the Ice Seal Committee and NMFS, Alaska Region.

Project lead: Lori Quakenbush and Mike Taras

Project partners: ADF&G, NMFS/NMML, IUM, Ice Seal Committee

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