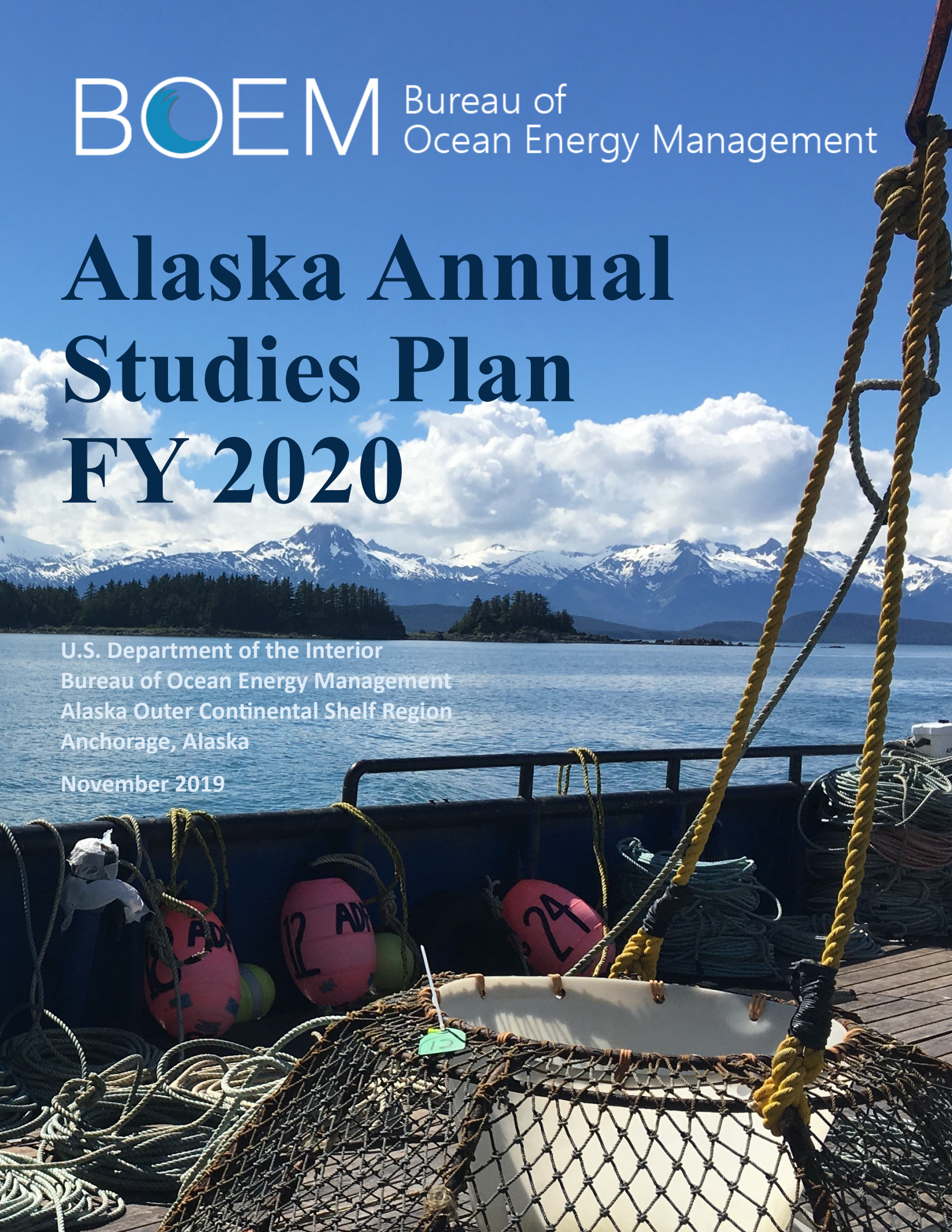
BOEM Bureau of Ocean Energy Management

Alaska Annual Studies Plan FY 2020



U.S. Department of the Interior
Bureau of Ocean Energy Management
Alaska Outer Continental Shelf Region
Anchorage, Alaska

November 2019

Prepared by
U.S. Department of the Interior
Bureau of Ocean Energy Management
Anchorage, Alaska Office
3801 Centerpoint Drive, Suite 500
Anchorage, Alaska 99503-5823

November 2019

The Environmental Studies Program chosen to "go green." This document can be accessed in electronic format at http://www.boem.gov/akstudies/. For assistance accessing the document or for further information about the Studies Program and our planning process, please contact Dr. Heather Crowley at heather.crowley@boem.gov.

The inclusion of study profiles in this document does not constitute a commitment by the U.S. Department of the Interior, Bureau of Ocean Energy Management to conduct or fund any or all of the studies. Method of procurement may be selected at the discretion of BOEM. The scope of the studies is subject to change prior to initiation of any work.

Any use of trade names is for descriptive purposes only and does not constitute endorsement of these products by the Bureau of Ocean Energy Management.

Cover Image: Collecting crab samples in Southcentral Alaska.

Photo credit: "Using Genotyping-by-Sequencing (GBS) Population Genetics Approaches to Determine the Population Structure of Tanner Crab (*Chionoecetes bairdi*) in Alaska" project team; Genevieve Johnson, Principal Investigator.

United States Department of the Interior

BUREAU OF OCEAN ENERGY MANAGEMENT

Anchorage, Alaska Office

3801 Centerpoint Drive, Suite 500

Anchorage, Alaska 99503-5823

November 8, 2019

Dear Stakeholder:

Thank you for your interest in the Environmental Studies Program (ESP) of the Bureau of Ocean Energy Management (BOEM). As BOEM's priorities evolve, we continue to our assess information needs and identify new study ideas each year to meet these needs. We are providing this *Alaska Annual Studies Plan FY 2020* as a convenient reference describing our recent programmatic updates and our plans for fiscal year (FY) 2020 and beyond.

The *Alaska Annual Studies Plan* is developed from submissions and input we receive from our partners within and outside of the Federal Government. We are interested to know your perspectives and to receive any suggestions you may have for the BOEM *Alaska Annual Studies Plan FY 2021*, which we are now beginning to formulate. We assess information needs and develop new study profiles each year, following a well-established process that involves a role for both stakeholder input and scientific peer review (see a complete description of our process beginning on p. 3).

To assist us in processing any suggestions for new studies, we ask that you follow the formatting guidance for a study profile as shown on the next page. Please keep in mind that studies proposed for our consideration must address specific BOEM mission and decision needs. Suggestions may be submitted via email to Alaska.Studies@boem.gov, and must be received by us no later than December 10, 2019, to ensure consideration for the 2021 fiscal year (October 1, 2020– September 30, 2021). Following revisions to the plan, we will issue a final *Alaska Annual Studies Plan FY 2021* in the autumn of 2020.

We sincerely appreciate your participation in this process and we look forward to receiving your suggestions. If you have any questions about the submission process, you are urged to contact Dr. Heather Crowley, Alaska Studies Coordinator, at heather.crowley@boem.gov.

Sincerely,

Catherine Coon
Chief, Environmental Sciences Management

Bureau of Ocean Energy Management
http://www.boem.gov/akstudies/
Alaska.Studies@boem.gov

Proposed Study for FY 2021

Formatting Guidance: We recommend study profiles be less than 2 pages. Profiles are not a detailed scope of work; BOEM will prepare a detailed scope of work if one is needed.

Title: Enter a brief, descriptive title

Administered by: Anchorage, Alaska Office

Period of Performance: FY 2021-202X

Study Framework: *(Provide one or two sentences for each of the following elements, as appropriate)*

Problem: Who or what is potentially affected? This includes baseline studies.

Intervention: What is your solution to the problem? How do you measure potential interactions and/or change?

Comparison: What is the intervention measured against? Consider in terms of hypothesis testing, control vs. treatment, and/or natural change.

Outcome(s): What is the expected outcome and understanding?

Context: What are the circumstances and/or geographic domain(s)?

BOEM Information Need(s): Provide brief and conclusive reason(s) why BOEM needs the information. Explain how this information will be used to manage Outer Continental Shelf (OCS) resources. The specific decision or document relying on the information should be stated.

Background: Provide a brief narrative of relevant issues. Explain what information is required and provide pertinent background. Include details about whether this study ties in with other efforts, and if so, how. Include a description of the current status of information. That is, what is the level of adequacy of existing information, does any exist, does it need to be more geographically specific?

Objectives: Clearly and succinctly state the overall purpose of the study by identifying one or more specific objectives.

Methods: Provide a brief description of how the objectives of the study will be accomplished, including what information, techniques or methods are available that could be used. Also note expected study products in this section (e.g. technical reports, database, model, bibliography)

Specific Research Question(s): Identify specific research questions this study will address.

Additional information: Provide additional relevant information, such as dates when products would be most useful and for what purpose, such as "Final report is needed by November 2024 to support NEPA analysis for exploration or development activities at current and potential future leases in Cook Inlet."

** Please keep in mind that studies proposed for our consideration must address specific BOEM mission and decision needs.*

TABLE OF CONTENTS

LIST OF STUDY PROFILES

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ACRONYMS AND ABBREVIATIONS

ADF&G	Alaska Department of Fish and Game
AEWC	Alaska Eskimo Whaling Commission
ANIMIDA	Arctic Nearshore Impact Monitoring in Development Area
ANTHC	Alaska Native Tribal Health Consortium
ASP	Alaska Annual Studies Plan (BOEM)
AOOS	Alaska Ocean Observing System
BLM	Bureau of Land Management
BOEM	Bureau of Ocean Energy Management
BSMP	Beaufort Sea Monitoring Program
BSEE	Bureau of Safety and Environmental Enforcement
CAB	Chemistry and Benthos
cANIMIDA	Continuation of Arctic Nearshore Impact Monitoring in Development Area
CESU	Cooperative Ecosystem Studies Unit
CIRCAC	Cook Inlet Regional Citizens Advisory Council
CMI	Coastal Marine Institute
COMIDA	Chukchi Offshore Monitoring in Drilling Area
COSA	Committee on Offshore Science and Assessment of the National Academies of Sciences, Engineering, and Medicine
DPP	Development and Production Plan
DWM	Department of Wildlife Management (North Slope Borough)
EA	Environmental Assessment
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EP	Exploration Plan
EPA	Environmental Protection Agency
ESA	Endangered Species Act
ESP	Environmental Studies Program (BOEM)
ESPIS	Environmental Studies Program Information System
FY	Fiscal Year
IARPC	Inter-agency Arctic Research Policy Committee
IOOS	Integrated Ocean Observing System
MML	Marine Mammal Laboratory
MMPA	Marine Mammal Protection Act
MMS	Minerals Management Service
NAAQS	National Ambient Air Quality Standards
NASA	National Aeronautics and Space Administration
NCEI	National Centers for Environmental Information
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service

NOAA	National Oceanic and Atmospheric Administration
NOPP	National Oceanographic Partnership Program
NPRB	North Pacific Research Board
NPS	National Park Service
NSB	North Slope Borough
NSSI	North Slope Science Initiative
NSF	National Science Foundation
NWS	National Weather Service
OCS	Outer Continental Shelf
OCSEAP	Outer Continental Shelf Environmental Assessment Program
OCSLA	Outer Continental Shelf Lands Act
ONR	Office of Naval Research
PSD	Prevention of Significant Deterioration
SOAR	Synthesis of Arctic Research
UAA	University of Alaska Anchorage
UAF	University of Alaska Fairbanks
USARC	U.S. Arctic Research Commission
USDOI	U.S. Department of the Interior
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UT	University of Texas
UW	University of Washington
WHOI	Woods Hole Oceanographic Institution

SECTION 1.0 PROGRAMMATIC OVERVIEW

1.1 Introduction to the Anchorage, Alaska Office

Background

The U.S. Department of the Interior's Bureau of Ocean Energy Management (BOEM) manages the responsible exploration and development of offshore energy and marine mineral resources on the U.S. Outer Continental Shelf (OCS). The Bureau promotes energy independence, environmental protection, and economic development through responsible management of these offshore resources based on the best available science. The OCS refers to 1.7 billion acres of Federal jurisdiction lands submerged under the ocean seaward of state boundaries, generally beginning three nautical miles off the coastline (for most states) and extending for 200 miles. The OCS off Alaska alone contains approximately 1 billion acres.

BOEM's Environmental Studies Program (ESP) was established in 1973 to support the OCS oil and gas leasing program of the U.S. Department of the Interior (USDOI). Originally administered by the Bureau of Land Management (BLM) then by the Minerals Management Service (MMS) and now BOEM, the consistent mandate of the ESP since its inception has been to establish the scientific information used for assessment and management of potential impacts from oil and gas development on the human, marine and coastal environments of the OCS. Mandated by Section 20 of the Outer Continental Shelf Lands Act (OCSLA) of 1953, as amended (43 U.S. C. 1344 et seq.), the Environmental Studies Program is an indispensable requirement informing BOEM's decisions on offshore oil and gas, offshore renewable energy, and the marine minerals program for coastal restoration.

In addition, the National Environmental Policy Act (NEPA) of 1969 requires that all Federal Agencies use a systematic, interdisciplinary approach that will ensure the integrated use of the natural and social sciences in any planning and decision-making that may have effects on the environment. Final reports, data, and peer-review journal articles from ESP-funded studies are used by teams of NEPA analysts within the BOEM Environmental Analysis Sections when they prepare Environmental Impact Statements (EISs) and Environmental Assessments (EAs) related to lease sales, Geological and Geophysical permit applications, Exploration Plans (EPs), and Development and Production Plans (DPPs). The study products are also used within BOEM to develop documentation for consultations and other requirements under various Federal laws, including but not limited to the Marine Mammal Protection Act (MMPA); Endangered Species Act (ESA); Magnuson-Stevens Fishery Conservation and Management Act; Marine Protection, Research and Sanctuaries Act; and Clean Air Act.

Over the last 46 years, the ESP has provided more than $1.2 billion nationally for scientific research on the OCS. Nearly $500 million of that amount has funded studies across Alaska's 15 planning areas in the Arctic, Bering Sea and Gulf of Alaska sub-regions (Figure 1) to produce more than 1,000 technical reports and innumerable peer-reviewed publications.

Figure 1. BOEM Alaska OCS Planning Areas

Early in the development of the ESP, the focus was on obtaining baseline information on the vast biological resources and physical characteristics of the Alaskan environment for pre-lease decision-making. As a broader base of information was established, the focus turned to more topical studies in smaller areas to answer specific questions and fill identified information needs. Today, the ESP in Alaska typically manages about 50-60 ongoing study projects in disciplines such as physical oceanography, air quality, fate and effects of pollutants, protected species, marine ecology, and the social sciences, including traditional knowledge.

Completed study reports are posted on the Environmental Studies Program Information System (ESPIS) at http://www.boem.gov/ESPIS/. Alaska Office study reports can also be found at http://www.boem.gov/AKpubs. Project data are typically delivered to Federal data repositories such as the National Centers for Environmental Information (NCEI), and posted to the Alaska Ocean Observing System (AOOS) and customized project websites.

Scientific Studies are Developed and Conducted in Partnership

As studies information has been amassed, greater focus on collaboration and integration across scientific disciplines is required. BOEM co-sponsors the Alaska Marine Science Symposium each year to facilitate formation of partnerships, exchange of information, development of multidisciplinary research approaches, and sharing of study results. In fact, the entire studies planning, procurement, and dissemination process, from start to finish, involves constant coordination with multiple organizations and scientific entities.

In the Alaska Office, research planning is a continual process that follows a longstanding annual cycle (Figure 2), beginning with the distribution of the *Alaska Annual Studies Plan* (ASP) in autumn to more than 200 partner and stakeholder groups across Federal, State, Alaska Native, Tribal, academic, and industry sectors spanning international, regional, and local interest groups. While the ASP describes ongoing research and reveals proposed new studies for the coming fiscal year, it also requests input from scientists, stakeholders, partners and the general public about information needs and suggestions for new studies.

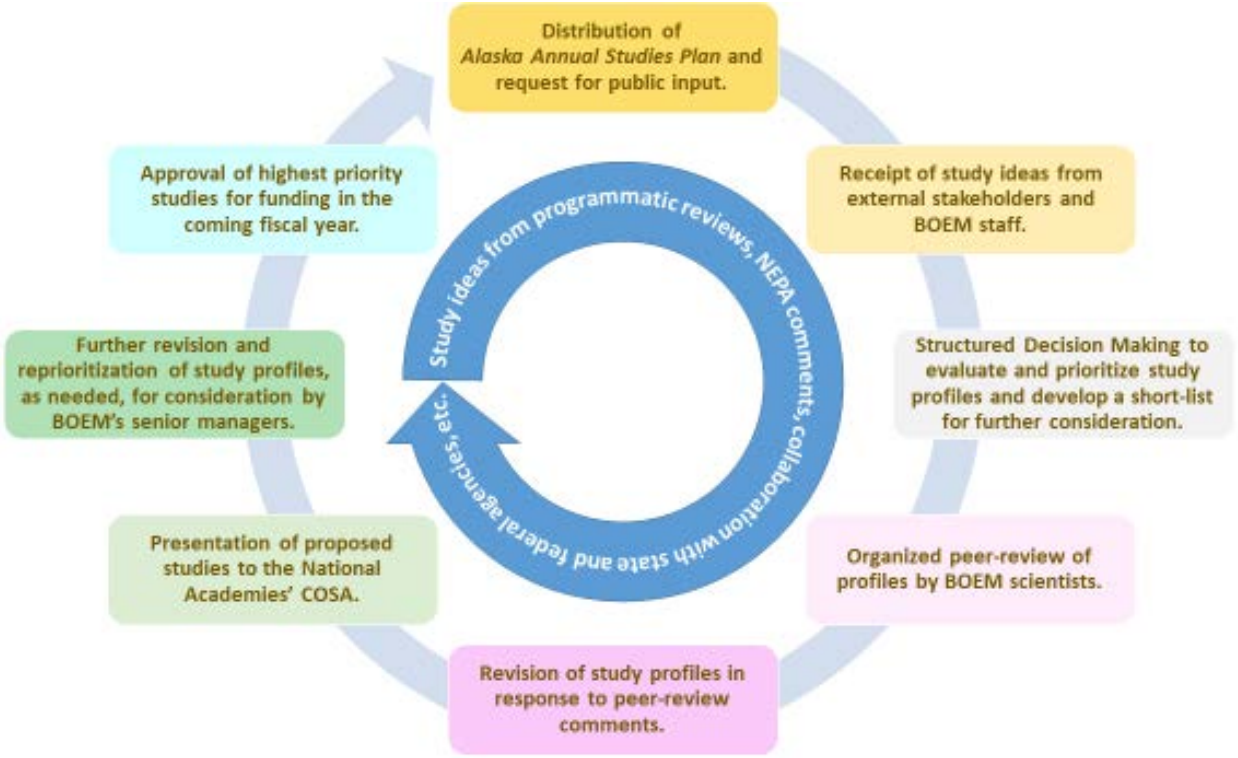

Figure 2. The Alaska Office's Annual Studies Planning Cycle begins in autumn with the distribution of the Alaska Annual Studies Plan and call for input. Additional ideas for new research derive throughout the year from programmatic reviews and analyses.

More than 70 individual study suggestions are received from external stakeholders and BOEM staff each year, with additional ideas for new research developed from programmatic reviews and analyses, such as those coming from the National Academy of Sciences, the Interagency Ocean Policy Task Force, and the Arctic Council; public

hearings; input from working groups and advisory panels such as the North Slope Science Initiative (NSSI); and correspondence from agencies such as the National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), and the State of Alaska related to interagency consultations under ESA and other processes.

The ESP takes a structured decision-making approach to prioritizing study ideas for funding consideration. Each submitted study idea is carefully evaluated by BOEM subject-matter experts based on the following seven criteria, which are detailed in the ESP's *Studies Development Plan 2020-2022* (USDOI, BOEM, ESP 2019):

1. Need for the information in BOEM decision-making
2. Contribution to existing knowledge
3. Research concept, design, and methodology
4. Cost-effectiveness
5. Leveraging of funds
6. Partnerships and collaboration
7. Multi-regional and strategic utility

From this evaluation, a short-list of high priority study profiles is identified for further consideration. The proposed profiles undergo an organized process of peer-review by scientists throughout the Bureau to evaluate the priority and quality of each proposed study, including providing feedback on technical aspects of proposed study methods. The proposed studies are then presented to the Committee on Offshore Science and Assessment (COSA) of the National Academies of Sciences, Engineering, and Medicine for additional input. The profiles are again revised and reprioritized as needed, and finalized during summer for consideration by senior managers at the regional and national levels, and ultimately funding allocation in the new fiscal year. The ASP is then published and circulated to the public in autumn, when the cycle starts all over again.

When conducting research projects, the ESP in Alaska coordinates routinely with numerous Federal entities, including: the National Oceanic and Atmospheric Administration (NOAA) and NMFS-Alaska Fisheries Science Center; NOAA's Marine Mammal Laboratory (MML); the National Weather Service (NWS); U.S. Geological Survey (USGS)-Alaska Science Center; USFWS; National Park Service (NPS); Office of Naval Research (ONR); the National Oceanographic Partnership Program (NOPP); the U.S. Integrated Ocean Observing System (IOOS); the National Aeronautics and Space Administration (NASA); National Science Foundation (NSF); U.S. Arctic Research Commission (USARC); the Polar Research Board; and NSSI. The ESP also coordinates closely with active industry research and monitoring programs in Alaska conducted by Hilcorp, ConocoPhillips, and others.

In addition, the ESP works directly on specific projects with AOOS; the North Pacific Research Board (NPRB); Alaska Department of Fish and Game (ADF&G); the North Slope Borough (NSB) Department of Wildlife Management (DWM); the Alaska Eskimo Whaling Commission (AEWC); the Alaska Native Tribal Health Consortium (ANTHC);

the Cook Inlet Regional Citizens Advisory Council (CIRCAC); and academic institutions including the University of Alaska Anchorage (UAA), University of Alaska Fairbanks (UAF), Woods Hole Oceanographic Institution (WHOI), University of Washington (UW), and University of Texas (UT).

BOEM strives to incorporate local and traditional knowledge of Alaska Natives, Alaskan residents, and the permanent participants of the Arctic Council in its decision-making processes (Kendall et al. 2017; Brooks et al. 2019). The ESP considers and integrates local and traditional knowledge at all stages, beginning with the study development process through the preparation of study products and interpretation of results. In field-oriented studies sponsored by the ESP, researchers typically coordinate directly with local communities to discuss their plans, seek advice and ensure that interested individuals learn about the project and its results. The process of integrating local and traditional knowledge and community-based monitoring varies from project to project, but the outcome of better information for decision-making is a common goal.

The University of Alaska Coastal Marine Institute (CMI), a cooperative arrangement created in 1993, allows the ESP to tap the scientific expertise of regional and local experts to collect and disseminate environmental information about coastal topics associated with the development of energy resources in the Alaska OCS. Through the CMI, the ESP stimulates important studies with a budget of up to $1,000,000 and a cost-saving dollar-for-dollar match arrangement. In its first 25 years, the CMI has funded approximately 110 studies and leveraged over $20 million of agency funds into $40 million of relevant marine-based research, with non-Federal matching funds from more than 50 different organizations. During that time, the CMI program has also provided more than 200 years of student training and nearly $2.5 million in student support. More information about the CMI can be found at http://www.cfos.uaf.edu/cmi.

The ESP also conducts cooperative research with universities through the Cooperative Ecosystem Studies Units (CESUs). The CESUs are working partnerships among leading academic institutions, Federal, State, and non-governmental organizations. A national network of seventeen CESUs has been established to facilitate collaboration through the working partnerships to provide high quality research, education and technical assistance for stewardship of cultural and natural resources. BOEM currently participates in seven CESUs that encompass the State of Alaska, the Pacific Northwest, California, Hawaii and the Pacific Islands, the North Atlantic Coast, the South Atlantic Coast, and the Gulf of Mexico.

Additional linkages have been established at an international level with other arctic nations' research and regulatory entities. The ESP in Alaska coordinates with Arctic Council activities, such as the Arctic Monitoring and Assessment Programme, Conservation of Arctic Flora and Fauna, Protection of the Arctic Marine Environment, and other working groups. The ESP provides information to these working groups through review of reports and plans, such as the Arctic Climate Impact Assessment, and helps to inform participants of available information sponsored by BOEM. Further, the ESP identifies and facilitates specific studies that can coordinate and integrate with working group activities.

1.2 Issues To Be Addressed

BOEM's research mandate under OCSLA is fundamentally to assess and understand how the Bureau's decision-making impacts the environment, including the human environment, and how those impacts can be avoided or minimized. To achieve this mandate, the ESP seeks to develop science that addresses the following strategic questions:

- How can BOEM best assess cumulative effects within the framework of environmental assessments?
- What are the acute and chronic effects of sound from BOEM-regulated activities on marine species and their environment?
- What are the acute and chronic effects of exposure to hydrocarbons or other chemicals on coastal and marine species and ecosystems?
- What is the effect of habitat or landscape alteration from BOEM-regulated activities on ecological and cultural resources?
- What are the air emissions impacts of BOEM-regulated activities to the human, coastal, and marine environment and compliance with the National Ambient Air Quality Standards (NAAQS) and Prevention of Significant Deterioration (PSD) increments?
- How will future ocean conditions and dynamics amplify or mask effects of BOEM-regulated OCS activities?
- How does BOEM ensure the adequate study and integrated use of social sciences in assessing the impacts of OCS activities on the human environment?
- How can BOEM better use existing or emerging technology to achieve more effective or efficient scientific results?
- What are the best resources, measures, and systems for long-term monitoring?

Due to the great differences that exist between Alaskan environments and those in other OCS Regions, the ESP in Alaska must remain especially flexible in planning and implementing needed studies. To be responsive to current and future OCS activities and changing technologies, the Alaska Office continually proposes new studies and pursues information needs in conjunction with ESP goals. Additional questions that must be considered in Alaska include:

- What role will ocean currents and sea ice play in distribution of anthropogenic pollutants near exploration and development prospects?
- How are ocean currents and biota affected by reduced sea ice conditions?
- How do cold temperatures and presence of sea ice alter the fate of spilled oil?

In addition to the physical and biological shifts, environmental change also entrains many socioeconomic issues. Some immediate concerns include: increased shoreline erosion and permafrost melt that threatens Arctic communities and infrastructure; changes in

distribution and availability of hunted subsistence species; and potential changes in commercial and subsistence fisheries as commercial species such as salmon move north. In consideration of such basic transition, scientists are challenged to project how the changing environment will interact with OCS activities over the next 25–50 years.

Because the people of Alaska's remote arctic and subarctic communities rely so heavily on subsistence resources of the marine environment, they are especially concerned about industrial activities that may directly or indirectly affect hunting success or the habitats of the species important to subsistence. The people of Cook Inlet also have concerns about potential effects of OCS activities on subsistence, commercial fishing, sport fishing, and tourism. Many other related issues potentially could be affected by OCS activities, such as the well-being of marine mammals and threatened and endangered species. Coastal residents of Alaska have concerns about these resources, as do State and Federal agencies responsible for their management by law.

1.3 Projected OCS Activities

The *Alaska Annual Studies Plan* reflects consideration of the many changes occurring in Alaska, as well as anticipated needs for the future. In a frontier region such as the Arctic, additional planning lead-time is necessary to conduct adequate environmental studies. Specific challenges include: large and remote planning areas, diverse and extreme environmental conditions, still-evolving hydrocarbon extraction technology, and potential environmental hazards associated with OCS activities.

Considerations at the Lease Sale Stage

Preparation of an environmental document based on the best available information, pursuant to NEPA, is an essential part of the lease sale process and ensures that decisions on whether to make areas of the OCS available for leasing are based on consideration of potential environmental impacts. Although much relevant information exists for some Alaska OCS planning areas, data related to certain topics are sparse in some areas and environmental and other conditions are changing over time. Updating past studies to address current information needs and changing conditions can substantially improve the quality of the information upon which our environmental analyses are based and help facilitate informed leasing decisions.

In 2016, BOEM released the *Proposed Final OCS Oil & Gas Leasing Program 2017–2022* (USDOI, BOEM 2016b), which includes a lease sale in the Cook Inlet Planning Area in 2021. However, as directed in Executive Order 13795 (April 28, 2017) and DOI Secretary's Order 3350 (May 1, 2017), BOEM began developing a new National OCS Program for 2019–2024 to replace the 2017–2022 Program. The *National Outer Continental Shelf Oil and Gas Leasing Draft Proposed Program* (USDOI, BOEM 2018), released on January 4, 2018, proposes 19 lease sales for Alaska OCS planning areas: three sales in the Beaufort Sea in 2019, 2021, and 2023; three sales in the Chukchi Sea in 2020, 2022, and 2024; two sales in Cook Inlet in 2021 and 2023; and one sale in each of the other Alaska OCS Planning Areas, except the North Aleutian Basin, in 2023. Further development of the *National Program* is currently paused.

Considerations at the Exploration and Development and Production Stages

In accordance with mandates of Section 20 of the OCSLA (43 U.S. C. 1346), the need for studies providing information to support environmental review and decision-making continues into the post-lease period. The ESP acquires additional information for environmental analyses related to exploration and development and production. Many of the studies at this stage are more closely related to proposed exploration and development schedules and related monitoring needs to supplement the broader studies that are the focus of the pre-lease stage. In addition to the requirements of OCSLA, BOEM has jurisdiction to regulate air emissions associated with oil and gas activities on portions of the Alaska OCS adjacent to the North Slope Borough.

A total of 2,365 leases have been issued in 26 OCS lease sales in Alaska, including 929 tracts leased in ten OCS lease sales in the Beaufort Sea Planning Area. Industry has drilled a total of 85 exploratory wells in seven planning areas, including 30 wells in the Beaufort Sea and six wells in the Chukchi Sea. As of November 2019, there are 40 active leases in the Beaufort Sea Federal offshore area (Figure 3) and 14 active leases in Cook Inlet (Figure 4). There are no active leases from previous lease sales in the Chukchi Sea, Bering Sea, or Gulf of Alaska subregions.

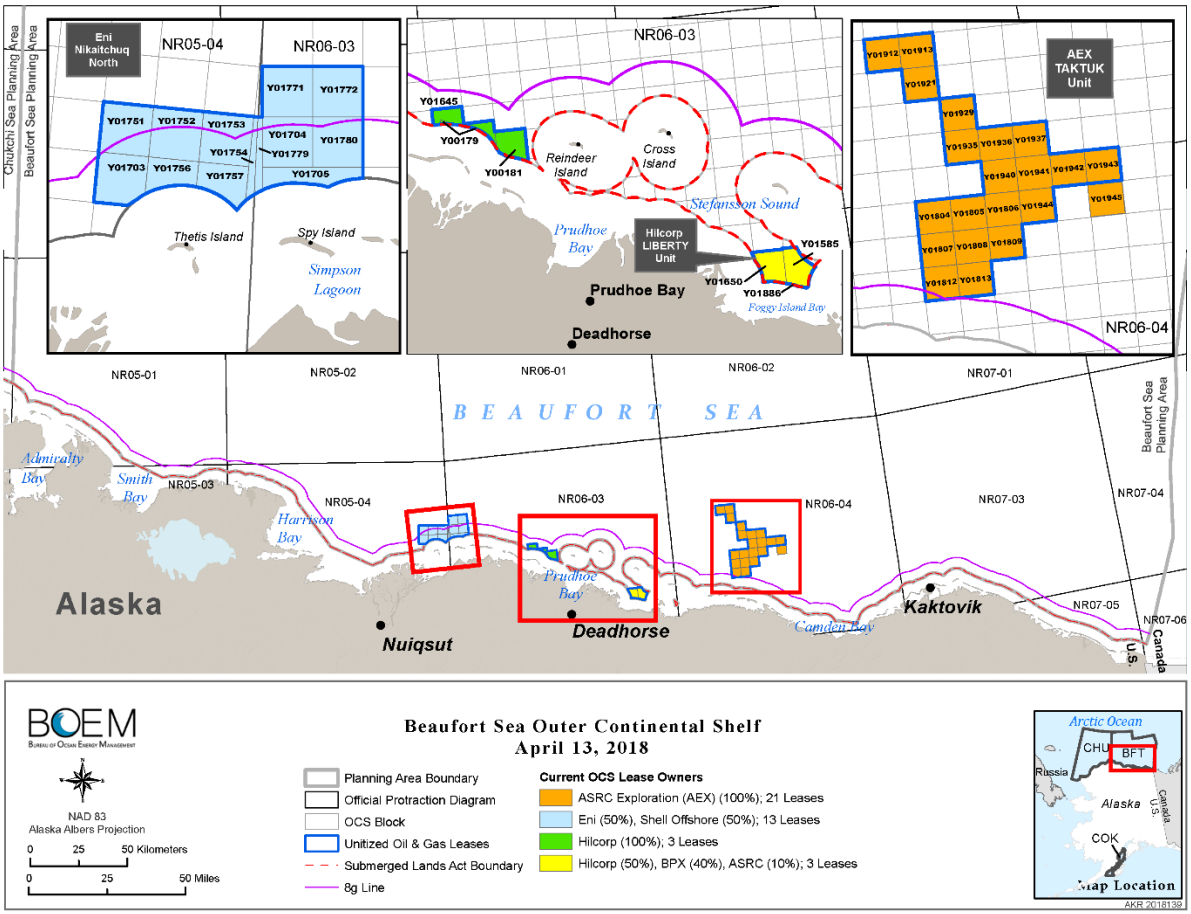

Figure 3. Beaufort Sea OCS Leases

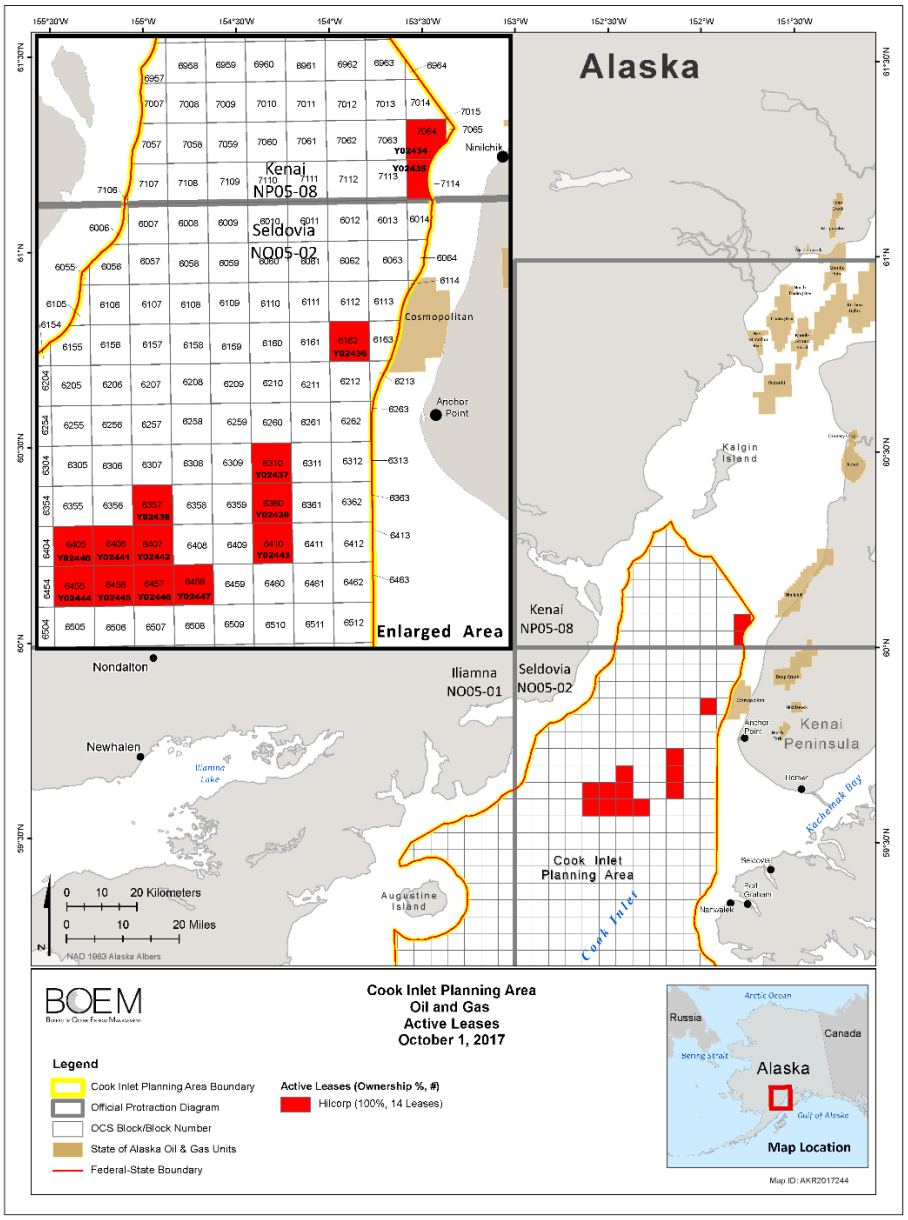

Figure 4. Cook Inlet OCS Leases

Data related to these oil and gas activities are sparse. However, environmental analyses for the U.S. Arctic are informed by activity at ten production units located in nearshore State waters along the Beaufort Sea coast, including the Oooguruk, Nikaitchuq, Prudhoe Bay, and Duck Island units, as well as production of natural gas condensate at the high-pressure Point Thomson reservoir since April 2016, and recent oil production within the National Petroleum Reserve-Alaska at the CD-5 site in the Alpine field.

Production:
Northstar – Northstar is a joint Federal/State of Alaska unit located in state waters in the Beaufort Sea about 12 miles northwest of Prudhoe Bay (see Figure 5). The six producing Federal wells fall under Bureau of Safety and Environmental Enforcement (BSEE) regulatory authority, the State wells fall under the State's oversight. Production started in 2001 and peaked in 2004. Total production of crude oil through September 2019 is more than 175 million barrels, with the Federal portion comprising more than 30.6 million barrels.

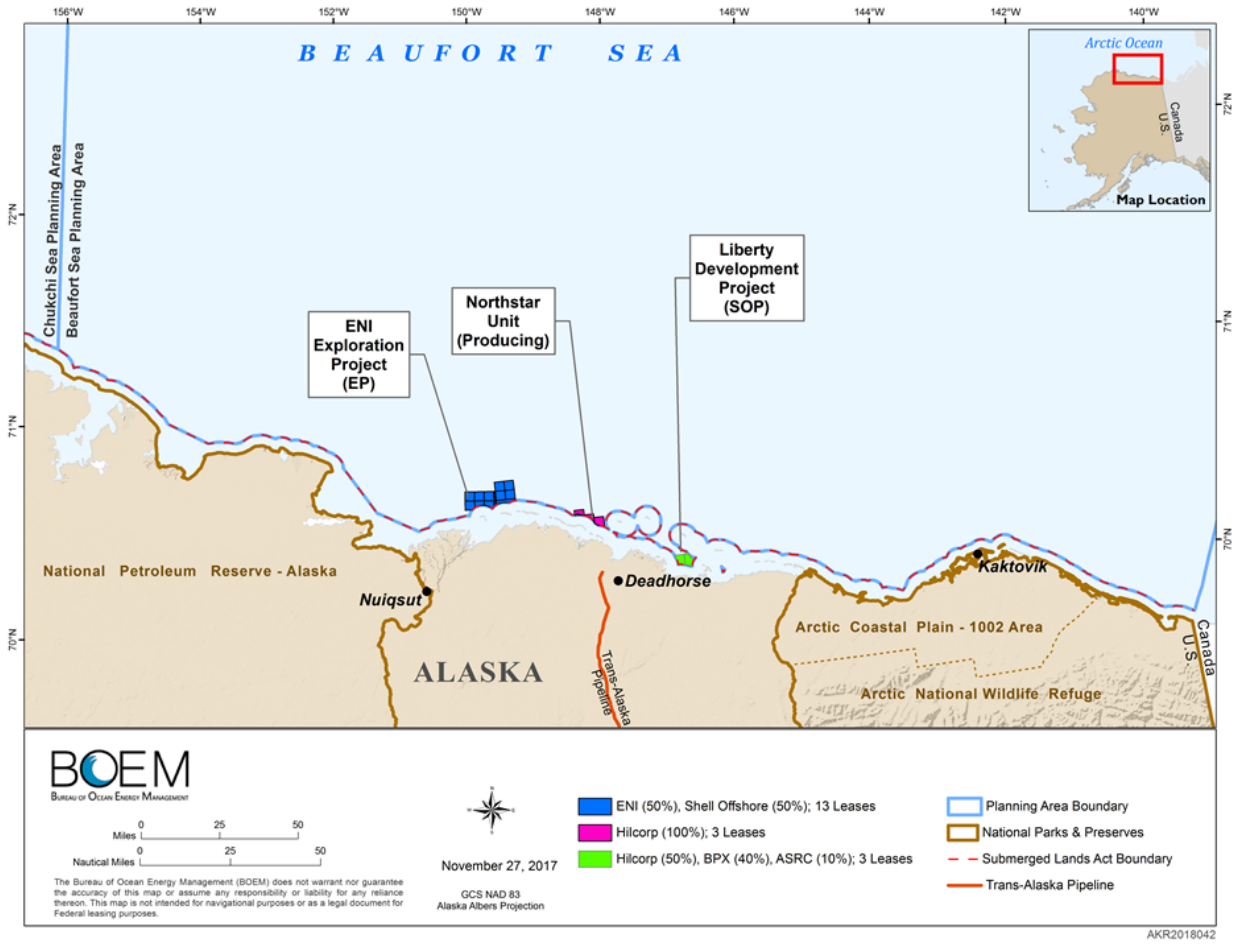

Figure 5. Location of Northstar, Liberty, and ENI project areas in the Beaufort Sea

Development:
Liberty – The Liberty prospect is located in the central Beaufort Sea, to the east of the existing Endicott Satellite Drilling Island (see Figure 5). In November 2014, primary ownership and operatorship of Liberty was acquired by Hilcorp Alaska LLC. Hilcorp submitted a DPP for the Liberty Unit, which is estimated to contain up to 150 million barrels of recoverable crude oil. In their DPP (Hilcorp 2015), Hilcorp proposes construction of a Liberty Drilling and Production Island, which will be built of reinforced gravel in 19 feet of water about 5 miles offshore in Foggy Island Bay. Process facilities on the island will separate crude oil from produced water and gas, which will be

injected into the reservoir to provide pressure support and increase recovery from the field. A single-phase subsea pipe-in-pipe pipeline will transport sales-quality crude to shore, where an above-ground pipeline will transport crude to the existing Badami pipeline and into the Trans-Alaska Pipeline System. BOEM conditionally approved the Liberty Project Development and Production Plan on October 24, 2018.

Exploration:
Harrison Bay – On July 12, 2017, BOEM conditionally approved an Exploration Plan (EP) submitted by Eni US Operating Company, Inc. proposing to conduct drilling into leased OCS areas from an existing gravel island located in State waters (see Figure 5). BOEM approved a revision of Eni's EP on April 13, 2018.

1.4 Identification of Information Needs

BOEM has an ongoing need for updated information about the physical and biological environment in Alaska to support NEPA analysis for future lease sales, EPs, or DPPs on the OCS. Questions to be addressed include the characteristics of major oceanographic and meteorological processes and how they influence the human, marine, and coastal environments. In recent years, BOEM has placed primary emphasis on studying the Beaufort Sea, Chukchi Sea and Cook Inlet Planning Areas, conducting interim baseline research and monitoring for trends in diverse fields of interest. Most of the projects have exhibited complex, multilateral collaborations, with explicit inter-disciplinary linkages between the physical and biological sciences. Many of them also provide a role for active participation by Alaska Native residents and input from sources of traditional knowledge.

In consideration of the wide-ranging environmental changes observed throughout Alaska in recent years, as well as the areas included in the *Draft Proposed Program*, the Studies Program is looking to broaden its geographic focus to consider studies across the OCS in Alaska. The wide range of environmental conditions from the Gulf of Alaska and Cook Inlet to the Bering Sea and the Arctic is, of course, an important consideration during the process of formulating new studies. However, these vastly diverse areas share many of the same information needs, such as the need for assessment of variability and long-term trends in oceanographic conditions and biological communities. For example, a better understanding of trophic and community structure in nearshore habitats is needed to support evaluation of resiliency of fish and invertebrate populations under changing environmental conditions.

Residents of Beaufort Sea coastal communities have expressed concerns about long-term effects of OCS activities, particularly changes to currents and sedimentation rates and potential effects on social systems, including subsistence whaling activities, in the vicinity of Northstar and Liberty. The need for information about Arctic cod is particularly acute, including description of essential fish habitat and details about timing and location of spawning. Additional information also is needed about recent changes in landfast ice and under ice circulation, and improved tools are needed to help assess the effects on marine mammals of anthropogenic activities, including increased

noise and vessel traffic through the Chukchi and Beaufort seas in support of oil and gas exploration and development activities.

The fundamental issues in the Chukchi Sea are very similar to those in the Beaufort Sea, although many species that regularly appear within the Chukchi Sea are not typically found in the Beaufort Sea. Projects in these areas typically pursue multi-year data collection efforts on a regional scale, with careful attention to inter-annual variability and ecosystem processes. Most of the studies exhibit complex, multilateral collaborations, with explicit inter-disciplinary linkages between the physical and biological sciences, and many of them also provide a role for active participation by Alaska Native residents and input from sources of traditional knowledge.

In Cook Inlet, some particular interests for information include, but are not limited to: an improved understanding of distribution and geographic range of the endangered Cook Inlet beluga whale stock; assessment of variability and long-term trends in oceanographic conditions and biological communities, including the presence and distribution of the critically endangered North Pacific right whale; and obtaining further baseline information about potential impacts from oil and gas-related activities to the economy and subsistence use of lower Cook Inlet.

Specific Information Needs by Discipline

Interdependent Physical, Biological and Social Processes: The Alaska Office has a long history of supporting multidisciplinary research, beginning with the "Outer Continental Shelf Environmental Assessment Program" (OCSEAP) surveys conducted between the 1970s and early 1990s and the "Beaufort Sea Monitoring Program" (BSMP) in the 1980s. The "Arctic Nearshore Impact Monitoring in the Development Area" (ANIMIDA) program and its continuation (cANIMIDA) began in 1999 to provide baseline data and monitoring results for trace metal and other chemical contamination, turbidity, and subsistence whaling in the vicinity of Northstar and Liberty development sites. The second follow-on project (ANIMIDA III) continued this monitoring and was expanded to include Camden Bay. Similarly, the multiple components of the "Chukchi Sea Oceanographic Monitoring in the Drilling Area" (COMIDA) program, which evolved from a planning workshop in November 2006, represent an ecosystem-based approach for providing baseline data and tracking environmental changes across the Chukchi Sea, with particular focus on the highly productive area around Hanna Shoal.

In addition to the ongoing need for integrated research programs like ANIMIDA and COMIDA, there is also a need for synthesis of results from multiple studies and analyses to facilitate interpretation of data across disciplines. The study "Comprehensive Synthesis of Impacts to Marine Mammals from Oil and Gas Activities in the Alaska Outer Continental Shelf (OCS), 2000–2020," planned for FY 2020, seeks to integrate information about the potential effects of oil and gas exploration and development and production activities on marine mammals in Alaska. This study will synthesize the relevant environmental analyses and reports to provide an enhanced understanding of how effects of oil and gas development relate to the overall impact of anthropogenic activities in Alaska. A number of ongoing studies also take an integrated approach to

examining the interdependence of physical, biological and social processes and filling identified information needs across the various disciplines.

Ocean Circulation and Sea Ice: Accurate information on surface wind fields, ocean currents, and sea ice is important for determining the fate of spilled oil and the potential impacts on biota in the area. It is particularly important to know locations and seasonal changes in the distribution of polynyas, leads, and landfast ice, as well as the motion of the seasonal ice pack. Studies conducted by the Alaska Office have demonstrated that water motion is very different under landfast ice than in adjoining open or pack-ice areas. Information about ice gouge characteristics and recurrence rates also supports assessments of risks associated with burial of oil production pipelines to support BOEM's fault tree modeling.

Air Quality: The transfer to BOEM of authority to regulate emissions from oil and gas activities in OCS areas adjacent to the North Slope Borough of Alaska necessitates increased focus on Arctic OCS air quality considerations. Arctic oil and gas exploration and extraction activities proposed for the OCS require environmental evaluations pursuant to NEPA, as well as air quality operating approval, to comply with the impact analysis under BOEM's implementation of the OCSLA.

Pollutants: The environmental effects of oil and gas development on biota, including effects from potential oil spills, is a concern for residents of coastal communities in Alaska. Up-to-date information on ocean currents and sea ice and how they affect the motion of spilled oil is necessary to fully address these concerns. North Slope residents are especially concerned about potential contamination of their food supply. In the Beaufort Sea such foods include bowhead whales, seals, waterfowl and fish.

Information on Marine Mammals and Other Wildlife: Information is needed across Alaska about the current spatial and temporal use patterns on the OCS of sensitive species including cetaceans, sea otters, pinnipeds, and seabirds. BOEM is currently collaborating with NOAA Fisheries to identify the winter range of the critically endangered Cook Inlet beluga whale population. In the Arctic, BOEM has an ongoing need for information about the populations of bowhead whales, polar bears, spectacled eiders, spotted and ringed seals, walruses and other arctic species. Potential effects from loss of sea ice are a particular concern, especially for those species listed as threatened or endangered. More comprehensive abundance estimates for these ice-associated marine mammals enhance the assessment of potential impacts under NEPA and assist NOAA and USFWS in ensuring compliance with Federal management and regulatory mandates for marine mammals under the MMPA.

A particular information need is the effect of noise on the well-being and the behavior of bowhead whales. The bowhead whale is central to Alaska Native cultural and spiritual life and the Iñupiat rely heavily on bowhead whales for subsistence. Whale hunters have reported that migrating bowhead whales deflect from their normal migratory route well upstream of active industry vessels and may divert a great distance from their migration route, making them potentially more difficult to hunt. It is also important to assess the factors that may be affecting the habitat use, health, population status and migration routes of bowhead whales and the potential cumulative impacts from multiple factors

(e.g. noise from industry activities combined with environmental change) on the whales. Furthermore, North Slope residents are also concerned about potential disturbance of beluga whales, bearded seals, waterfowl and other subsistence-wildlife species by oil and gas activities such as helicopter overflights.

Fish and Lower Trophic Communities: Fishes fill an essential role in the ecosystem by consuming small prey and in turn providing a food resource for larger fishes, birds, marine mammals, and people. It is important to assess the distribution and abundance of fishes in the waters off Alaska and to distinguish between changes due to anthropogenic and natural effects. In addition, assemblages and populations of fish and benthic organisms in marine ecosystems off Alaska have undergone observable regime-shifts in diversity and abundance over the last 20-30 years.

The Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) governs U.S. marine fisheries management for all OCS waters. Under the Magnuson-Stevens Act, each fishery management plan must describe and identify Essential Fish Habitat (EFH) for the fishery, minimize to the extent practicable the adverse effects of fishing on EFH, and identify other actions to encourage the conservation and enhancement of EFH. BOEM engages in consultation with NMFS regarding any action that may adversely affect EFH, conferring on EFH assessment related to adult and late juvenile life-stages of a number of species, including Arctic cod, Pacific salmon, and saffron cod.

Alaska Native Culture: The Iñupiat report in public testimony that their culture is vulnerable to short-term, long-term and cumulative effects from OCS activities. They are concerned that OCS activities might lead to:

- Social disruption and a change in cultural values through population shifts (immigration of large numbers of non-Iñupiat to the North Slope)
- Impacts to community health
- Cumulative effects of multiple industrial activities, alteration of subsistence-harvest patterns, and displacement of hunters and subsistence resources

There is an ongoing need to monitor key indicators of socioeconomic and cultural changes on the North Slope. The Iñupiat rely on a wide variety of marine resources as significant sources of food. In addition, the harvesting, sharing and consuming of subsistence resources form an important part of the traditional Iñupiaq culture and spiritual life. A temporary or permanent elimination of primary subsistence foods could cause large numbers of North Slope residents either to shift to less desired subsistence resources or to replace subsistence foods with expensive store-bought foods. The Iñupiat are concerned about mitigation of impacts and compensation for potential losses, though an anticipated decline in oil revenues to the NSB is also an issue of concern. Another key interest is the use of local and traditional knowledge in analysis of potential environmental effects. We continue to seek and include firsthand knowledge of local subsistence hunters to enhance the scientific knowledge base.

Archaeological Resources: The archaeological significance of offshore areas has been recognized in recent years and marine archaeological studies have been showing the presence of prehistoric sites on the shelves beneath the modern ocean. Basic information and analysis is needed for assessments of archaeology potential in the Beaufort and Chukchi seas to support the National Historic Preservation Act and NEPA review.

1.5 Notable Programmatic Highlights

IARPC support: As an active participant of the Inter-agency Arctic Research Policy Committee (IARPC), the BOEM Environmental Studies Program has played a lead role in implementing national research priorities in the Arctic. Appendix 1 provides a table that displays the substantial progress that BOEM has made in recent years toward fulfilling itemized IARPC research priorities while meeting its own regulatory mission.

Collaboration with the North Pacific Research Board (NPRB): Since 2015, BOEM has collaborated with NPRB as a co-sponsor of the "Arctic Integrated Ecosystem Research Program," which is investing more than $16 million in studying marine processes in the U.S. Arctic through 2021. The study "Arctic Integrated Ecosystem Survey, Phase II" is a key component of this program. In addition, BOEM regularly co-sponsors with NPRB the annual Alaska Marine Science Symposium to allow our Principal Investigators to brief the scientific community about results from ongoing research.

Renewable Energy Research: In partnership with UAF, BOEM is assisting the State of Alaska in its effort to assess the feasibility and potential environmental effects of a wave energy converter project off Yakutat in the Gulf of Alaska. The "Alaska Wave Energy Converter Impact Assessment" study is collecting data to improve scientific understanding of seabed dynamics, ambient underwater noise, and fish and marine mammal presence and habitat requirements in the project area. A key goal of the project is to evaluate implications of findings from the Yakutat Wave Energy Project to inform feasibility studies in other coastal regions of Alaska, including extensions onto the OCS.

Recent Reports and Publications: The ESP in Alaska has published more approximately 70 OCS Study reports (Appendix 2) in the past five years that address a broad range of topics, including:

- Arctic Ecosystem Integrated Survey on Distribution of Fish, Crab, and Lower Trophic Communities in the Northeastern Bering Sea and Chukchi Sea
- Satellite-tracked Drifter Measurements in the Chukchi and Beaufort Seas
- Coastal Community Vulnerability Index and Visualizations of Change in Cook Inlet, Alaska
- Migration Trends for King and Common Eiders and Yellow-billed Loons past Point Barrow in a Rapidly Changing Environment
- Arctic Air Quality Impact Assessment Modeling Study

- Physical and Chemical Analyses of Crude and Refined Oils: Laboratory and Mesoscale Oil Weathering

During this same period, studies in Alaska generated over 250 peer review journal publications (Appendix 3). These publications include four special journal issues derived from three projects:

Synthesis of Arctic Research (SOAR): This study conducted a synthesis of multidisciplinary marine science information in the northern Bering, Chukchi and Beaufort Seas from recent and ongoing research conducted by BOEM, as well as other Federal and State agencies and industry. In addition to two OCS Study reports (BOEM 2012-031 and BOEM 2018-017), the SOAR project produced two special journal issues:

Moore, S. E. and P. J. Stabeno (editors). 2015. *Synthesis of Arctic Research (SOAR)*. Progress in Oceanography. 136:1-274.

Moore, S. E., P. J. Stabeno, and T. I. Van Pelt (editors). 2018. *Synthesis of Arctic Research SOAR Phase II*. Deep Sea Research Part II: Topical Studies in Oceanography. 152:1-214.

Arctic Ecosystem Integrated Survey: This partnership with NOAA and UAF documented and characterized the distribution of pelagic and demersal fish and invertebrate communities in the Chukchi Sea. The study included field surveys to obtain baseline data on the structure and function of the Chukchi ecosystem and the ecology of important fish species in the region. Products from this study include an OCS Study report (BOEM 2017-077) and an issue of Deep Sea Research Part II:

Mueter, F. J., J. Weems, E. V. Farley, M. F. Sigler (editors). 2017. *Arctic Ecosystem Integrated Survey (Arctic Eis): Marine ecosystem dynamics in the rapidly changing Pacific Arctic Gateway*. Deep Sea Research Part II: Topical Studies in Oceanography. 135:1-190.

Hanna Shoal Ecosystem Study: This study built on the ecological monitoring of the COMIDA-Chemistry and Benthos (CAB) study with a specific focus on the area of Hanna Shoal. The study documented the circulation and density fields, as well as ice conditions, at Hanna Shoal and examined important chemical, physical and biological interactions with the unique ecological regime in this highly productive area. Products include an OCS Study report (BOEM 2016-047) and an issue of Deep Sea Research Part II:

Dunton, K., J. Grebmeier, and J. Trefry (editors). 2017. *The Hanna Shoal Ecosystem Study of the Northeastern Chukchi Sea*. Deep Sea Research Part II: Topical Studies in Oceanography. 144:1-190.

The precursor to the *Hanna Shoal Ecosystem Study*, called *Chukchi Sea Offshore Monitoring in Drilling Area: Chemistry and Benthos* (BOEM 2012-012), also produced an issue of Deep Sea Research Part II:

Dunton, K. H., J. M. Grebmeier, and J. H. Trefry (editors). 2014. *The Northern Chukchi Sea Benthic Ecosystem: Characterization, Biogeochemistry, and Trophic*

Linkages. Deep Sea Research Part II: Topical Studies in Oceanography. 102:1-164.

SECTION 2.0 STUDY PROFILES

Up-to-date information about planned new studies, as well as ongoing projects, can be found at: http://www.boem.gov/AKstudies

This information is updated three times each year and includes:

- An updated status of each study.
- Report due dates.
- Related publications.
- Affiliated websites.

Reports from completed ESP Studies can be found at: http://www.boem.gov/ESPIS/ and http://www.boem.gov/AKpubs.

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2.1 Profiles of Planned New Studies

Table 1. BOEM Anchorage, Alaska Office Studies Planned for FY 2020*

Page Number	Discipline	Study Title
21	BIO	Monitoring the Recovery of Seabirds and Forage Fish Following a Major Ecosystem Disruption in Lower Cook Inlet (LCI)
23	MM	Cook Inlet Beluga Acoustic Monitoring in Lower Cook Inlet (LCI) Rivers
25	ID	Alaska Marine Science Symposium
27	PO	Update of River Overflood On Sea Ice and Strudel Scour Database
29	MM	Quantifying Sea Otter Abundance, Distribution, and Foraging Intake in Cook Inlet Alaska, using Unmanned Aircraft Systems (UAS) Technology
31	FE	Improvements to the Oil Spill Risk Analysis (OSRA) Input Quality Assurance/Quality Control (QA/QC) and Validation
33	SSE	Subsistence Harvest and Iñupiaq Knowledge of Beluga Whales for Kaktovik, Alaska
35	BIO	Early Detection Plan for Marine Non-Native Species on the Arctic Outer Continental Shelf (OCS)
39	MM	Comprehensive Synthesis of Impacts to Marine Mammals from Oil and Gas Activities in the Alaska Outer Continental Shelf (OCS), 2000–2020
41	BIO	The Impact of Marine Fish Communities on Red-throated Loon Productivity in the Beaufort Sea

Discipline Codes	
BIO = Biology	ID = Interdisciplinary & Information Management
FE = Fates & Effects	MM = Marine Mammals & Protected Species
PO = Physical Oceanography	SSE = Social Science & Economics

* Initiation and conduct of any of these planned studies is subject to availability of funds.

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Title	Monitoring the Recovery of Seabirds and Forage Fish Following a Major Ecosystem Disruption in Lower Cook Inlet (LCI)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	TBD
Conducting Organizations(s)	TBD
Total BOEM Cost	TBD
Performance Period	FY 2020–2023
Final Report Due	TBD
Date Revised	October 16, 2019
PICOC Summary	
Problem	Monitoring of forage fish and seabird populations during and following the North Pacific marine heat wave indicates the Gulf of Alaska (GOA) marine ecosystem is undergoing dramatic changes, including massive seabird die-offs, breeding failures, low at-sea density, and depleted prey resources.
Intervention	Continued monitoring of seabird and forage fish populations at sea including using emerging technology such as Unmanned Aircraft Systems (UAS) is important to understanding the natural variability of the ecosystem and determine the status of resources in areas of oil and gas development.
Comparison	Data will be compared to the same measures collected in previous years.
Outcome	This study will inform resource assessments and facilitate an understanding of ecosystem resilience to development.
Context	Lower Cook Inlet

BOEM Information Need(s): Monitoring of seabird populations and forage fish stocks in potential oil and gas lease areas is important to mitigate impacts of development and to assess the impact of potential oil spills and environmental change. Results from this study will support National Environmental Policy Act (NEPA) analyses for future oil and gas-related activities in Cook Inlet. The study will be especially useful for cumulative effects evaluation in the context of recent seabird die-offs in the GOA.

Background: The USGS has been monitoring seabirds and forage fish in LCI intermittently since 1995 (1995–2001, 2016–2018). Recently, a prolonged marine heat wave caused a major disruption in the GOA marine ecosystem. In 2015–2016, hundreds of thousands of common murres died from starvation, and seabirds failed to produce offspring at multiple colonies in the GOA, including several in LCI. Despite a return to normal water temperatures in 2017–2018 from the extremely high temperatures realized in 2014–2016, food webs still had not recovered in LCI by 2018. Forage fish were patchier and depleted, and densities of seabirds at sea were the lowest ever documented. Common murres failed to produce any young for at least the third year in

a row, population counts at colonies remain well below historic levels, and emaciated murres were commonly observed at colonies—a heretofore unknown phenomenon. Predator disturbances at colonies were also unusually frequent. To date, there are no obvious explanations for all these aberrant observations, but their occurrence makes clear the need to monitor recovery (or failure) of these populations with greater precision to facilitate a better understanding of the mechanisms of change.

Traditional survey methods often include the visual census of marine birds and mammals on transects at sea, co-spatial trawl and hydroacoustic surveys of forage fish, aerial assessments of fish schools, and concurrent measurements of seabird population trends and breeding biology at nearby colonies (Piatt 2002). However, vessel-based survey methods for assessing seabirds and forage fish are costly and time consuming. Advances in seabird and forage fish survey methods using innovative technology such as UAS may provide cost-efficient, precise, and accurate indices of population abundance compared to traditional vessel-based surveys. Incorporating UAS capabilities into existing sampling methods will enable BOEM to leverage ongoing studies through increased data collection, while allowing for comparisons of efficiency and cost with traditional methods.

Objectives: The objectives of this study are to:

- Assess seabird and forage fish status, trends, and ecology in LCI.
- Develop UAS survey protocols to monitor seabird and forage fish populations in LCI.

Methods: Researchers will follow protocols for monitoring forage fish and seabirds in LCI developed during the 1995–2001 colony surveys for BOEM, including at-sea surveys for forage fish (hydroacoustics, trawling, seining and associated oceanographic measurements) and concurrent measurements of seabird breeding biology (egg and chick production, chick growth, population status and trends) and foraging behavior (diets, feeding rates, foraging time). At-sea work will be conducted along fixed transects within 50 km of two colonies, Gull Island and Chisik Island.

Researchers will develop UAS protocols for monitoring seabirds and forage fish in offshore areas of LCI and Kachemak Bay. UAS data collection will be tested for efficiency, safety, and comparability to ongoing vessel-based work. For at-sea seabird density estimates from UAS, various transect widths and viewing angles will be tested with the purpose of maximizing sampling efficiency. Concurrent sampling of Black-legged Kittiwake and Common Murre colonies with still photography and a UAS will allow a direct comparison of accuracy and precision between the two methods.

Automated techniques and the latest imagery software will be used to classify fish school characteristics (shape, color, size, *etc.*), which will help to reduce observer bias and uncertainty in species composition and school size estimates as compared to earlier techniques. Innovative digital image processing techniques, such as “fluid-lensing” to provide clearer images under the water surface, will also be evaluated.

Specific Research Question(s):

1. What analyses are best for contrasting the functional responses of seabirds to prey fluctuations and changes in the environment within and between decades?
2. What sources will be used to quantify natural variability to evaluate possible future trends to distinguish these from potential direct human impacts of OCS oil and gas exploration and development or oil spills in Cook Inlet?
3. What tests will be used to identify the utility of UAS surveys to provide at-sea and colony-based census data for seabirds to augment and/or replace traditional protocols in the future?
4. How will imagery be collected using a UAS in conjunction with traditional fisheries sampling methods to assess the ability of UASs to provide species identification, count forage fish schools, and quantitatively measure fish school surface areas?

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Title	Cook Inlet Beluga Acoustic Monitoring in Lower Cook Inlet (LCI) Rivers
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	TBD
Conducting Organizations(s)	TBD
Total BOEM Cost	TBD
Performance Period	FY 2020–2022
Final Report Due	TBD
Date Revised	October 16, 2019
PICOC Summary	
Problem	Cook Inlet belugas (CIB) (*Delphinapterus leucas*) are an endangered and genetically distinct population in decline, with an estimated population size of only 328 whales in 2016. Although the reason for a lack of recovery is uncertain, one potential contributor is disturbance from anthropogenic noise, especially in critical foraging habitat such as river mouths.
Intervention	The year-round presence and habitat use of CIB in LCI near river mouths will be monitored for acoustically active whales, with a focus on quantifying feeding bouts. Changes in feeding activity or spatial displacement from feeding areas due to anthropogenic activities will be monitored.
Comparison	Study results will be evaluated in the context of recent and historical observations and assessments of CIB habitat use in LCI.
Outcome	Findings from this study would assist with formulating effective mitigation measures (*e.g.*, temporal, spatial) for oil and gas exploration and development activities in or near CIB critical habitat, to help in the recovery of the endangered population.
Context	Cook Inlet Planning Area

BOEM Information Need(s): BOEM needs information about the summer and winter range of CIB and how the range might overlap with areas of potential oil and gas activities. A better understanding of beluga movements, location and timing of important feeding areas, and characterization of the acoustic environment year-round will support BOEM's Oil Spill Risk Analysis, National Environmental Policy Act analyses, Endangered Species Act (ESA) Section 7 consultations, and development of mitigation measures related to future lease sales in Cook Inlet, as well as potential exploration and development on existing leases.

Background: The Distinct Population Segment of Cook Inlet beluga whales, which remains within Cook Inlet year-round, was listed as endangered under the ESA in 2008 following a major decline in abundance (~50%) in the 1990s associated with overhunting. Although hunting ended in 2000, the CIB population is not increasing, indicating that factors other than hunting currently impede recovery. The summer

range of CIBs now occurs mostly in the Upper Cook Inlet (UCI), north of Kalgin Island, however prior to 1980, belugas ranged south of Kalgin Island and into Kachemak Bay. Their winter range is largely unknown but limited satellite telemetry data showed use of deeper water habitats farther from shore. Research efforts in 2018 (BOEM/ National Marine Fisheries Service [NMFS] funded aerial surveys, NMFS supported citizen science efforts, NMFS/Sea Grant study) have demonstrated the presence of belugas through much of LCI, including along the coastline and in the rivers, as well as near or within the lease areas. Four belugas were also observed in Kachemak Bay for the first time in several years.

Historical accounts from Native hunters and local residents indicate that belugas have used river mouths such as the Kenai and Kasilof Rivers between April and November while feeding on anadromous fish species, notably eulachon and Pacific salmon. While little contemporary work has focused on these LCI rivers, the presence of CIB has been noted in these areas through passive acoustic monitoring and sightings.

Beluga whales are highly dependent on sound to communicate, navigate, and find prey. Understanding natural ambient noise levels will allow noise from anthropogenic sources to be evaluated and provide insight about whether noise is a factor in beluga habitat use.

Objectives:

- Acoustically determine the seasonal foraging occurrence of CIB in LCI rivers.
- Characterize the type and level of noise from anthropogenic activities that have the potential to disturb CIB in LCI, and quantify the overlap with CIB distribution.
- Develop a range-wise evaluation of noise levels (natural and anthropogenic), potential feeding areas, and other relevant attributes.
- Assess correlations of CIB occurrence with currents, tides, and physical characteristics.
- Summarize acoustics recorded for other marine mammals

Methods: Acoustic cetacean and porpoise detectors (C-PODs) will be deployed to monitor beluga presence and foraging at various river mouths, including the Kenai and Kasilof rivers. C-PODs "listen" continuously for over 200 days and can detect beluga echolocation up to 900 m away. CIB presence will be identified by detection of echolocation signals and results will be analyzed to build seasonal presence plots. Foraging will be identified by the unique echolocation signature emitted by odontocetes when chasing prey (click trains ending in buzzes). The Kenai River would be monitored year-round while NMFS will monitor UCI locations only during the open water season.

This project will also leverage NMFS's citizen science efforts to incorporate visual observations to provide a quantified measure of the level and type of anthropogenic activities in and around the river sections monitored acoustically. NMFS will also collaborate with the Beluga Whale Alliance and Alaska Wildlife Alliance to collect additional visual observation data at the several acoustically monitored river locations.

Helicopters or small planes may be needed to deploy C-PODs in difficult to access locations. This study can build upon previous experience acoustically monitoring river mouths in Cook Inlet (*e.g.*, Eagle River, Chickaloon River, and Little Susitna River).

Specific Research Question(s):

1. What rivers are used by CIB to feed and when?
2. Do CIB change behavior in the presence of anthropogenic activities and if so, is it due to certain levels or types of anthropogenic activities?
3. How do the acoustic data and visual data compare?

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Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	Alaska Marine Science Symposium
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	TBD
Conducting Organizations(s)	TBD
Total BOEM Cost	TBD
Performance Period	FY 2020–2024
Final Report Due	TBD
Date Revised	October 16, 2019
PICOC Summary	
Problem	There is a need to bring together marine scientists conducting research in Alaska to discuss their current research interests and provide an update on current scientific awareness of the ever changing Alaska ecosystem.
Intervention	Help fund the annual Alaska Marine Science Symposium by co-sponsoring the event.
Comparison	Without adequate funding the event cannot occur.
Outcome	A successful venue where marine scientists from government and non-government agencies, within Alaska and around the nation, share research and highlight future research needs. Many of the highlighted studies are from BOEM funded projects.
Context	Alaska Marine Environment and OCS

BOEM Information Need(s): This annual Symposium provides technical analysts and Principal Investigators for BOEM studies in Alaska a unique forum to share their research findings on the Alaska marine environment and to network with other scientists from around Alaska, the Pacific Northwest, and the nation. Because it is impossible for any single agency or group to conduct all of the needed research within the Alaska Office, this forum provides marine scientists with the opportunity to gather information on other areas of similar research and foster important future collaborative efforts.

Background: The Alaska Marine Science Symposium (AMSS) is the largest and most comprehensive annual marine science conference within the State of Alaska (http://www.alaskamarinescience.org/). The AMSS is unique since it brings together government and non-government sponsored marine scientists within the State of Alaska, from around the nation, and from other nations in a forum to discuss their common interests in the dynamic and ever changing Alaska marine ecosystem. The Symposium is organized into three large marine ecosystems of Alaska which includes the Arctic (U.S. Beaufort and Chukchi Seas), the Bering Sea, and the Gulf of Alaska. The presentations, poster sessions, and workshops showcase the ocean research within these areas. Daily sessions are focused on the main components of the marine ecosystem

including climate and oceanography, lower trophic level productivity, fish and fish habitat, seabirds, marine mammals, and human dimensions.

More than 800 people attended the most recent Symposium, and many organizations pitched in to make it a success. The BOEM project investigators attended the Symposium and provided important information on the Arctic and the Bering Sea from information collected under the Environmental Studies Program. The BOEM staff and sponsored scientists connected with other scientists that were conducting concurrent research in the Arctic, Bering Sea, Cook Inlet and Gulf of Alaska regions.

In the recently completed Symposium in 2019, there were separate workshops on a recently completed BOEM funded study, Characterization of the Circulation on the Continental Shelf Areas of the Northeastern Chukchi and Western Beaufort Seas, numerous updates of ongoing and nearly completed studies funded jointly through the Coastal Marine Institute at the University of Alaska, Fairbanks, discussions on marine mammals, fish, and bird distribution, and workshops on community involvement. In addition, there were other workshops on Arctic Research Planning and on communicating ocean science. The Symposium also encourages presentations on the Alaska marine environment from graduate students from local universities and from universities within the lower 48. The Symposium presents awards to the best student poster and oral presentation at the meeting.

Objectives

- Produce a successful Alaska Marine Science Symposium, which provides a forum for marine scientists and local communities to present their information on the changing marine environment in Alaska.
- Provide a venue for presenting BOEM Alaska Office environmental studies research for the Arctic, Bering Sea, Cook Inlet, and Gulf of Alaska
- Provide a forum for Alaska Office scientists and Principal Investigators to comingle with other researchers that are conducting similar scientific studies within the Alaska OCS or adjoining areas of the Alaska marine ecosystem.

Methods: As a member of the AMSS organizing committee with other scientists and officials from Federal and State agencies, assist in producing a forum for BOEM staff and marine and coastal scientists, and local communities to present their findings on the changing marine environment in Alaska. Provide monetary support for scientists from within the State of Alaska and from around the nation to present their findings at the meeting. Provide abstracts and workshop discussions from the Symposium to the general public for distribution.

Specific Research Question(s): What is the current research being conducted in the Alaska Marine environment and what are future research goals?

Title	Update of River Overflood on Sea Ice and Strudel Scour Database
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	TBD
Conducting Organizations(s)	TBD
Total BOEM Cost	TBD
Performance Period	FY 2020–2022
Final Report Due	TBD
Date Revised	October 16, 2019
PICOC Summary	
Problem	River overflood on the sea ice occurs annually in the nearshore region of the Alaskan Beaufort Sea during a brief period in the spring when river break-up precedes the break-up of the landfast sea ice. River overflood constitutes a potential hazard to offshore oil and gas development, as it relates to facilities access, oil spill spreading and response, and the associated phenomenon of strudel drainage and potential seabed scouring, which can increase the possibility of an oil spill.
Intervention	The Department of the Interior commissioned a study in 2007 (Outer Continental Shelf [OCS] Study MMS-2009-017; Hearon, *et al.*, 2009) designed to map the annual extent of peak river overflooding onto the landfast ice of the Alaskan Beaufort Sea during the 13-year period from 1995 and 2007. The proposed study will update the original by incorporating an additional 12 years of overflood observations, nearly doubling the existing database. In addition, the database of industry-based strudel scour measurements developed during the initial study will be updated to the extent industry is willing to grant access to the information acquired since 2007.
Comparison	The overall goal of this study is to improve the knowledge of the spatial and temporal variability in overflooding and related pipeline and facility siting concerns. The results will be used for environmental assessment and hazard mitigation for present and future oil and gas facilities that may be located within or adjacent to the areas influenced by the overflood.
Outcome	The project will produce a more comprehensive geographic information system (GIS)-based dataset of river overflood boundaries and strudel scour characteristics. The results will include a probabilistic assessment of annual overflood extent, and evaluation of potential changes in river overflood associated with climate change.
Context	Alaska Beaufort Sea nearshore coastal areas.

BOEM Information Need(s): BOEM requires an improved understanding of the spatial and temporal variability in overflooding to evaluate environmental impacts and hazards associated with 1) subsea pipelines traversing through the zone of river overflood from offshore federal leases and 2) ice roads used to access offshore federal leases. Furthermore, BOEM needs an understanding of the potential impacts of climate

change on the overflood phenomena. Because river overflooding marks the transition from winter to break-up, the study results will provide valuable information on the timing, length, and trends associated with the ice road season and the open-water season.

Background: River overflood constitutes a potential hazard to offshore oil and gas development in that it can impede access to facilities, disperse spilled oil, and expose buried subsea pipelines through scouring of the seabed below the landfast ice (strudel scouring). A comprehensive database of river overflood boundaries and strudel scour characteristics will allow BOEM to assess environmental impacts and hazards for present and future oil and gas facilities that may be located within or adjacent to the areas influenced by the overflood. The proposed study will update an earlier project by extending the record of overflood observations by more than a decade (Hearon *et al.*, 2009). While the existing study provides critical information on river overflood, the expanded database will provide additional information on the statistical variability of the phenomena. In addition, because river overflooding marks the transition from winter to break-up, this study also will complement a recent investigation of sea ice break-up commissioned by the Bureau of Safety & Environmental Enforcement (Coastal Frontiers and Vaudrey, 2018).

Objectives: The overall goal of this study is to improve the knowledge of the spatial and temporal variability in overflooding and related pipeline and facility siting concerns. The specific study objectives are to:

- Expand the existing overflood and strudel scour database by documenting maximum river overflood boundaries and collating industry acquired strudel scour data from Smith Bay to Camden Bay between 2008 and 2019.
- Evaluate isolines of annual overflood occurrence probability.
- Assess hazards associated with river overflood.

Methods: Researchers will map river overflood boundaries for all major rivers and streams in the study area for the 12-year period between 2008 and 2019 using satellite imagery. The 2009 study concluded that several imagery platforms are suitable for mapping river overflood boundaries. The study products will be incorporated into an ArcGIS® database that includes interpreted overflood boundaries, isolines of annual overflood occurrence probability, and available strudel drain and scour data.

Specific Research Question(s):

1. Has the seasonal timing of spring overflooding or the spatial extent of the overflooding changed over the last twelve years?
2. Have the ice roads from offshore development impacted the location and extent of overflooding events?
3. What is the severity of strudel scour occurrence associated with the zone of overflooding, areas of ice road construction, and the locations of offshore sub seabed pipelines? Has this changed overtime?

Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	Quantifying Sea Otter Abundance, Distribution, and Foraging Intake in Cook Inlet Alaska, Using Unmanned Aircraft Systems (UAS) Technology
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	TBD
Conducting Organizations(s)	TBD
Total BOEM Cost	TBD
Performance Period	FY 2020–2023
Final Report Due	TBD
Date Revised	October 16, 2019
PICOC Summary	
Problem	In Lower Cook Inlet (LCI), sea otter occurrence overlaps much of the Outer Continental Shelf (OCS) lease area (Garlich-Miller *et al.*, 2018). Currently, information is limited on the effects of oil and gas development activities (*e.g.*, seismic surveys and drilling infrastructure) on sea otter distribution and behavior. Additionally, more information is needed on the level of connectivity between the eastern and western LCI sea otter stocks.
Intervention	This study will assess spatial and temporal patterns of use by females with pups and the status of the LCI sea otter population relative to the available food resources as indexed by foraging energy intake rates. Genetic samples from a representative number of sea otters will be obtained from stocks in both eastern and western LCI to determine the level of variation between eastern and western stocks.
Comparison	Researchers will use UAS-based sea otter surveys to compare sea otter distribution patterns and quality of different areas of offshore foraging habitats between. Further, data from offshore foraging habitats will be compared with nearshore sea otter foraging data collected under separate U.S. Geological Survey (USGS) studies (Coletti *et al.*, 2016) including additional USGS/U.S. Fish & Wildlife Service (USFWS) work in the LCI that will begin in Fiscal Year (FY) 2019.
Outcome	Information gained from this study will inform incidental take authorizations under the Marine Mammal Protection Act (MMPA) for USFWS management needs and inform BOEM's National Environmental Policy Act (NEPA) analyses.
Context	Cook Inlet

BOEM Information Need(s): Sea otters are protected under the MMPA and one of the LCI stocks is listed under the Endangered Species Act (ESA). Scientists need to understand the effects of seismic activities and potential future oil and gas activities on sea otter behavior and habitat to minimize impacts. This study will provide data on sea otter (*Enhydra lutris*) distribution, abundance, habitat quality, feeding and resting habitats, and level of genetic isolation between eastern and western stocks in LCI. This

research will provide baselines for monitoring sea otter responses to oil and gas development activities and will inform incidental take authorizations under the MMPA. Study results will support BOEM analysts and decision-makers in relation to cumulative assessment for NEPA analyses for lease sales, exploration plans, and development and production plans.

Background: Traditional, manned aerial observer-based surveys are routinely used to estimate abundance (Bodkin and Udevitz 1999), and shore-based observations of foraging otters are a sensitive metric for population status and habitat quality (Dean *et al.*, 2002; Coletti *et al.*, 2016). The LCI presents unique constraints to the use of traditional research methods, and this study would apply innovative technology employing UAS to identify important sea otter feeding and resting areas in LCI, as well as address questions regarding seasonal differences in sea otter distributions. Sea otters appear tolerant of small vertical take-off and landing (VTOL) UAS, indicating that collecting offshore sea otter forage data from UAS in the OCS is achievable. In addition, a collaborative project involving USFWS and USGS will capture and radio tag sea otters in LCI in FY 2019, which will provide a sample of animals for targeted UAS work along with additional logistic support for this project.

Objectives:

- Document sea otter distribution and habitat use patterns relative to oil and gas development activities at appropriate temporal and spatial scales.
- Develop a cost effective and statistically defensible methodology to use UAS for multi-replicate, seasonal abundance surveys in LCI that also document annual changes in sea otter distribution and habitat use.
- Assess offshore habitat quality and sea otter foraging behavior for comparison with nearshore land-based foraging data.
- Evaluate the genetic variations between the eastern and western LCI stocks.

Methods: USGS researchers will work with the National Park Service (NPS) and USFWS partners to continue development of a photo-based survey plan that can be transferred to UAS platforms. The team will develop UAS protocols to collect survey imagery and foraging observation data, select UAS platforms (*e.g.*, marine capable fixed wing platforms for surveys and VTOL platforms for foraging observations), select sensors (*e.g.*, forward-looking infrared thermal camera and digital single-lens reflex camera, lens and red-green-blue filter combinations for surveys, and ultra-high definition 1080p+ video camera for foraging observations), optimize flight patterns, and develop statistical procedures to account for diving sea otters (*i.e.*, availability bias) that will allow unbiased estimates of true abundance from photo-based surveys. During testing both manned and UAS platforms will be compared utilizing vessel-based observers to “ground-truth” results. In addition, UAS-based sea otter foraging observations piloted from vessels will provide estimates of energy recovery rates in offshore habitats that can be compared to traditional nearshore land-based foraged data. Blood samples will be collected from a representative number of sea otters from both the eastern and western LCI stocks for genetic analysis.

Specific Research Question(s):

1. What effect might oil and gas development activities have on seasonal sea otter abundance and distribution in LCI?
2. Where are sea otter resting and foraging habitats in LCI and which habitats are of highest quality based on use and prey quality?
3. Are UAS surveys a better alternative than manned aircraft surveys with respect to image quality and disturbance levels to sea otters?
4. How much genetic isolation exists between eastern and western stocks of LCI sea otters?

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Title	Improvements to the Oil Spill Risk Analysis (OSRA) Input Quality Assurance/Quality Control (QA/QC) and Validation
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	TBD
Conducting Organizations(s)	TBD
Total BOEM Cost	TBD
Performance Period	FY 2020–2021
Final Report Due	TBD
Date Revised	October 16, 2019
PICOC Summary	
Problem	General Circulation Model (GCM) inputs to the OSRA model do not have a standardized QA/QC check. Every contracted GCM is validated in a different way from the one previous. A need exists for standardized validation and QA/QC procedures.
Intervention	Model results need to be examined in detail for GCM quality and errors. Artifacts such as insufficiently radiative boundaries and grid issues need to be identified if present. Sea ice concentration, velocity and water velocity need to be examined for reasonable values and to determine that the GCM is performing well.
Comparison	Sea ice concentrations and velocities will be compared with available passive microwave public products such as Special Sensor Microwave Imager (SSMI) ice concentration and the Institut français de recherche pour l'exploitation de la mer (IFREMER) ice drift velocity products. Surface current velocities will be compared to Acoustic Doppler Current Profiler (ADCP) data BOEM has already collected in the Alaska Outer Continental Shelf (OCS), subject to temporal and geographic limitations.
Outcome	A product will be created to compare GCM output to passive microwave and in-situ ADCP data in a standardized way.
Context	Study products will be applicable to all Alaska OCS Planning Areas and may be extended to all OCS Planning Areas.

BOEM Information Need(s): Output from the OSRA model is used to drive National Environmental Policy Act (NEPA) analyses for OCS block sales. Refinements in GCM inputs are essential for keeping the OSRA model up to date. Understanding oil spill risk is essential to managing OCS resources.

Background: OSRA is a key component in driving NEPA analysis. Oil spill trajectories are essential when identifying impacts to important sociocultural, biological, and ecological resources. When offering up lease blocks for sale, it is vital that BOEM provides both the risk of an oil spill occurring and the chance a spill could contact these resources. GCM inputs are key in order to accurately forecast the chance of a spill contacting resources, thus it is pertinent to validate these data before input into the

OSRA model. Currently we have no formal validation of this data and would like to standardize this process. Standardization of this process will apply to every part of the Alaska OCS and all OSRA runs.

Objectives:

- Streamline QA/QC of OSRA GCM inputs.
- Provide additional ground-truthing of OSRA GCM inputs with real world data.

Methods: SSMI sea ice concentration will be downloaded from the National Snow and Ice Data Center using NASA algorithm 51 (Cavalieri *et al.*, 1996). This dataset will be processed into the appropriate time and space bins for GCM comparison. Correspondingly the IFREMER sea ice drift dataset (Girard-Ardhuin and Ezraty, 2012) will also be processed into the appropriate time and space bins for comparison to GCM output. An example of an ADCP dataset used to validate surface current vectors could come from OCS Study BOEM 2017-65 (Weingartner, Pickart *et al.*, 2017). This dataset would also be processed into the appropriate time and space bins for comparison to the GCM. Other circulation studies would be used for various parts of the Alaska OCS. After processing into the appropriate time and space bins, statistics of fit will be performed by a linear regression for all three datasets.

Specific Research Question(s): How can validation of results from a GCM be standardized?

Title	Subsistence Harvest and Iñupiaq Knowledge of Beluga Whales for Kaktovik, Alaska
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	TBD
Conducting Organizations(s)	TBD
Total BOEM Cost	TBD
Performance Period	FY 2020–2023
Final Report Due	TBD
Date Revised	October 16, 2019
PICOC Summary	
Problem	OCS resource developments could affect residents of Kaktovik and their subsistence way of life. Available information about where and when Kaktovik harvests beluga whales and associated traditional knowledge is either limited or dated, and tends to be scattered among multiple sources.
Intervention	BOEM proposes a comprehensive synthesis of knowledge about beluga hunting for Kaktovik to learn about changes and analyze potential impacts of resource developments. This will include documentation of past practices and conditions, including indigenous knowledge of how people hunt belugas, and the cultural significance of belugas and beluga harvest.
Comparison	BOEM will compare study results and insights with existing data and management plans of the Alaska Beluga Whale Committee and the North Slope Borough, Department of Wildlife Management (DWM). BOEM will also compare study results and insights with existing data from state and federal studies, including previous BOEM studies examining subsistence practices.
Outcome	BOEM will learn how people in Kaktovik currently hunt belugas and the cultural importance of beluga harvest. BOEM will gain spatial, temporal, and contextual information about beluga hunting to support impact analyses.
Context	Offshore waters of the Beaufort Sea in and around Kaktovik.

BOEM Information Need(s): The National Oil and Gas Leasing Program proposes multiple lease sales in the Beaufort Sea between 2020 and 2023. BOEM needs up-to-date information on where, when, and how people in Kaktovik harvest beluga whales to inform National Environmental Policy Act (NEPA) analysis for these lease sales. BOEM will use the information to describe the affected environment, develop alternatives, and analyze potential impacts to the community from exploration and development activities. BOEM needs accurate harvest location and search data to define hunting areas for temporal and spatial mitigation measures.

Background: Beluga whales are the most abundant whale in the Beaufort Sea and provide an important source of food for people living in the North Slope Borough (NSB, 2014). Beluga is a core subsistence species for Kaktovik; in 2011, beluga was widely shared in the community; 76 percent of households reported using beluga whale for subsistence purposes; and households used on average 121 pounds of beluga in 2011 (Kofinas *et al.*, 2016).

To better understand this important resource, this study will tie into other efforts, including the Beluga Whale Management Plan (ABWC, 1995) and harvest monitoring programs of the Alaska Beluga Whale Committee, as well as research and management conducted by the North Slope Borough DWM. The study will complement and interpret existing information found in previous BOEM-funded studies of subsistence activities in the Beaufort and Chukchi seas (*e.g.*, SRBA, 2010; SRBA, 2013; Kofinas *et al.*, 2016).

Objectives:

- Evaluate baseline temporal and spatial data about subsistence beluga hunting in Kaktovik.
- Document how the people of Kaktovik hunt belugas and how beluga is processed.
- Examine the cultural importance of belugas and beluga harvest for Kaktovik.

Methods: For the first phase of the study, researchers will review and synthesize existing information (*e.g.*, ethnographies and harvest reports) about beluga hunting in Kaktovik. They will coordinate with the Alaska Beluga Whale Committee and the North Slope Borough DWM to obtain harvest records. The researchers will work to establish a trusting relationship with hunters and other residents of the community. Following the principles of conducting research with indigenous communities (IARPC, 2018), they will meet with community members to discuss their research plans and obtain input for the project, including but not limited to: which methods are appropriate, potential key informants, and what type of study products the community would like to receive.

For the second phase of the study, researchers will be present at Kaktovik for two seasons to document to document all aspects of the hunts. They will record details about hunts and harvests, and may use the global positioning system (GPS) to collect locations for hunting tracks, beluga sightings, and strikes, similar to methods used by Galginaitis (2014). In addition, researchers will incorporate subsistence mapping, participant observation with field notes, and key informant interviews. Beluga hunters, elders, and other key informants will be selected using a referral technique called snowball sampling to participate in appropriate study activities (Bernard, 2006). Interviews will be audio recorded and modeled after established ethnographic techniques (Bernard, 2006; SRBA, 2010).

Study products will include a map of the subsistence use area for beluga searching, herding, and harvesting and a synthesis report that incorporates study findings, maps, transcripts, and photographs. Researchers will ask the community how to best develop audience-appropriate presentations and products such as written summaries in glossy brochure format and short videos in documentary format. The study will hire local

residents to provide research assistance whenever practicable. Appropriate honoraria will be provided to project participants.

Specific Research Question(s):

1. What is the history of beluga hunting in Kaktovik?
2. How and why has beluga hunting changed over time?
3. Where and when do people hunt belugas?
4. How do people hunt and process belugas?
5. What is the cultural significance of belugas and beluga harvests for Kaktovik?

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Title	Early Detection Plan for Marine Non-native Species on the Arctic Outer Continental Shelf (OCS)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	TBD
Conducting Organizations(s)	TBD
Total BOEM Cost	TBD
Performance Period	FY 2020–2023
Final Report Due	TBD
Date Revised	October 16, 2019
PICOC Summary	
Problem	The threat of introductions of marine Non-Native Species (mNNS) in the Arctic is increasing with the uptick in Arctic shipping activity and infrastructure development. Coastal communities that are reliant on the services that marine ecosystems provide are particularly vulnerable. Early detection of mNNS is vital for potential control, eradication, and prevention of further spread.
Intervention	This project will create a baseline record of marine biodiversity, both by establishing monitoring plans and by collecting reference taxonomic and molecular samples of marine invertebrates, algae, and hard substrate community organisms in the Beaufort Sea and Chukchi Sea. The project will also capture the state of local traditional knowledge (LTK) on mNNS and establish long-term monitoring of the coastal ecosystem, offering a direct and cost-effective way to detect presence of mNNS.
Comparison	This monitoring complements ongoing measures by multiple organizations elsewhere in Alaska (*e.g.*, Prince William Sound, Cook Inlet, Boulder Patch & Kelp Communities) to establish a baseline record of plankton, algae and hard-substrate communities, including those currently associated with existing infrastructure in state waters. Repeat monitoring in the future will enable detection of introduced species against natural variability.
Outcome	This study will create a baseline data record that incorporates LTK and establish continued monitoring involving local residents at offshore infrastructure.
Context	Beaufort Sea and Chukchi Sea, focusing on areas with existing or potential future offshore infrastructure.

BOEM Information Need(s): BOEM is required under the National Environmental Policy Act (NEPA) to evaluate potential impacts that may be associated with Outer Continental Shelf (OCS) oil and gas exploration, development, and production activities. Potential introductions of mNNS to the U.S. Arctic are a recognized issue in relation to increases in ship traffic, including vessels related to offshore oil and gas activities. During the Liberty project approval process the need for mNNS monitoring was

emphasized during an Essential Fish Habitat Consultation with the National Oceanic & Atmospheric Administration's (NOAA's) National Marine Fisheries Service (NMFS). Results from this study will inform cumulative effects analyses under the National Environmental Policy Act (NEPA) for future lease sales and may facilitate development of potential mitigation measures.

Background: New infrastructure on the Alaska OCS would create new habitats that could be optimal for establishment of mNNS. Ship traffic to support installations and ocean warming further increase the potential for the introduction of mNNS. Because of the remoteness of the Arctic Ocean, monitoring for mNNS has not been a primary focus, but the risk of introductions is increasing.

The project will complement BOEM-supported efforts in Cook Inlet (*e.g.* NT-x10; Expanded Guide to Some Common Fouling Invertebrates of Alaska with Focus on Known and Potential Marine Invasive Species Kachemak Bay Marine National Estuarine Research Reserve), contribute to AK-15-01 (Arctic Marine Biodiversity Observing Network [AMBON]), and augment AK-11-14 (Arctic Nearshore Impact Monitoring in Development Area [ANIMIDA] III: Boulder Patch and other kelp communities in the development area). Additionally, it will capture LTK and make it accessible to a global audience (*e.g.*, through the Alaska Ocean Observing System [AOOS] and Local Environmental Observer [LEO] network). This study also could help to extend the reach of PlateWatch (platewatch.nisbase.org), a citizen science network operational in southeast Alaska, and parallel efforts by the Prince William Sound Regional Citizens' Advisory Council to monitor plankton communities.

Objectives: This project will:

- Establish a monitoring scheme for detection of attached and planktonic mNNS in the vicinity of offshore infrastructure in the Arctic.
- Record LTK for comparison and inclusion into biological assessments.
- Establish a continued monitoring scheme that includes citizen science with participation by local residents.

Methods: Biological surveys will include deployment of settlement devices (ceramic panels) to monitor the fouling community, and plankton tows and collection of open water environmental deoxyribonucleic acid (eDNA) samples to detect and quantify invertebrate assemblage composition. Taxonomic and genetic data will be verified by experts, compared with and submitted to public databases (*e.g.*, Ocean Biogeographic Information System [OBIS], GenBank) to establish identity and likelihood of mNNS. Species records will be published on the AOOS website, sequences will be accessible through GenBank. The data will also be linked with results from other relevant projects, such as the AMBON and the Arctic Shelf Growth, Advection, Respiration and Deposition Rate Experiments (ASGARD).

The status of LTK as it relates to marine invertebrates and introductions of non-native species will be captured via community and panel discussions (AK-15-05: *Traditional Knowledge Implementation: Accessing Arctic Community Panels of Subject Matter*

Experts) and digitization of physical records. Local citizens will be involved with the field surveys and plans to establish a long-term monitoring scheme.

Specific Research Question(s):

1. What do marine invertebrate communities look like near proposed installations in the OCS?
2. Are marine species being introduced to the region in association with oil and gas exploration activities?
3. How can LTK inform mNNS monitoring and management?

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Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	Comprehensive Synthesis of Impacts to Marine Mammals from Oil and Gas Activities in the Alaska Outer Continental Shelf (OCS), 2000–2020
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	TBD
Conducting Organizations(s)	TBD
Total BOEM Cost	TBD
Performance Period	FY 2020–2022
Final Report Due	TBD
Date Revised	October 16, 2019
PICOC Summary	
Problem	A large amount of information exists related to the potential effects of oil and gas exploration and development and production activities on marine mammals in Alaska. However, this information is dispersed throughout the body of scientific literature, or held by government agencies and other entities.
Intervention	This study will synthesize the relevant environmental analyses and reports to develop a summary document that is readily accessible to BOEM's analysts and the public.
Comparison	The synthesis will provide an enhanced understanding of how effects of oil and gas development relate to the overall impact of anthropogenic activities in Alaska.
Outcome	A synthesis of potential direct, indirect, and cumulative effects on marine mammals from oil and gas activities.
Context	Beaufort Sea, Chukchi Sea, Cook Inlet

BOEM Information Need(s): This study will provide BOEM, other Federal agencies, and industry analysts with a synthesis of potential direct, indirect, and cumulative effects on marine mammals from oil and gas activities. This will include a retrospective summary of mitigation measures that have been implemented to avoid or minimize adverse impacts to marine mammals based on federal and state agency documents, as well as reports provided to BOEM, the National Marine Fisheries Service (NMFS), or the U.S. Fish & Wildlife Service (FWS) by industry. Information on the integration of local and traditional knowledge into mitigation measures (if available) from Alaska Natives and Alaska Native Organizations into the development of mitigation measures will also be summarized. Results from this study will support cumulative effects analysis under the National Environmental Policy Act (NEPA), the Marine Mammal Protection Act (MMPA), and the Endangered Species Act (ESA) for future lease sales, exploration plans, and development and production plans in the Beaufort Sea, Chukchi Sea, and Cook Inlet planning areas.

Background: BOEM, as well as other federal and state agencies (*e.g.*, FWS, NMFS, and the Alaska Department of Fish & Game) are required to understand the impacts of their actions on the natural environment as well as the human environment. BOEM, specifically, is required by Section 20 of the Outer Continental Shelf Lands Act (OCSLA), to "provide the information needed to predict, assess, and manage impacts from offshore energy and marine mineral exploration, development, and production activities on human, marine, and coastal environments." Since 1973 BOEM has accomplished accumulating and archiving much of the information needed in Alaska through the Environmental Studies Program (ESP).

However, all agencies are required to review the effects of their actions under several environmental statutes including NEPA, MMPA, and ESA. The studies produced by FWS and NMFS as a result of these requirements are often not part of the ESP. This information sits not just within the ESP, or in peer reviewed literature, but also in scores of other reports and impact analyses that are required for each permitted, funded, or authorized project by the above environmental statutes, and reside in agency files not readily accessible in many cases.

Objectives: This study will synthesize information from various environmental analyses about the direct, indirect, and cumulative impacts of oil and gas resource development in the Arctic and Cook Inlet on marine mammals and put these impacts in a context relative to overall impacts of human activities in OCS areas.

Methods: Researchers will work with BOEM Subject Matter Experts (SMEs), and staff from other federal agencies, to obtain and review pertinent literature (*e.g.*, reports to federal agencies, MMPA authorizations, NEPA environmental impact analyses, biological opinions, produced by the Alaska regional offices of BOEM, FWS and NMFS, and the NMFS Office of Protected Resources, Silver Spring, Maryland). These studies have been in large part the result of federal actions permitted, funded, and authorized since 2000 and have addressed impacts of oil and gas activities in the Alaska OCS. Researchers will also coordinate with staff from the State of Alaska to obtain similar information related to oil and gas activities in state waters. Information that addresses the aforementioned objectives in peer-reviewed literature, reports, and summary documents will be synthesized into concise statements that can be easily and readily used in future environmental analyses to describe the effects of oil and gas infrastructure and activities in context with other anthropogenic activities to support future planning and decision-making.

Specific Research Question(s):

1. What are the direct, indirect, and cumulative effects on marine mammals of increased levels of anthropogenic noise from exploration and construction activities in Alaska from 2000–2020?
2. What are the direct, indirect, and cumulative effects on marine mammals of increased levels of other sources of disturbance including, but not limited to, construction and maintenance of ice roads, increased levels of traffic including vehicle, air support, and vessel traffic?

Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	The Impact of Marine Fish Communities on Red-throated Loon Productivity in the Beaufort Sea
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	TBD
Conducting Organizations(s)	TBD
Total BOEM Cost	TBD
Performance Period	FY 2020–2023
Final Report Due	TBD
Date Revised	October 22, 2019
PICOC Summary	
Problem	Red-throated loons are potentially sensitive to disturbance and environmental change. Red-throated loon populations have declined in northern Alaska, and because adults have high survival rates, this trend suggests that reproductive success is poor. Lower reproductive success may be driven by shifts in marine fish prey that red-throated loons depend upon because prey availability and species composition has shifted across decadal timescales concurrent with the negative population trend of red-throated loons.
Intervention	This study will evaluate offshore marine factors affecting the reproductive success of red-throated loons in two regions of the Beaufort Sea: Foggy Island Bay and the Canning River delta, Alaska. Cameras at loon nests will be used to estimate nest success and chick survival. A subset of loons will be captured to acquire tissue samples for diet composition and to be outfitted with Global Positioning System (GPS) transmitters that will provide fine-scale resolution of loon feeding habitat prior to oil development. Concurrent fish sampling will assess prey preferences by identifying the relative abundance and species composition of fish prey.
Comparison	This study will compare the reproductive success of red-throated loons nesting in the two focal regions of the Beaufort Sea with differing availability and diversity of whitefish prey (*e.g.*, least cisco, *Coregonus sardinella*). Offshore use areas will be compared between the two sites and detailed use information will be generated for Foggy Island Bay to allow comparison of pre-development information will be available for post-development comparisons.
Outcome	This project will evaluate if differences exist in fish communities and if these drive changes in loon reproductive success. Study products will include spatially explicit maps of loon feeding areas, distances to foraging areas, and assessments of loon diet and prey quality, as well as pre-development habitat use and reproductive success information that can be compared to post-development periods. The project also will assess evidence for a hypothesized driver of the current population decline of red-throated loons on the North Slope of Alaska.
Context	Nearshore Beaufort Sea

BOEM Information Need(s): BOEM requires information to assess cumulative impacts on red-throated loons due to potential disturbance and displacement around offshore and inshore industrial facilities, ecological changes in nearshore environments, or accumulation of contaminants exposure. Information from this study will support BOEM in assessing red-throated loon habitat use in marine waters prior to oil and gas development and dynamics of predator-prey relationships of loons and their prey to evaluate the sensitivity of loon reproductive success to fish prey type and availability.

Background: Proposed nearshore oil development and production in the Beaufort Sea has created a need for identifying potential impacts on wildlife in the region. The proposed Liberty Development Project will include the construction of an artificial island in Foggy Bottom Bay, an area likely used by breeding red-throated loons, which may be sensitive to anthropogenic disturbance and environmental change. The population decline of red-throated loons in northern Alaska has continued and a possible driver is changing foraging conditions in the nearshore marine environment. Given their predilection for marine fish of high fat content, populations of red-throated loons may be sensitive to the abundance and nutritional value of fish prey. Previous studies from other geographic regions have shown that some keystone fish species (*e.g.*, least cisco) are critical to enabling red-throated loon breeding success. Flight and dive costs to capture fish are high, thus perturbations or habitat differences that result in lower densities or quality of fish prey or decreased foraging opportunities may have energetic consequences that contribute to the observed population decline via deficient breeding success. Ongoing nearshore fish community research in the Beaufort Sea, *Nearshore fish surveys in the Beaufort Sea: Examining long-term community change and the role of nearshore habitats*, provides recent (2017–2018) spatial contrast in fish communities and an understanding of temporal variation in the relevant fish communities by revisiting historic sample sites and drawing comparisons to previous decades.

Objectives: This study will evaluate the offshore marine use areas of breeding adult loons and assess the response of red-throated loon reproductive success to differences in the relative abundance, composition, and nutritional content of nearshore fish communities that vary in space and time.

Methods: Researchers will conduct an integrative study of fish and loons at two locations along the Beaufort Sea coast over three years. Time-lapse cameras will acquire images of nesting loons to estimate breeding success. GPS transmitters attached to a sample of adult loons will allow documentation of flight patterns, foraging areas and foraging behaviors to quantify energy expenditure of loons during foraging trips. GPS locations will be used to identify important marine habitats prior to industrial development. Fat biopsy and serum samples from adult birds and nearly fledged young will be used for fatty acid diet analysis and stable isotope analysis, respectively, to provide taxa-specific prey information through comparisons to a fish prey library. Fyke nets and 3 m beam trawls will be used to sample fish in nearshore habitats. Trawls provide access to habitat distant from the shoreline and comparable to collection methods used on BOEM-funded Transboundary cruise. These gear types allow for

comparability to existing databases of fish abundance and species composition in nearshore and continental shelf habitats.

This project will include 50% co-funding from the U.S. Geological Survey Alaska Science Center.

Specific Research Question(s):

1. What is the reproductive success of red-throated loons nesting along the Beaufort Sea coastline?
2. Where are the important Beaufort Sea nearshore and offshore feeding areas for red-throated loons?
3. What is the diet of red-throated loons during the breeding season?
4. What is the relative quality of common fish prey?
5. Is loon reproductive success related to diet composition?
6. Is loon diet composition similar to the fish community composition?
7. Are there differences in foraging activity budgets between study sites?

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2.2 Profiles of Studies to be Considered for FY 2021

Table 2. BOEM Anchorage, Alaska Office Studies to be Considered for FY 2021

Page Number	Discipline	Study Title
57	MM	Acoustic Detection of Critically Endangered North Pacific Right Whales in the Gulf of Alaska (GOA)
59	ID	Offshore Renewable Energy Potential on Alaska's Outer Continental Shelf (OCS)
Discipline Codes		
ID = Interdisciplinary & Information Management MM = Marine Mammals & Protected Species SSE = Social Science & Economics		

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Title	Acoustic Detection of Critically Endangered North Pacific Right Whales in the Gulf of Alaska (GOA)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	TBD
Conducting Organizations(s)	TBD
Total BOEM Cost	TBD
Performance Period	FY 2021–2025
Final Report Due	TBD
Date Revised	October 16, 2019
PICOC Summary	
Problem	The eastern population of the North Pacific right whale occurs in areas of the GOA potentially affected by oil development activities in Cook Inlet, as well as potential future lease sales in the Cook Inlet, Kodiak, and GOA Outer Continental Shelf (OCS) Planning Areas.
Intervention	The year-round occurrence of right whales will be assessed through detections by passive acoustic recorders deployed in multiple locations off Kodiak Island. Co-located oceanographic moorings will provide associated oceanographic data on a similar spatial scale.
Comparison	The results of this study will be compared to the results of BOEM's oil-spill trajectory modeling efforts, which indicated that North Pacific right whales could be affected by a potential oil spill in Cook Inlet.
Outcome	This project will provide new baseline information regarding the habitat use of North Pacific right whales in the study area.
Context	Lower Cook Inlet and the National Oceanic & Atmospheric Administration (NOAA)-designated Critical Habitat for right whales on Albatross Bank off Kodiak.

BOEM Information Need(s): Information on right whale occurrence is needed to refine our understanding of the overlap with potential future oil and gas exploration and development activities that may result from Cook Inlet Lease Sale 244, as well as potential future oil and gas lease sales in the Cook Inlet, Kodiak and GOA Planning Areas. Results from this study will support decision-making related to management of human use conflicts and inform National Environmental Policy Act (NEPA) analyses and Endangered Species Act (ESA) Section 7 consultations associated with lease sales in these planning areas.

Background: The eastern population of the North Pacific right whale is critically endangered, with abundance likely only in the tens of whales. Basic information on current abundance, trends, and distribution of this stock is needed. While new information on right whale distribution has come from NOAA surveys of the Bering Sea, efforts in the Cook Inlet, Kodiak, and GOA Planning Areas have been more limited. Right whale habitat extended through the offshore waters of the GOA as recently as the

1960s when the Soviet Union was conducting illegal whaling activities. In July 2017, a North Pacific right whale was observed in the GOA between Sand Point and Kodiak at Kilokak Rocks.

The oil-spill trajectory modeling conducted by BOEM for the 2017 Cook Inlet Lease Sale 244 showed that potential right whale habitat including Kilokak Rocks could be affected by oil in the event of a spill in Cook Inlet. In addition, vessel traffic and other activity associated with oil and gas development pose threats to right whales in the region through noise, pollution, and/or ship collisions. With additional lease sales being considered for Cook Inlet, as well as the Kodiak and GOA Planning Areas, additional information is needed to identify the use of this area by right whales.

Objectives: This project will evaluate the current occurrence of right whales in the GOA around Kodiak Island and in Lower Cook Inlet and how their presence may correlate with oceanographic conditions. This will provide additional baseline information on this critically endangered species' occurrence in these Planning Areas, which would be needed to develop appropriate mitigation measures should leasing occur in this geographic area

Methods: In collaboration with NOAA, long-term passive acoustic recorder moorings will be deployed to provide year-round data on right whale spatial and temporal occurrence as well as ambient noise measurements. Researchers will review results and suggestions from recent similar efforts to monitor North Atlantic Right Whales off Maryland and Virginia to help refine their approach and improve the likelihood of detections.

Researchers will analyze acoustic data from these recorders to refine knowledge of the spatial and temporal occurrence of right whales in the GOA around Kodiak Island and near to the species' designated Critical Habitat on Albatross Bank. Density estimation may also be possible from these single-recorder moorings through the use of novel passive acoustic methods and integration with recent survey data, including results from the International Whaling Commission's Pacific Ocean Whale and Ecosystem Research (POWER) survey. As practicable, recordings will also be analyzed for information related to other species and include additional sensors on the moorings to collect information about oceanographic conditions. Recorders will be deployed for two or three years, with a scheduled maintenance each year. Deployments will take advantage of local proximity to human populations which will make logistics easier than an existing similar project in the Bering Sea.

Specific Research Question(s):

1. What is the temporal occurrence year-round of critically endangered North Pacific right whales in areas potentially affected by activities associated with oil and gas exploration and development on the OCS of lower Cook Inlet?
2. How does right whale presence in these areas correlate with oceanographic conditions?

Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	Offshore Renewable Energy Potential on Alaska's Outer Continental Shelf (OCS)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	TBD
Conducting Organizations(s)	TBD
Total BOEM Cost	TBD
Performance Period	FY 2021–2023
Final Report Due	TBD
Date Revised	October 16, 2019
PICOC Summary	
Problem	The Energy Policy Act of 2005 (EPAct) delegated regulatory authority to BOEM over renewable energy resources on the U.S. OCS, but the current program does not actively consider renewable energy in Alaska. Information about ocean energy resources on the OCS is needed to inform a decision about whether to pursue an Alaska Renewables Energy Program.
Intervention	This study will assess offshore renewable energy potential on the OCS off Alaska as well as consider the economic viability of recovering and transporting energy.
Comparison	OCS wind energy, ocean thermal energy, ocean wave energy, and ocean current energy will be assessed for Alaska and compared to other regions.
Outcome	This study would enable a more informed decision about whether to develop a renewables program on the Alaska OCS. Future renewable energy projects, if economically feasible, have the potential to make significant contributions to our nation's energy portfolio.
Context	All renewable energy potential for the Alaska OCS would be considered.

BOEM Information Need(s): The consideration of a renewable energy program in Alaska is needed to uphold the OCS Lands Act mandate to manage the exploration and development of the nation's offshore energy and mineral resources in an environmentally and economically responsible way. The development of a renewables program would be in line with current political priorities including Executive Order 13795 – *Implementing an America-First Offshore Energy Strategy* by advancing energy innovation, exploration, and production. BOEM's Renewable Energy Program states that "the areas appropriate for renewable energy development have likely never been studied for such development and, in some cases, there is information lacking about the physical and biological environment." It emphasizes that "the need for continuing to pursue information to ensure access to the OCS for renewable energy development is a high priority for BOEM (BOEM 2017)."

Background: A 2008 BOEM study titled *Worldwide Synthesis and Analysis of Existing Information Regarding Environmental Effects of Alternative Energy Uses on the OCS and Workshop* did not consider resources on the Alaska OCS, but serves as a good model for this study. The 2008 study objectives were to identify, collect, evaluate, and synthesize existing information on offshore alternative energy activities. A workshop was also held to identify alternative energy environmental information needs.

A recent report "America's Oceans: A Decadal Vision" by the National Science and Technology Council (2018) recognized that "America's coastline and extensive EEZ [exclusive economic zone] contains vast untapped renewable (wave, tidal, wind, thermal) and non-renewable (oil and gas) energy sources to help power the Nation. Aligning energy innovation with emerging developments in ocean science, security, and maritime technology could provide dynamic opportunities to further drive coastal economic development." Exploring potential energy sources is one of the report's identified research priorities for the next decade. This study would be the first step in achieving this goal in Alaska.

Objectives: The objective of this study is to establish an understanding of the offshore renewable energy potential on the Alaska OCS, focusing on identifying high potential areas and sources, economic feasibility, and management strategies that would be relevant for expanding BOEM's Renewable Energy Program to the Alaska OCS.

Methods: This study will conduct a literature review compiling all available information about offshore renewable energy potential on the Alaska OCS with analysis focused on identifying areas most attractive for leasing, likely near population centers or existing infrastructure. Energy potential is defined to include what is recoverable with current technologies or those that may be realistically developed in the next ten years. The analysis would include a discussion of economic feasibility, through literature investigations and interviews with technology and industry experts as well as state and local governments. Finally, the study will provide recommendations for further research required for National Environmental Policy Act (NEPA) analysis that would be needed should a renewable energy program be implemented in Alaska. These recommendations would consider habitat and landscape alteration, cumulative effects, integration of social sciences into environmental assessments, and other issues.

Specific Research Question(s):

1. What is the overall offshore renewable energy potential on the Alaska OCS?
2. Where are the areas most attractive for leasing?
3. Is it economically feasible to recover this energy with current technologies? Economic feasibility should consider changes in energy resources throughout a year, in different climate scenarios, different levels of infrastructure, and reasonably foreseeable technological advancements in energy capture, storage, and transport.
4. How does this potential compare with offshore renewable energy potential and current activities on the Atlantic and Pacific OCS?

5. If a renewable energy program is practical at this time: What strategy should BOEM take to effectively design studies to provide baseline data needed for a leasing program?
6. If a renewable energy program is not practical at this time: Under what conditions could it be more viable, and what indicators may demonstrate a need to reconsider development of a program in the future?

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2.3 Profiles of Ongoing Studies

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Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Study Area(s):	Cook Inlet
Administered By:	Anchorage, Alaska Office
Title:	Nearshore Food Web Structure on the OCS in Cook Inlet, Alaska (AK-13-03-22)

BOEM Information Need(s) to be Addressed: Updated and readily accessible intertidal and shallow subtidal habitat information will support environmental analyses for future Cook Inlet lease sales and potential future Exploration Plans, and Development and Production Plans in Cook Inlet, as well as for BSEE's ongoing spill response planning. The subtidal and intertidal areas are home to many grazing invertebrates which provide an important source of prey for marine and terrestrial mammals, birds, other invertebrates and humans and are particularly susceptible to oil spills. Updated information from this study will be important to understanding and assessing potential impacts of an oil spill in Cook Inlet.

Total BOEM Cost: $124,402
plus Joint Funding ($124,402)

Period of Performance: FY 2017-2020

Conducting Organization: CMI, UAF

BOEM Contact: Catherine Coon

Description:
Background: Nearshore marine habitats are particularly vulnerable to potential impacts of marine oil and gas extraction activities and shipping, as well as to influences from climate change or other anthropogenic activities. In addition to the direct lethal effects that a severe incident such as an oil spill could have on nearshore species of all trophic levels, more subtle effects include the reduction of resilience and health of species and the disruption of the energy flow among the various nearshore ecosystem components.

Food web structure is the representation of how species within the nearshore system are linked through energy flow, thus building a network. Food web interactions are responsive to perturbations from human activities such as oil and gas extraction as well as from climate change, potentially leading to disruptions in energy flow to higher trophic levels.This project will examine food web structure in nearshore, macroalgal-dominated systems in Kachemak Bay and in Kamishak Bay, adjacent to the Cook Inlet 2017-2022 Program Area. These nearshore systems are highly diverse, and current efforts are underway to characterize the community composition and diversity of these systems (AK-15-08; AK-14x-10) partnering with National Park Service, University of Alaska Fairbanks, and the Cook Inlet Regional Citizens Advisory Council. Leveraging off these ongoing BOEM funded studies, this study will add a dynamic, food web oriented characterization of the ecosystem. Adding a food web perspective to simultaneously ongoing studies of species occurrence and richness provides a more

dynamic, interaction-driven view of the ecosystem that can be useful in understanding key species function in an ecosystem.

Objectives: The overarching goal of the study is to identify the food web structure (trophic levels and trophic niche use) of the nearshore macroalgal-based systems in Cook Inlet, to provide an assessment of the potential vulnerability of the nearshore food webs, and to establish a benchmark for monitoring changes in food web characteristics over time. Specific objectives include:

- To quantitatively describe and compare nearshore macroalgal-based food web structure in two regions in Cook Inlet using stable isotope analysis.
- To gauge resilience of nearshore food webs in Cook Inlet based on measures of food web structure and trophic niche space.

Methods: This project will provide quantitative measures of nearshore food webs, such as food web length, trophic level of main taxa, food web niche structure, and carbon sources within the Cook Inlet OCS. Sampling will occur in two regions in Lower Cook Inlet: Kachemak Bay and Kamishak Bay in 2017 and 2018. Lab analysis will use carbon and nitrogen stable isotope of nearshore primary producers (macroalgae, phytoplankton) and abundance consumers (mussels, limpets, whelks, sea stars, and crabs) combined with quantitative abundance data.

Revised Date: October 1, 2019

Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Study Area(s):	Cook Inlet
Administered By:	Anchorage, Alaska Office
Title:	Ecological Processes in Lower Cook Inlet and Kachemak Bay: A Partnership in Monitoring (AK-14-x10; AK-14-x11; AK-14-x12)

BOEM Information Need(s) to be Addressed: NEPA analysts require updated information regarding the physical and biological environment, including variability in oceanographic conditions and plankton communities, as well as data related to sensitive species. The results will support NEPA analysis and documentation for lease sales, Explorations Plans (EPs), and Development and Production Plans (DPPs). Collected oceanographic, benthic and seabird data will support validation and sensitivity testing of ocean circulation models used for BOEM's Oil-Spill Risk Analysis efforts.

Total BOEM Cost: $350,000 plus Joint Funding (~$1,000,000) **Period of Performance:** FY 2014-2019

Conducting Organization: NOAA; USFWS (completed); NPS (completed)

BOEM Contact: Catherine Coon

Description:

Background: Cook Inlet circulation patterns are influenced by intrusions of the Alaska Coastal Current, large seasonal changes in freshwater input, geographically-influenced wind forcing and a large tidal range. The lower Cook Inlet and Kachemak Bay also support rich nearshore and pelagic biological communities. Improving understanding of this complex marine environment will improve understanding of biological variability and potential impacts from oil and gas development activities.

The *Exxon Valdez* Oil Spill Trustee Council (EVOSTC) and State and Federal agencies are currently supporting a five-year, $12 million long-term monitoring program in the Gulf of Alaska region affected by the 1989 *Exxon Valdez* oil spill, including lower Cook Inlet. The multidisciplinary monitoring program, called GulfWatch Alaska, seeks to build upon the extended restoration research and monitoring by providing data to identify and help understand the impacts of multiple ecosystem factors on the recovery of injured resources. This program, headed by the Alaska Ocean Observing System (AOOS), Prince William Sound Science Center, and the NOAA Kasitsna Bay Laboratory, links changes in environmental conditions with population trends in nearshore benthic and pelagic species. In lower Cook Inlet and Kachemak Bay, the program includes seasonal oceanographic and plankton surveys, annual near-shore benthic surveys, and opportunistic seabird and marine mammal surveys.

Data management for the GulfWatch Alaska program is coordinated by AOOS and science synthesis is led by the NOAA Kasitsna Bay Laboratory. Oceanographic data

from this study will also support NOAA's ongoing validation efforts for the NOS circulation model to improve model use in environmental assessments and oil-spill response planning. Collaboration with the GulfWatch Alaska program and partner organizations (AOOS, NOAA, USGS, UAF, ADF&G, USFWS, etc.) presents a unique opportunity for BOEM to leverage funds and obtain needed information through support of expanded ecosystem monitoring efforts in lower Cook Inlet.

Objectives:

- Quantify seasonal and inter-annual variability in oceanographic conditions and plankton communities and provide information to assess long-term trends.
- Enhance monitoring of sensitive species (seabirds, sea otters) in conjunction with monitoring of environmental conditions.
- Improve understanding of water mass movement in lower Cook Inlet/Kachemak Bay for use in environmental analysis and circulation model validation.
- Compile existing historical data and literature in regards to intertidal studies and canopy kelps in the subtidal from Cook Inlet. Information will be accessible for use in planning as well as for use in future site selection and recommendation for more extensive evaluations.

Methods: This study will enhance existing oceanographic surveys, plankton surveys, near-shore benthic surveys, and upper trophic level surveys of seabirds and marine mammals to support NEPA analyses. Collected data include: temperature, salinity, phytoplankton and zooplankton samples, water samples for acidification analyses, benthic surveys, and seabird and sea otter observations when possible. Currently, oceanographic and plankton surveys are conducted quarterly along three transects in lower Cook Inlet and two transects in Kachemak Bay. Based upon consideration of results from analysis of data collected in 2012, surveys will be expanded in time and/or space to improve assessment of seasonal conditions. The need for expanded benthic monitoring will be assessed and implemented if appropriate. This study will also provide for addition of seabird and marine mammal observers to all surveys in Cook Inlet. Standard agency protocols are used for intertidal, bivalve and subtidal canopy kelp, at-sea seabird and marine mammal monitoring. A pilot field season occurred in 2015 in the Kamishak Bay Area.

Revised Date: October 1, 2019

Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Study Area(s):	Cook Inlet
Administered By:	Anchorage, Alaska Office
Title:	Subtidal and Intertidal Habitats and Invertebrate Biota in Lower Cook Inlet, Alaska (AK-15-08)

BOEM Information Need(s) to be Addressed: Updated and readily accessible intertidal and shallow subtidal habitat information is needed to conduct environmental analyses for OCS development in Cook Inlet, as well as for BSEE's ongoing oil-spill response planning. The subtidal and intertidal areas are home to many grazing invertebrates which provide an important source of prey for marine and terrestrial mammals, birds, other invertebrates and humans and is particularly susceptible to oil spills. Updated information from this study will be important to understanding and assessing potential impacts of an oil spill in Cook Inlet.

Total BOEM Cost: $600,000 plus Joint Funding (~$150,000) **Period of Performance:** FY 2015-2019

Conducting Organization: National Park Service

BOEM Contact: Catherine Coon

Description:

Background: Benthic invertebrates and their habitats are susceptible to effects from oil and gas exploration and development activities. The subtidal invertebrates and habitats adjacent to the OCS are particularly susceptible to oil spills and updated information is needed to assess impacts from a potential large oil spill in Cook Inlet. Previous research on intertidal and subtidal habitats in Cook Inlet includes the Outer Continental Shelf Environmental Assessment Program (OCSEAP) begun in 1975, as well as work done by the Cook Inlet Regional Citizens Advisory Council (CIRCAC) in 2000.

Subtidal and intertidal communities are also an important conduit of energy, nutrients, and pollutants between terrestrial and marine environments; provide resources for subsistence, sport, and commercial harvests; and are important for recreational activities such as wildlife viewing and fishing. Changes in the structure of the intertidal community serve as valuable indicators of disturbance, both natural and human induced. Further, changes in overall and relative abundance of intertidal species may have serious consequences for the bird and mammal species that forage in nearshore areas.

Marine bivalves (clams, mussels, and chitons [badarkis]) in particular are subsistence species for Alaska Natives and residents. Native communities in Port Graham and Nanwalek have noted a substantial decline in shellfish populations and have expressed concern over the potential loss or contamination of subsistence resources. Bivalves are ubiquitous and critical components of the nearshore intertidal environment, and have

been used widely as sentinels in monitoring programs. Community monitoring for bivalves for potential contaminants would be an important component to address concerns about release of contaminants, most notably polycyclic aromatic hydrocarbons (PAH), into the environment. It is important to improve our understanding of the following: the extent and details of benthic habitat that support subsistence resources, hydrocarbon loads in these resources, as well as the sources and extent of local contamination, particularly those where subsistence harvest continues.

This study will be conducted with a collaborative approach between communities and Federal agencies. The study will provide a better understanding of invertebrate biota including distribution and densities, and will depict the variety of habitat structures. A subset of the species will be used as sentinel species to assess the vulnerability of marine ecosystems to the effects of oil contamination. Hydrocarbon work will also leverage previous surveys by CIRCAC and NOAA-NOS. Potential cooperators include USGS, CIRCAC, NOAA, USFWS, Gulf Watch Alaska, Kenai Peninsula Watershed Forum, and the Port Graham Tribe and Chugach Regional Resources Commission.

Objectives:

- Describe lower Cook Inlet nearshore habitats, including invertebrate and algal communities, using existing ShoreZone data and imagery and the results of prior intertidal and shallow subtidal sampling programs.
- Identify areas and habitats across a range of different habitat strata in Lower Cook Inlet that should be included in a long-term monitoring program to provide baseline conditions.
- Conduct intertidal and shallow subtidal sampling in identified monitoring areas, including appropriate habitats within Kamishak Bay and extending north to Tuxedni Bay.
- Based on evaluation of existing hydrocarbon data, develop and facilitate a plan for a community monitoring program that monitors hydrocarbon concentrations in tissues of potential nearshore sentinel species (e.g. clams, mussels, chitons) for important subsistence areas near Port Graham and Nanwalek in Kachemak Bay.
- Integrate new information collected during the biological monitoring component with existing spatial habitat data in the context of known physical and oceanographic conditions.

Methods: This study will compile and collate important historical and ongoing temporal and geospatial habitat and intertidal and shallow subtidal data into a publically-accessible interactive platform. Data will be compiled in a manner that allows creation of digital and web-based synoptic maps to better portray ecological information and support resource management decisions. Researchers will conduct targeted subtidal surveys across an range of habitat types and areas using protocols from the Census of Marine Life/NaGISA (Natural Geography In-Shore Areas), Exxon Valdez Oil Spill Trustee Council-Gulf Watch Alaska, and National Park Service Inventory programs, as well as the BOEM-MARINe program where suitable. Researchers will apply an analytical approach to utilize existing habitat data supplemented with newly collected

biological data to better document ecological processes in nearshore areas, producing derived geographical datasets and maps to help inform resource managers, stakeholders, and decision-makers.

This project has a multi-phased approach:

Phase I: Historical Database - Compile existing historical intertidal and shallow subtidal data and literature from Lower Cook Inlet (completed).

Phase II. Intertidal and Subtidal Assessments - Conduct rocky intertidal and shallow subtidal (< 15 m water depth) community assessments- completed for 2015, 2016, and 2017.

Phase III. Develop sampling plans and recommendations for more extensive evaluations and potential monitoring based on the historical analyses and field assessments of Phases I and II.

Information about existing nearshore benthic habitat data in the area was summarized prior to the 2015 field season. Relevant biological historical data for this compilation included nearshore macroalgae, eelgrass, and bivalves and a range of geomorphic shore types. The information was compiled into a geo-referenced database to be integrated into an AOOS Cook Inlet on-line data portal and visualization tool, and will be used to help identify research gaps in terms of habitat, species, and geographic areas.

Field seasons occurred in 2015, 2016, 2017 and 2018. Low-angle rocky habitats in Lower Cook Inlet were assessed for intertidal and subtidal community assemblages. During these field seasons six intertidal rocky, macroalgal-dominated sites were randomly selected from the Alaska ShoreZone habitat classification data. A series of subtidal dive sites were also established near each intertidal site where possible. In 2018 opportunistic UAS was also flown over a set number of transects.

Revised Date: October 1, 2019

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Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	Initiating an Arctic Marine Biodiversity Observing Network (AMBON) for Ecosystem Monitoring (AK-15-01)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	Catherine Coon, Catherine.Coon@boem.gov
Conducting Organizations(s)	University of Alaska Fairbanks
Total BOEM Cost	$1,750,000 plus Joint Funding (~$4,200,000)
Performance Period	FY 2015–2020
Final Report Due	September 2020
Date Revised	October 1, 2019
PICOC Summary	
Problem	The Arctic has ongoing and prospective energy activities, coupled with natural environmental variability that may disrupt ecosystem function and services, a cost effective system is needed to determine the type and magnitude of these impacts and the resiliency of the ecosystem to change.
Intervention	Long-term studies that monitor marine ecosystems are necessary to distinguish between changes caused by natural processed and those caused by human activities. By leveraging existing datasets and building upon previous work, select indicator species from microbes to whales will be assessed at scales appropriate for impact analysis.
Comparison	Potential effects will be identified by integrating and synthesizing past and ongoing research programs in the Chukchi Sea to assess natural variability to provide a backdrop to assess impacts from development. The range and patterns of natural variability, and relationships to environmental drivers can only be discerned from long term data collection.
Outcome	Study products will assist BOEM in performing NEPA impact analyses and address stakeholders' concern about potential ecosystem consequences from offshore energy development and natural resiliency during great environmental change.
Context	Chukchi Sea

BOEM Information Need(s): BOEM needs a more rigorous monitoring system to improve information about the health of biodiversity in the Chukchi Sea as a means to enhance environmental impact assessments and develop better metrics for cumulative impact analysis. Biodiversity measures for the marine environment need to be acquired through systematic and comprehensive methodology.

Background: Biological diversity is defined as the variety of life, encompassing variation at all levels of complexity – genetic, species, ecosystems, and biomes – and including functional diversity and diversity across ecosystems. A growing body of research demonstrates that: (1) the maintenance of marine biodiversity (including coastal biodiversity) is critical to sustained ecosystem and human health and to

resilience in a globally changing environment; and (2) the condition of marine biodiversity offers a proxy for the status of ocean and coastal ecosystem health and the ability to provide ecosystem services. Thus, managing our marine resources in a way that conserves existing marine biodiversity would help address other ocean management objectives. For example, it would provide information to enhance management against threats such as invasive species and infectious agents, enable predictive modeling, better inform decision-making, and allow for adaptive monitoring and Ecosystem-Based Management.

The overarching goal of the AMBON project is to build an operational marine biodiversity observing network from microbes to whales. AMBON is a 5-year research partnership (2015-2020) between university and Federal investigators that integrates with the Alaska Ocean Observing System (AOOS) as the central data node to provide a publicly accessible and user- friendly database. AMBON is funded through the National Ocean Partnership Program, with contributions from the National Oceanographic and Atmospheric Administration (NOAA), the Bureau of Ocean and Energy Management (BOEM), and Shell Exploration and Production Company. AMBON is primarily focused on the continental shelf in the Chukchi Sea, but through these partnerships, AMBON will make biodiversity data available to a broad audience of users and stakeholders, from local to pan-Arctic to global. The AMBON project samples two of the Distributed Biological Observatory (DBO) lines.

The assessment of possible adverse risk from OCS energy development hinges on being able to differentiate human-induced effects from natural variability. Given the complexity of marine ecosystems and the possible effects of global climate change, this often requires making observations over large ocean areas, seasonally, and over multiple years and even decades to acquire reasonable statistical confidence.

Objectives: The AMBON has four principal objectives to develop a sustainable model of continuous biodiversity observation including all levels of diversity from genetic to organismal to ecosystem:

- To improve taxonomic and spatial coverage in biodiversity observations on the Chukchi shelf.
- To integrate and synthesize past and ongoing research programs on the US Arctic shelf into an Arctic biodiversity observation network with publicly accessible data.
- To demonstrate how a sustainable observing network could be developed for this and other regions and ecosystems.
- To link with international programs on the pan-Arctic level.

Methods: AMBON has had two field seasons – one in 2015 and one in 2017. During those field efforts, AMBON collects ecosystem level biodiversity information along five cross-shelf and one along-shelf transect in the Chukchi Sea. State of the art genetic techniques complement traditional taxonomic approaches to include the small size fractions (microbes, nano- to microplankton, meiofauna) into biodiversity assessments.

Through working with the Alaska Ocean Observing System (AOOS), the program creates open access data and coordinates with other national BON demonstration projects. Outreach is pursued through a website (through AOOS), and interactions with local communities, specifically the Native Alaska communities of the north that are most directly affected by the changes in the Arctic. Various stakeholders are engaged through direct communications (e.g., BOEM, Shell, IOOS), workshops, database, scientific meetings, etc.

Specific Research Question(s): What are the regional patterns of biodiversity on the Alaska Arctic shelves, how do they influence ecosystem complexity and function, and how do they inform energy resource management?

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Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	Arctic Integrated Ecosystem Survey, Phase II (AK-16-07)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	Sean Burril, sean.burril@boem.gov
Conducting Organizations(s)	NOAA; USFWS; UAF
Total BOEM Cost	$2,500,041 plus Joint Funding
Performance Period	FY 2017-2022
Final Report Due	July 2022
Date Revised	September 26, 2019
PICOC Summary	
Problem	Limited information exists on the distribution abundance and life history of Arctic Marine fish species in the Chukchi and Beaufort Seas.
Intervention	A comprehensive assessment of demersal and pelagic fish communities in the Chukchi and Beaufort Seas to improve
Comparison	Differences in the Arctic fish community structure based on our most recent understanding
Outcome	A comprehensive assessment of the demersal and pelagic fish species in the Chukchi and Beaufort Seas, with a plan for a long term monitoring protocol.
Context	Beaufort and Chukchi Seas

BOEM Information Need(s): BOEM needs a comprehensive assessment of both demersal and pelagic fish communities in the Chukchi and Beaufort Seas to improve benchmark information about the distribution, abundance, and life history of Arctic marine fish species. In particular, systematic surveys of the midwater fish community are currently lacking for the western Beaufort Sea. There is also a need for monitoring fish communities on a regular basis at least every 3-5 years to document variability and long-term changes. This information is needed to enhance environmental impact assessments, particularly with respect to early life history stages of key species such as Arctic cod (*Boreogadus saida*) and forage fishes, to develop indices and benchmarks against which to compare future changes, and to identify the distribution of the vulnerable life stages to facilitate development of effective mitigation measures.

Background: The goal of Arctic IES Phase II is to improve understanding of processes that structure the Arctic ecosystem and influence the distribution, abundance, and life history of lower (phytoplankton, zooplankton) and upper trophic level species (invertebrates, fishes, seabirds, mammals), and their vulnerability to a rapidly changing environment. The lower trophic level component aims to better understand the climatological, physical, chemical, and biological processes that influence energy flow from primary producers to zooplankton and ichthyoplankton, and the upper trophic level component will work to describe and understand how lower trophic processes reverberate through the food web to influence invertebrate, fish, and seabird

communities. Additionally BOEM needs a comprehensive assessment of both demersal and pelagic fish communities in the Chukchi and Beaufort Seas to improve benchmark information about the distribution, abundance, and life history of Arctic marine fish species. There is also a need for monitoring fish communities on a regular basis at least every 3-5 years to document variability and long-term changes. This information is needed to enhance environmental impact assessments, particularly with respect to early life history stages of key species such as Arctic cod (*Boreogadus saida*) and forage fishes, their prey and predators and to identify the distribution of the vulnerable life stages to facilitate development of effective mitigation measures.

Objectives:

- Quantify the distribution, abundance, and condition of demersal fishes and shellfishes throughout the U.S. shelf waters of the Chukchi Sea and Western Beaufort Sea.
- Quantify the distribution, abundance, and condition of mid-water marine fishes, in particular young-of-the year Arctic gadids and forage fishes, throughout the U.S. shelf waters of the Chukchi Sea and Western Beaufort Sea.
- Combine results from previous Arctic surveys (Arctic EIS, Phase 1, BASIS) and planned surveys (Arctic IES Phase 2) to assess variability in pelagic and demersal fish ecology over time relative to ocean conditions.
- Establish the relative abundance, size, and condition of juvenile salmonids that utilize the coastal regions of the Pacific Arctic Region and establish whether juvenile salmon utilize the coastal waters of the Beaufort Sea during late summer and determine their likely origin.
- Develop spatially explicit bioenergetics models for Arctic cod and saffron cod as well as juvenile pink and chum salmon and test the impact of warming summer temperatures on their growth and distribution.
- Provide a geodatabase including base maps and attribute tables of marine fish and lower trophic communities.
- Facilitate collaboration for an integrated ecosystem analysis with other researchers including the partnership with the NPRB Arctic Program.
- (Part B)Test the hypothesis that a large under-ice spawning aggregation of Arctic cod in the northern Chukchi Sea serves as a source for Arctic cod in the Beaufort Sea, whereas saffron cod form local populations in the coastal waters of the Chukchi and Beaufort Seas.
- (Part C) Quantify the distribution, abundance, and prey association of seabirds in the PAR in relation to oceanographic conditions, prey abundance, and feeding guilds.

Methods: Survey protocols will follow established methods such as those employed during the Arctic Ecosystem Integrated Survey (Arctic EIS) with sampling conducted from at least two platforms (bottom trawl survey, mid-water/acoustic survey and surface trawl survey). Sampling will be adapted based on Arctic EIS results and

experience. In particular, mid-water/acoustic surveys will be the primary surveys in the northern Chukchi Sea and Beaufort Sea for assessing young-of-the-year and forage fish, while surface trawl sampling for juvenile salmon will be adaptive and exploratory as it is unknown if juvenile salmon utilize the Beaufort Sea. Oceanographic and plankton sampling in the Chukchi Sea will be coordinated with the recently funded Arctic Marine Biodiversity Observation Network (AMBON) project. However, the sampling design in the Chukchi Sea will likely differ from the transect-based AMBON design to more closely match the 2012 bottom trawl survey and 2012/13 oceanographic and fisheries surveys. The appropriate sampling design for the Beaufort Sea remains to be determined, but may proceed either along a grid or along a series of onshore-offshore transects. If resources permit, acoustic transects will be extended offshore to detect possible aggregations of Arctic cod along the slope and into the basin, based on similar surveys conducted in the Canadian Beaufort Sea.

Seabird surveys will be conducted using visual observations and standardized strip transects, with adjustments used for previous Alaska surveys. Surveys will be conducted during daylight hours while transiting between sample stations. The observer records all marine bird and mammal sightings within 300m and a 90° arc forward from the 'center line' (line of travel). Standard transect width will be 300m, with individual sightings recorded in distance bins (0-50m, 50-100m, 100-200m, 200-300m, >300m), and angle from the observer in 5 degree increments. Birds in the water or actively foraging are recorded continuously, while flying birds are recorded during quick 'scans' of the transect window at intervals of approximately 1• min-1 (depending on vessel speed) to avoid overestimating. The observer records observations directly into a laptop computer using survey software DLog3 (A.G. Ford, Inc., Portland, OR), recording species, number of individuals, behavior (on water, in air, on ice, foraging), distance bin, and angle. Environmental variables such as sea state (Beaufort scale), glare, weather, and sea ice cover (proportion in tenths) are recorded at first entry and automatically thereafter unless updated as necessary.

Survey data will be combined with recent laboratory results on the growth of Arctic gadids and results from modeling possible transport pathways of particles from the Chukchi Sea to resolve the connectivity of Arctic cod and saffron cod between the Chukchi Sea and the Beaufort Sea. In addition, specimens collected during the surveys may be shared with a variety of researchers to further improve understanding of the biology of Arctic fishes (age & growth, genetic structure, energetics, trophic dynamics). Integration will occur from the benthos to the pelagic and the near surface waters, and will include fish, oceanography, and plankton sampling, coupled with seabird observations. All components will provide inputs into an Integrated Ecosystem Assessment.

Specific Research Question(s): What is the current composition, distribution, relative abundance and condition of the demersal and pelagic fish communities in the Chukchi and Beaufort Seas?

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Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	Updating Status and Trends of Seabirds and Forage Fish in Lower Cook Inlet (AK-16-09)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	Rick Raymond, richard.raymond@boem.gov
Conducting Organizations(s)	USGS
Total BOEM Cost	$300,000
Performance Period	FY 2018-2020
Final Report Due	April 2020
Date Revised	September 26, 2019
PICOC Summary	
Problem	Information on seabird populations and forage fish stocks in Lower Cook Inlet (LCI) is outdated. New information on population dynamics and current trends is needed due to ongoing environmental change occurring in the LCI.
Intervention	This study will conduct field surveys to assess current abundance, distribution and species composition of forage fish around seabird colonies (Chisnik and Gull Islands) in LCI through demographic data on seabirds and their prey base.
Comparison	Study results will document changes in seabird and forage fish populations over time.
Outcome	The analysis will contrast the functional response of seabirds to prey fluctuations, relate trends in birds and fish, and directly measure local changes in the environment to the larger scale indices of climate change.
Context	Cook Inlet

BOEM Information Need(s): Seabird densities in lower Cook Inlet are among the highest in Alaska—one reason why the greatest damage to marine bird populations from the Exxon Valdez oil spill occurred there. Resident and migratory seabirds are supported by abundant local stocks of key forage fish species such as herring, sand lance and juvenile pollock. Monitoring of seabird populations and forage fish stocks in potential oil and gas lease areas has been a BOEM priority for decades, both to mitigate impacts of development and to assess the impact of potential oil spills. Both tasks are compromised when population estimates are outdated, and prediction of resilience to development or spills is enhanced by knowledge of population dynamics and current trends. Following intensive investigations of seabirds and forage fish in lower Cook Inlet during 1995-2000, collection of such data in lower Cook Inlet has been limited. The information collected in this new study will be used to support environmental analyses for potential future lease sales and exploration, development and production activities in Cook Inlet.

Background: USGS led seabird and forage fish studies in lower Cook Inlet during 1995-1999 to assess the recovery of seabird populations following the 1989 Exxon Valdez oil spill. The original project was designed to measure the foraging and population responses of six seabird species to fluctuating forage fish densities around three seabird colonies in lower Cook Inlet (Barren, Chisik and Gull islands). These studies included at-sea surveys for forage fish (hydroacoustics, trawling, seining and associated oceanographic measurements) while measuring aspects of seabird breeding biology (egg and chick production, chick growth, population status and trends) and foraging behavior (diets, feeding rates, foraging time) at the three colonies. The most detailed data were collected on Common Murres (*Uria aalge*) and Black-legged Kittiwakes (*Rissa tridactyla*), the most commonly monitored species in Alaska. The breeding biology and population trend of seabirds differed markedly between colonies relative to persistent geographic differences in forage fish abundance, which were in turn related to persistent oceanographic structuring of habitat in lower Cook Inlet.

Fifteen years have passed since these studies were completed, and little comparable work has been conducted during the interim. Anecdotal reports suggest that major ecosystem changes have occurred, including rather large changes in ocean temperature from warm to cold and back to warm that may influence the timing of breeding and reproductive success of birds on Gull and Chisik Islands. Whether these changes have resulted in changes to the population trajectories observed in the 1990s remains unknown. Additionally, in the winter of 2015/2016 there has been a massive die-off of Common Murres, possibly due to starvation. Murre die-offs have occurred in previous winters, but not in the numbers Alaska is seeing. A return to lower Cook Inlet to gather new data on seabird demography and forage fish communities will help establish the range of natural variability in population parameters in relation to environmental factors and provide an updated baseline of ecosystem condition in advance of new oil and gas leasing.

Objectives: This study will conduct a pilot year of field surveys which will focus on assessing the prey base around seabird colonies (Chisnik and Gull Island) in lower Cook Inlet, while also gathering basic demographic data on seabirds at the colonies. This pilot year may broaden into a larger planned study, which has the following overarching objectives:

- Assess the current abundance, distribution and species composition of forage fish near the two main seabird colonies in lower Cook Inlet over four years.
- Assess foraging behavior (diets, feeding rates, foraging time) at the three colonies.
- Census current populations of murres and kittiwakes at their colonies in lower Cook Inlet, and assess average levels of annual production over four years.
- Compare findings for fish and seabirds with data collected in 1995-1999, and relate trends to long-term environmental changes in ocean climate.

Methods: To facilitate comparisons with data from the prior studies, similar protocols for measuring food availability and seabird population biology will be employed, with some refinements. Forage fish abundance will be assessed using mid-water trawls

(CPUE, catch composition) and acoustic surveys (biomass in MT/km^2) around each colony. Densities of seabirds and marine mammals, and sea surface temperature/ salinity will also be recorded continuously on transects. A CTD profiler will measure temperature, salinity, chlorophyll, and turbidity at depth on selected stations. USGS researchers will coordinate and collaborate with the NOAA Kasitsna Bay Laboratory in collection of oceanographic data, and provide all data to the NOAA Kachemak Bay National Estuarine Research Reserve data archives.

At the colonies researchers will census kittiwakes and murres on established monitoring plots, measure reproductive success of adult birds, and collect data on diet composition of adults and chicks. If USGS researchers obtain supplementary funding from other sources (e.g., EVOSTC, NPRB) the work may be expanded to monitor foraging time budgets at colonies, and resume banding studies to measure annual adult survival rates of murres and kittiwakes. Researchers will coordinate and collaborate with the USFWS Alaska Maritime National Wildlife Refuge on studies of seabirds at Chisik and Barrens islands, and with the Seldovia Native Corporation for studies on Gull Island.

Methods of data analysis will center on contrasting the functional responses of seabirds to prey fluctuations within and between decades of study, and relating trends in birds and fish to directly measured local changes in the environment (e.g., temperature, salinity) and to larger scale indices of climate change (e.g., ENSO, Pacific Decadal Oscillation, Global Warming Trend). It will be important to quantify these sources of natural variability to evaluate possible future trends under different climate scenarios, and distinguish these from potential direct human impacts of OCS oil and gas exploration and development or oil spills in Cook Inlet.

Specific Research Question(s):

1. How has forage fish and seabird populations changed since USGS led seabird and forage fish studies in LCI during 1995-1999?
2. What are the climate factors occurring in Cook Inlet are affecting fluctuations in seabird population and their prey and what are the anticipated long-term effects?

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Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	Alaska Wave Energy Converter Impact Assessment (AK-17-02)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	Dr. Heather Crowley, heather.crowley@boem.gov
Conducting Organizations(s)	University of Alaska Fairbanks
Total BOEM Cost	$780,000
Performance Period	FY 2017–2020
Final Report Due	March 2020
Date Revised	October 3, 2019
PICOC Summary	
Problem	Alaska holds vast potential for tidal and wave energy development, which can be harnessed to supply a cost-effective source of energy to Alaska's remote communities.
Intervention	This study will assess the feasibility of a wave energy conversion demonstration project already underway off the coast of Yakutat, Alaska, through collection of environmental data to support required environmental analyses.
Comparison	Researchers will work with UAF Alaska Center for Energy and Power, Alaska Energy Authority, DOE, FERC, NOAA, and USFWS to integrate and extend offshore environmental feasibility studies sufficient to fully assess the viability of wave energy projects in Yakutat and other areas of coastal Alaska.
Outcome	The project will provide a firm scientific understanding of seabed dynamics, ambient underwater noise, and fish and marine mammal presence and habitat requirements in the project area offshore of Yakutat and evaluate the implications for feasibility studies in other areas of Alaska.
Context	The study is focused on the Gulf of Alaska Planning Area, but will provide insight that is applicable to other areas of Alaska, particularly Cook Inlet. Results may also inform wave energy projects in other OCS areas.

BOEM Information Need(s): The Energy Policy Act of 2005 delegated regulatory authority to BOEM over renewable energy resources on the OCS. For hydrokinetic energy development, FERC manages permit authority for licensing while BOEM retains regulatory responsibilities for leasing and compliance requirements. To achieve complete assessment of the feasibility of a wave energy conversion demonstration project already underway off the coast of Yakutat, Alaska, additional environmental data is needed, including: subsea hazards, seabed sediment dynamics, ambient noise, and local distribution of marine mammals and fish. BOEM and other regulatory authorities will use this newly acquired information to make immediate decisions about the viability and planning of commercial interests in offshore renewable energy projects in Yakutat and other promising locations, including on the OCS.

Background: Alaska holds vast potential for tidal and wave energy development. With emerging technologies, these energy resources are becoming more attractive to coastal communities as a potential energy source to diminish reliance on costly diesel fuel. Yakutat is a remote community located along the northeastern Gulf of Alaska. Their current power generation is 100% from diesel fuel, which must be barged in, resulting in a high cost of electricity that averages $.60 per kilowatt hour. The City and Borough of Yakutat, along with tribal leaders, have identified other options to meet their energy needs, including wave energy. Their interest led to an effort in 2009 to launch initial research intended to assess both available wave energy and local environmental factors that would establish the feasibility of advancing a development project using emergent "wave energy converter" (WEC) technology available from the Boston-based company, Resolute Marine Energy. FERC approved a preliminary permit for the project in January 2013 to initiate such feasibility studies. The preliminary project design envisions an array of nine wave converters positioned beyond the surf zone on the seabed in State waters running parallel to shore.

Study results from this assessment indicate that Yakutat wave resources provide "excellent" energy source potential in both deep and shallow water. However, additional data on environmental factors is necessary to assess the viability of undertaking the development. In particular, comprehensive assessments are still needed in three specific topical areas: subsea hazards, seabed dynamics, and marine mammals. In 2016, bathymetry and seabed depth work will be funded by the Department of Energy. But information needs are still pressing to characterize seabed dynamics, including areas prone to sediment movement and their implications for benthic habitat. Information needs are also still pressing to characterize ambient underwater noise, as well as presence and habitat implications for local fish and marine mammals. Without BOEM engagement, this demonstration project will remain incomplete and inconclusive, inhibiting renewable energy momentum in Alaska.

Objectives:

- Collect scientific and technical data sufficient to complete assessment of the feasibility of the Yakutat Wave Energy Project.
- Establish firm scientific understanding of seabed dynamics, ambient underwater noise, and fish and marine mammal presence and habitat requirements in the project area offshore of Yakutat.
- Evaluate implications of findings from the Yakutat Wave Energy Project for feasibility studies in other coastal regions of Alaska, including extensions onto the OCS.

Methods: Researchers will work with UAF Alaska Center for Energy and Power, Alaska Energy Authority, DOE, FERC, NOAA, and USFWS to integrate and extend offshore environmental feasibility studies sufficient to fully assess the viability of wave energy projects in Yakutat and other areas of coastal Alaska.

Specific Research Question(s):

1. What physical and biological parameters may be affected by a wave energy conversion facility off Yakutat, Alaska?
2. How can lessons learned from the Yakutat Wave Energy Project inform similar projects in other areas?

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Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	Marine Bird Distribution and Abundance in Offshore Waters (AK-17-03)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	Rick Raymond, richard.raymond@boem.gov
Conducting Organizations(s)	USFWS
Total BOEM Cost	$510,000
Performance Period	FY 2017-2021
Final Report Due	September 2021
Date Revised	September 26, 2019
PICOC Summary	
Problem	Seabirds are wide-ranging apex predators and good indicators of changes in marine ecosystems. Therefore information on distribution, abundance, and habitat requirements of marine birds is needed to assess effects of oil and gas exploration, development and production in the Chukchi Sea, Beaufort Sea, and Cook Inlet Planning Areas.
Intervention	Information obtained from marine bird surveys would assist in development of mitigation measures and strategies to reduce potential impacts on all seabirds and listed species under the ESA.
Comparison	The results will document changes in marine bird populations over time and support ESA Section 7 consultations and NEPA analyses.
Outcome	The analysis will estimate the spatial distribution, species composition and seasonal changes in populations and estimate abundances for marine birds in designated Alaska OCS planning areas.
Context	Chukchi Sea, Beaufort Sea, and Cook Inlet Planning Areas

BOEM Information Need(s): This project will provide basic information on distribution, abundance, and habitat requirements of marine birds, necessary to assess potential effects of oil and gas exploration, development and production in the Chukchi Sea, Beaufort Sea, and Cook Inlet Planning Areas. Results from the project will support ESA Section 7 consultations and NEPA analyses for potential future lease sales and DPPs. The information obtained from these surveys may assist in development of mitigation measures and strategies to reduce potential impacts on listed and candidate species under the ESA (Spectacled Eider, Steller's Eider, Short-Tailed Albatross, Yellow-billed Loon) as well as Priority Species identified by the USFWS (11 Tier-1 species and 14 Tier-2 species). By collaborating with multi-disciplinary vessel-based projects, it will be possible to make linkages between physical and biological factors that influence the distribution of marine birds.

Background: Seabirds are wide-ranging apex predators and good indicators of changes in marine ecosystems. Seabirds spend most of the year offshore, yet our information needs are greatest for the pelagic aspect of their lives. To address these

needs, an At-sea Seabird Observer Program was initiated by the U.S. Fish and Wildlife Service with a grant from the North Pacific Research Board (Project 637; 2006-2008) and continued as part of the Bering Sea Study (B64; 2008-2010) and by an inter-agency agreement with BOEM (AK-10-10; 2010-2015) to provide marine bird data for areas of oil and gas activity. In total, these surveys provided > 200,000 km of survey effort to the North Pacific Pelagic Seabird Database and resulted in marine bird distribution files and multiple publications relevant to BOEM requirements for NEPA and other Environmental Assessments in offshore waters. Among the published findings: seabird and marine mammal 'hotspots' in the Chukchi Sea; evidence of shifts in distribution and species composition in the Bering and Chukchi Seas; new information was also obtained on seasonal changes in seabird distribution and on locations of molt areas for several alcid species. Additionally, BOEM has collaborated with USFWS in Cook Inlet as part of the GulfWatch Alaska program in 2014-2015. Because of observed and on-going climate change, it will be important to document shifts in species distribution, particularly following the exceptionally warm 2014 and 2015 years, with predicted warm conditions in 2016-2017.

Basic information on timing and duration of use within designated Alaska OCS planning areas is necessary to better define the impacts of perturbations and ultimately population effects. Breeding seabirds are generally monitored at colonies, yet they spend most of the year dispersed offshore. Additionally, one half or more of all seabirds do not breed in a given year, thus management of marine birds requires knowledge of spatial and temporal patterns of seabird distribution at sea.

Objectives:

- Estimate the spatial distribution, species composition and seasonal changes in species and estimate abundances for marine birds in designated Alaska OCS planning areas.
- Process the data for entry into the North Pacific Pelagic Seabird Database for future accessibility and facilitate management decisions for marine bird use of planning areas.
- Examine trends in abundance of key species by comparison to 1993 and 1995-99 for Cook Inlet, and for Kachemak Bay, relative to 2005-2007 and 2011. These historic data and the newly collected observations will be used to determine if there have been changes in marine bird distribution.
- Examine the effects of environmental drivers (climate and oceanographic conditions) as well as biological drivers (prey availability) on seabird distribution by collaborating with researchers who collected oceanographic and biological data during the same research cruises.

Methods: This project will build off established methods for an at-sea survey program, to opportunistically collect distribution data on seabirds via partnership and collaboration among the USFWS, NOAA-Fisheries and other vessel-based monitoring or research programs. Observers will conduct visual surveys using established protocol (strip transect or modified distance sampling) to identify all marine birds and mammals

while a vessel is in transit. Data is entered directly into a computer with location data (latitude and longitude) along with associated environmental conditions. Data is processed and submitted to the North Pacific Pelagic Seabird Database by converting counts into densities (birds/km2). Five data sets (time series) will be compared for abundance trends and analyzed for changes. The report will discuss how environmental drivers relate to spatial distribution and abundance of key species and discuss whether climate change is affecting listed species or document other potential causes (reduced breeding habitat, etc.).

Specific Research Question(s): Is the environmental change occurring in the Arctic affecting seabird distribution and abundance?

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Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	Environmental Resource Areas: Developing Products to Support Oil-Spill Risk Analysis (OSRA) and National Environmental Policy Act (NEPA) (AK-18-01)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	Sean Burril, sean.burril@boem.gov
Conducting Organizations(s)	USGS
Total BOEM Cost	$400,000
Performance Period	FY 2018-2022
Final Report Due	January 12, 2022
Date Revised	September 26, 2019
PICOC Summary	
Problem	Tools or methods for analyses are needed to identify environmental resource areas (ERAs) for consideration in the assessment of potential impacts to marine mammals, cetaceans, seabirds, and other resources from Outer Continental Shelf (OCS) oil- and gas-related activities.
Intervention	Synthesis of available information about individual species or other resources to facilitate development of methods for identifying ERAs.
Comparison	This study will provide improved efficiency defining ERAs over existing approaches that are individualized for various resources. This will also allow for better continuity to update the information when staffing changes.
Outcome	A consistent approach that can be applied to multiple resources and planning areas to produce a collection of ERAs in support of OSRA.
Context	All Alaska Planning Areas

BOEM Information Need(s): Refined information of the density distribution and temporal timing of resources susceptible to effects from potential oil spills will inform better decisions when developing inputs to BOEM's OSRA. Results from this project will help refine ERAs used in OSRA and will assist BOEM in National Environmental Policy Act (NEPA) analyses for potential future lease sales, for Exploration Plans (EPs), Development and Production Plans (DPPs), Endangered Species Act (ESA) Section 7 consultations, and decision-making on the Outer Continental Shelf (OCS) in Alaska by helping to identify the resources and geographic areas most susceptible to potential impacts from OCS activities.

Background: Having a good understanding of the seasonal distribution, relative abundance, and habitat use of birds, fish, marine mammals, and other species on the OCS is fundamentally important to evaluating the potential environmental impacts associated with oil and gas exploration and development, as well as cumulative impacts related to other activities. Different species have differing temporal and spatial distributions, which complicates the analyses, and many of the species are also used for

subsistence and form an important part of the diet and cultural base for people in communities along the Alaska coast.

BOEM and others have amassed extensive datasets documenting spatial presence and other information for a wide range of species. The distributions of many species are temporally and spatially structured, showing seasonal or interannual changes in response to various mechanisms. These factors affect the vulnerability of a species to contact from a potential oil spill that BOEM considers as part of its OSRA through identification of ERAs, which are areas of concern relating to social, environmental, or economic resources, including critical habitat or use areas for different species of concern. Each ERA has a spatial and temporal attribute and its vulnerability may vary according to the time of year. Numerous methods are used to define the location and geographical extent of ERAs, depending on the availability of data.

Using various analysis and modeling techniques (e.g. Quakenbush and Citta 2013 and Citta et al. 2015, Roberts et al. 2016, etc.), researchers have evaluated a range of species and simulated seasonal movement patterns that resemble those suggested in the literature. Results from these efforts were then used to produce monthly mean density maps for the species considered.

Objectives: The overall goal of this study is to establish a consistent foundation for developing and refining ERAs used for OSRA. This project will focus on evaluating the distribution and abundance of seabirds and forage fish in marine areas off Alaska. The specific objectives include:

- Assess the utility of different modeling techniques or other analyses to evaluate distribution, abundance and temporal timing of marine birds and forage fish;
- Evaluate patterns of movement and aggregation (i.e. herding, flocking, etc.), as well as spatial variations in seasonal density of identified species in marine areas off Alaska;
- Provide density information or other dataset that is appropriate for identifying ERAs for the species or populations evaluated to support OSRA.
- Estimate the absolute size of seasonal populations for the most common breeding and transient seabird species within each of Alaska's four Large Marine Ecosystems (Gulf of Alaska, East Bering Sea, Chukchi Sea, Beaufort Sea);
- Compile an Alaska Forage Fish Database (AFFD);
- Map forage fish abundance in the marine areas off Alaska.

Methods: This study will update the North Pacific Pelagic Seabird Database (NPPSD) by consolidating approximately 200,000 km of new survey information conducted in the Gulf of Alaska, Aleutian Islands, and the Bering, Chukchi and Beaufort seas since the last NPPSD update in 2012. Researchers will evaluate different modeling techniques that can be applied to NPPSD data to develop gridded seabird density estimates offshore of Alaska. The data will be analyzed to estimate seasonal populations for the most common breeding and transient seabird species and to produce maps of the relative

distribution and abundance of common breeding and transient (non-breeding) seabirds that utilize U.S. territorial waters off Alaska, including both continental shelf and oceanic habitats. Where sufficient data exist, seasonal patterns of distribution will be mapped as well.

Researchers will also compile an Alaska Forage Fish Database (AFFD), by combining all available data from research groundfish trawls, predatory fish stomach samples, and beach seines. Algorithms to convert raw data from forage fish samplers into indices of abundance will be used to combine data from the various sources into a single dataset to facilitate mapping of forage fish abundance in all marine areas of Alaska.

Specific Research Question(s):

1. What consistent method or methods can be identified to define a set of ERAs to facilitate the OSRA process in an efficient manner?
2. How can existing data for seabirds and forage fish be best utilized for defining ERAs to support OSRA?

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Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	Impacts of Sedimentation and Drivers of Variability in the Boulder Patch Community, Beaufort Sea (AK-19-01)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	Rick Raymond richard.raymond@boem.gov
Conducting Organizations(s)	University of Texas at Austin and UAF
Total BOEM Cost	$750,000
Performance Period	FY 2019–2024
Final Report Due	June 2024
Date Revised	October 4, 2019
PICOC Summary	
Problem	The Boulder Patch provides complex and unique habitat and supports high biodiversity in an area of considerable oil and gas interest, which includes the proposed construction of Liberty Island (less than half a mile away). Impacts of industry activity may smother/bury/kill productive biological area, but mitigation measures may be possible.
Intervention	This study will conduct a monitoring program to examine long-term drivers of community variability during Liberty development activities. In addition, it will test possible mitigation measures using common industry materials to "reseed" or replace habitat lost due to Liberty Island development activities.
Comparison	The post-development community structure will be compared against historic data to assess impacts of O&G activity. Further, artificial substrate will be compared to buried boulders to test efficacy of using industry materials to mitigate development impacts.
Outcome	Results will include defined spatial gradients and temporal trends in environmental conditions, benthic community structure, and kelp production in the Boulder Patch community; evaluation of the effect of sediments on Boulder Patch community; and assessment of test artificial substrates as possible habitat mitigation.
Context	Impacts of Sedimentation and Drivers of Variability in the Boulder Patch Community, Beaufort Sea (AK-19-01)

BOEM Information Need(s): Impacts to the Boulder Patch from proposed gravel island construction were identified by local communities as a concern during scoping for Liberty Island. Information about how development activities and other disturbances affect Boulder Patch organisms will inform potential future NEPA and EFH analyses for island construction in the Beaufort Sea. Potential mitigation measures will be explored, and may be incorporated in future analyses.

Background: The Boulder Patch, which is located close to the proposed Liberty Development Project (less than a half a mile away), is an area of hard bottom substrate uncommon to the region. Its high biodiversity supports tightly linked food webs, and connects to higher trophic levels such as fishes, seals, and polar bears. It is highly

vulnerable to both natural and anthropogenic disturbances. Spatial isolation of boulder fields and slow development of benthic communities limits ecosystem recovery from disturbances. Previous BOEM-sponsored studies have shown that recovery in this area from disturbances can take a decade or more to resolve (Konar 2007 and 2013). Resiliency to anthropogenic disturbances is unknown, yet critically important to understand in maintaining ecological integrity. Sediment collecting on the hard-bottom rocky habitat could slow community recovery even more through burial and smothering rather than whole organism removal, since the hard-substrate would no longer be available to colonizers. This proposed study builds on previous work and provides an opportunity to assess possible ecological effects of environmental disturbances before and during the construction of a gravel island. Future lease sales in the Beaufort Sea are expected. This study provides invaluable information about impacts of gravel island construction on complex, specialized habitat and will assess potential mitigation measures.

Objectives:

- Define spatial gradients and temporal trends in environmental conditions, benthic community structure, and kelp production in the Boulder Patch community
- Evaluate the effect of sediments and nearby island construction on Boulder Patch community
- Test artificial substrates as possible habitat mitigation.

Methods: Monitoring of Boulder Patch habitat will occur before and during Liberty Island construction. Biological and physical data collected will include: kelp production, salinity, depth, temperature, depth, pH, irradiance, turbidity, fish and invertebrate presence, and stable isotopic trophic structure. Data collected during island construction can be contrasted with historic data. Artificial colonization substrates will be assessed and compared to existing Boulder Patch habitat using typical island materials. Recolonization will be assessed from settling plate experiments and reciprocal transplant manipulations of cobbles.

Specific Research Question(s):

1. What physical and chemical factors affect spatial distribution and abundance of kelp in the Boulder Patch?
2. What are the production and community composition responses of kelp in the Boulder Patch to year-round variations in light availability and oceanographic conditions?
3. How do invertebrate and fish use of under ice habitat in the Boulder Patch vary over time?
4. What is the effect of sedimentation on resilience and the abundance and distribution of Boulder Patch biota under winter and summer conditions?
5. What are potential mitigation and monitoring methods to minimize lost Boulder patch habitat through replacement or substitute substrates?

Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	Kelp Restoration in the Boulder Patch (AK-19-02-02)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	Dr. Jeffrey Brooks jeffrey.brooks@boem.gov
Conducting Organizations(s)	CMI, UAF
Total BOEM Cost	$138,884 plus Joint Funding ($138,884)
Performance Period	FY 2020–2023
Final Report Due	September 1, 2022
Date Revised	October 9, 2019
PICOC Summary	
Problem	The uniquely diverse kelp habitat in the Boulder Patch is located in an area that could be impacted by oil and gas extraction activities at Liberty.
Intervention	Experimental restoration, using artificial reefs, of kelps as mitigation for potential adverse effects from offshore construction projects
Comparison	Comparison of artificial reefs to adjacent benthic community composition
Outcome	Evaluation of the value of artificial reefs as a mitigation tool for potential disturbances to foundation kelp in the Boulder Patch
Context	The Boulder Patch in the central Beaufort Sea

BOEM Information Need(s): This project will provide information to better understand marine environments affected by oil and gas development. BOEM needs better information regarding restoration of kelp to support management decisions, environmental analyses, and mitigation measures. The proposed work to experimentally enhance new kelp settlement will provide better scientific understanding of how to mitigate potential impacts of OCS oil and gas activities on this sensitive habitat. Future construction of a gravel island for oil and gas extraction in the Liberty region presents an urgent need to investigate how kelp can be preserved and enhanced.

Background: The Boulder Patch in Stefansson Sound, Alaska is a highly diverse and sensitive ecosystem in the midst of ongoing oil and gas extraction activities. Construction activities related to new oil and gas extraction on the Beaufort Sea OCS have a high probability to impact the highly diverse but sensitive ecosystem of the Boulder Patch. Increased sedimentation from the building of a gravel island could affect the kelps, which are a foundation species of the Boulder Patch. Scientists know natural recovery of these kelps to such disturbances is slow and could take decades. The study will test mitigation through artificial reefs for kelp and habitat enhancement, which would increase settlement and recruitment chances of the dominant kelp species. The study builds on existing knowledge from long-term monitoring.

Objectives:

- Establish artificial reefs with reproductive individuals of the main kelp *Laminaria solidungula*, as well as the secondary kelp *Saccharina latissima*.

- Compare kelp recruitment on artificial reef with recruitment on surrounding naturally occurring boulders.

Methods: Three replicate small artificial reefs will be constructed and placed using SCUBA in three different areas within the greater Boulder Patch area. The rock distribution at the Boulder Patch sites is patchy and an area mostly devoid of rocks will be chosen to set up the reefs. One area will be at an established dive site close to the Liberty construction site that typically has the highest kelp production because of the lower total suspended sediment loads and associated higher light conditions (Aumack et al., 2007, Bonsell and Dunton, 2018). The other two locations will be determined based on historical data of community structure and light conditions and accessibility. Each reef will consist of about 15 low profile concrete blocks (~30 x 20 cm) loosely distributed around an approximately 4 m^2 area. Using concrete over natural rock will help minimize the impact of this experiment on the natural Boulder Patch community. The number of new kelp recruits will be correlated with light and sedimentation measurements using correlation analysis. Kelp recruitment success will also be evaluated for the natural boulders in each year, and the overall community structure, as percent cover, to determine natural variation and occurrence of major disturbance. The experiment will run for 2 years after initial set-up to ensure detectable levels of recruitment.

Specific Research Question(s):

1. Will close proximity of available artificial reef substrate and mature reproductive kelp increase recruitment success of kelp in the Boulder Patch?

2. Do artificial reefs work as an effective mitigation tool for potential disturbances to foundation kelp in the Boulder Patch?

Title	Utilization of the Under-ice Habitat by Arctic Cod in the Western Arctic Ocean: A Multidisciplinary Collaborative Study (AK-19-02-03)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	Sean Burril; sean.burril@boem.gov
Conducting Organizations(s)	CMI, UAF
Total BOEM Cost	$258,539 plus Joint Funding ($258,539)
Performance Period	FY 2019-2022
Final Report Due	January 21, 2022
Date Revised	September 26, 2019
PICOC Summary	
Problem	Limited information exists on the under-ice distribution and habitat of Arctic cod. The association with sea ice is assumed to be a critical part of the life history for Arctic cod. This information will inform effective management of development activities, assessment of development impacts, and mitigation measures.
Intervention	Conduct surveys of Arctic cod under-ice using a Surface and Under-Ice Trawl (SUIT) during the late fall and early winter in the western Arctic Ocean.
Comparison	Current baseline understanding of the distribution and habitat association of Arctic cod in the Alaskan Arctic compared to information gained from this study.
Outcome	A better understanding of the under-ice associations of Arctic cod life history and key under-ice habitat locations in the western Arctic Ocean.
Context	Alaska Outer Continental Shelf, Chukchi and Beaufort Seas

BOEM Information Need(s): Information on under-ice fauna, particularly the use of under-ice habitat by Arctic cod, has been a priority for BOEM for several years. A current BOEM study includes developing a description of Essential Fish Habitat (EFH) for Arctic cod (AK-19-07). This project will provide information to help refine the EFH description and is a first step toward a comprehensive winter spawning survey for Arctic cod. Information on the use of sea ice by Arctic cod is especially important for analyses of the potential impacts of spilled oil that may become trapped and held under ice. The information obtained through this project will aid in understanding how this critical environment may be potentially affected by oil and gas exploration and extraction, or by renewable energy development, on the Outer Continental Shelf of the Chukchi and Beaufort seas.

Background: Arctic cod (*Boreogadus saida*) are the most abundant and widely distributed forage fish in the Arctic Ocean and surrounding seas, including the Pacific Arctic (De Robertis et al. 2017, Gillispie et al. 1997, Lowry and Frost 1981). Because of their high abundance and energy density, they are an important prey resource for many

seabirds (Matley et al. 2012) and marine mammals (Bluhm and Gradinger 2008, Loseto et al. 2009). Adult Arctic cod have a bentho-pelagic lifestyle and can reach high biomasses in some Arctic shelf and slope regions. Spawning takes place under the ice in late fall to early winter (Borkin et al. 1987). The eggs float to the underside of the ice and hatch approximately 60-85 days after spawning at sub-zero temperatures (Altukhov 1981, Sakurai et al. 1998). Developing eggs and larvae are closely associated with sea ice and may be particularly susceptible to changing ice conditions.

Until very recently, estimates of the abundance of Arctic cod under sea ice, based on observations by divers and from ice-hole catches, were believed to be low compared to large schools in the pelagic realm (Gradinger and Bluhm 2004, Melnikov and Chernova 2013). However, sampling of the upper 2 m of the water column under the ice with a "Surface and Under-Ice Trawl" (SUIT, Flores et al. 2012, van Franeker et al. 2009) demonstrated that Arctic cod were ubiquitous at the ice-water interface during summer in the Eurasian Basin of the Arctic Ocean (David et al. 2016). The extent to which Arctic cod use under-ice habitat in the Pacific Arctic is unknown, however. Aggregations of different age classes have been documented in various shelf and slope areas of the Chukchi and Beaufort seas across the open water season, but it is uncertain where these Arctic cod overwinter. It is likely that at least some of these Arctic cod become associated with sea ice after its formation in late fall and early winter.

Objectives: This study is a component of the Go-West expedition, which will examine the entrainment of young Arctic cod into the sea-ice habitat in the Chukchi and Beaufort seas during the fall and evaluate sea-ice association as an important survival strategy, which may have positive effects on recruitment to the adult population the following summer. Specific objectives of this project include:

- Identify sea-ice habitats favorable for Arctic cod in terms of physical properties, ice algal biomass and prey composition.
- Test for the presence of scattering layers in the underlying water column.
- Assess the pre-winter condition of Arctic cod.
- Assess the under-ice composition and abundance of zooplankton in late fall.
- Using genetics, assess the connectivity between central Arctic under-ice populations and shelf-based spawning populations of Arctic cod.

Methods: Researchers will sample Arctic cod, sympagic fauna, sea-ice habitat properties, and hydroacoustics profiles of zooplankton and fish in the western Beaufort Sea when sea-ice formation and potential entrainment of juvenile Arctic cod are in progress. The target area will be flexibly adapted to the position of the ice edge to allow sampling across the marginal ice zone, where sea-ice formation is taking place during fall and facilitate observation of entrainment of Arctic cod. Sampling is expected to occur over deep water offshore of the narrow Beaufort Sea shelf, but may be moved westward or onto the Chukchi shelf if freeze-up occurs early.

Researchers will sample at least 12 stations along several transects from the marginal ice zone into the consolidated ice pack. At each station they will obtain temperature and

salinity profiles and collect water samples to a maximum depth of 600 m, sample plankton in the upper 100 m of the water column using a vertical Bongo haul, deploy the SUIT, and obtain echograms using an EK80 echo sounder. In light ice conditions researchers will also deploy a pelagic net at selected depths if scattering layers are present. The SUIT will be used to estimate the abundance and size composition of Arctic cod, as well as the abundance and community composition of other ice-associated fauna in the upper 2 m of the water column both under ice and in open waters well beside the cruise track of its towing vessel. Additional sensors will collect data on sea ice and water column properties (e.g., temperature, salinity, chlorophyll a, ice thickness), as well as the speed and inflow angle of the water entering the net. An under-water video camera will be used to visually assess sea ice structure and catch efficiency of the net. Hyper-spectral probes (RAMSES, TriOS) will monitor the spectral light transmission during trawling to allow estimating the amount of ice algal biomass along the sampling path (Lange et al. 2016). The trophic significance of ice algae in the Arctic pelagic food web will be investigated with molecular and isotopic biomarkers.

Specific Research Question(s):

1. What is the extent of under-ice habitat use by Arctic cod in the Pacific Arctic?
2. Where do Arctic cod in the Pacific Arctic overwinter?

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Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	Model-based Essential Fish Habitat (EFH) Descriptions for Arctic Cod, Saffron Cod and Snow Crab in the Alaskan Arctic (AK-19-07)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	Sean Burril, sean.burril@boem.gov
Conducting Organizations(s)	UAF
Total BOEM Cost	$125,000
Performance Period	FY 2019-2021
Final Report Due	June 28, 2021
Date Revised	September 26, 2019
PICOC Summary	
Problem	Current understanding of the Arctic Fisheries Management Plan (FMP) target species habitat distribution is inadequate to define EFH to the level required to fully identify and address potential habitat impacts from anthropogenic disturbances.
Intervention	This project will update EFH descriptions for Arctic FMP species using current, comprehensive data.
Comparison	Modeling strategies and outputs will be compared to the current EFH designations to look for areas of refinement.
Outcome	Model-based EFH designations will be produced with life stage information, where available, to update current habitat distributions.
Context	Beaufort and Chukchi Seas

BOEM Information Need(s): This project will conduct species distribution modeling to improve the descriptions of habitat use by key Arctic species. The resulting refined habitat maps and descriptions by life-stage will strengthen BOEM's impact assessments during EFH and NEPA analyses associated with Arctic resource development activities.

Background: Essential Fish Habitat (EFH) definitions for the three species (Arctic cod, saffron cod, and snow crab) covered under the Arctic Fisheries Management Plan (FMP) are qualitative and based on presence-absence data. Commercial fishing is prohibited in the Arctic Management Area, but the habitats of these three ecologically important species may be subjected to non-fishing effects, necessitating increased understanding of their current habitat distributions.

Species distribution models can be used to identify important habitat characteristics that influence spatial patterns in abundance and may provide insight into changes in species distribution. Specifically, the species distribution models can be used to link habitat characteristics to species occurrence and catch per unit effort (CPUE) data from surveys (including several BOEM-funded studies). The ultimate goal of this project is to

refine the EFH text and maps for juvenile, adult and possibly larval life stages of Arctic cod, saffron cod and snow crab for the next 5-year EFH revision (target date 2021).

Objectives:

- Identify habitat characteristics most important to distributions and habitat suitability of larval (if data is available), juvenile and adult Arctic cod, saffron cod and snow crab.
- Refine map and text descriptions of EFH for Arctic cod, saffron cod and snow crab based on species distribution models.

Methods: Researchers will use two types of species distribution models that have been used to define EFH for groundfish in the Gulf of Alaska, Bering Sea and Aleutian Islands (Laman et al. 2017, Pirtle et al., 2017, Turner et al. 2017). First, maximum entropy (MaxEnt) models will be applied, incorporating presence-only data and habitat covariates to predict habitat suitability. In cases where data from large-scale surveys are available and CPUE is recorded, generalized additive models (GAMs) will be used to predict abundance.

As most biological surveys have occurred during the ice-free season (i.e., summer) in the Arctic, the proposed models will describe EFH during the summer. Previous survey data from 1972-2015 will be compiled and supplemented with recent survey data from the nearshore Beaufort Sea and the productive Barrow Canyon as it becomes available. When available, researchers will use length data, von Bertalanffy growth curves, and maturity data to separate juveniles from adults and model the life stages separately. Length-based gear selectivity curves may be used to convert CPUE data for Arctic cod between gear-types to create a more comprehensive dataset for modeling abundance. For species distribution models, habitat covariates to be considered include productivity, bathymetry characteristics, sediment types (Jenkins 1997; dbSEABED), currents, temperature, and salinity (Curchitser et al. 2013). Other habitat covariates will be considered, such as bathymetry-derived seafloor terrain metrics, biogenic habitat features, and occurrence of prey. Model fitting procedures will be used to identify the most important habitat characteristics to be used in the best-fit models.

Specific Research Question(s): How can distribution models be used to update maps and text descriptions for Arctic cod, saffron cod, and snow crab EFH?

Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	Marine Arctic Ecosystems Study (MARES): A Multi-Agency NOPP Partnership (NT-13-05)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	Dr. Heather Crowley, heather.crowley@boem.gov
Conducting Organizations(s)	Stantec Consulting Services Inc.
Total BOEM Cost	$5,415,501 plus Joint Funding ($547,583)
Performance Period	FY 2015–2020
Final Report Due	Multiple reports expected
Date Revised	October 3, 2019
PICOC Summary	
Problem	BOEM needs additional comprehensive and integrated information to better understand and assess arctic ecosystem sensitivities and vulnerabilities that can aid decision-makers in minimizing the impact of the oil & gas activities on the Outer Continental Shelf.
Intervention	This partnership between BOEM, ONR, Shell, and USARC takes an integrated ecosystem approach to monitoring environmental change in the Arctic while coordinating the efforts of several Federal agencies.
Comparison	Coordinated observational and modeling efforts will produce information that will be analyzed from different perspectives: a) ecosystem understanding and environmental protection, b) climate change and monitoring, and c) Oil-Spill Risk Analysis.
Outcome	This study will develop a description of the biogeochemical-physical interactions and feedback processes in ice free and ice covered areas, including a detailed spatio-temporal description of ocean currents at different depths along the Beaufort continental shelf, including ice covered areas.
Context	The U.S.-Canada border region of the Beaufort Sea

BOEM Information Need(s): Through this multi-agency agreement under the National Oceanographic Partnership Program (NOPP) BOEM expects to enhance multi-lateral arctic research coordination and to improve regulatory decisions and NEPA analyses pertinent to lease sales, EPs, and DPPs in the Beaufort Sea. The partnership will lead to specific task orders and objectives that will be developed and procured as discrete study profiles. Final reports will be available to inform NEPA analyses and decision-making; interim data products and inputs may also be used to address information needs.

Background: BOEM needs additional comprehensive and integrated information in the Arctic on the spatio-temporal distribution of fundamental physical, biological and chemical variables, their associated interactions and regulating mechanisms, as well as the distribution of cultural and subsistence resources which sustain local communities. This information will be used to better understand and assess arctic ecosystem

sensitivities and vulnerabilities as a function of space and time to aid decision-makers in minimizing the impact of the oil & gas activities on the Outer Continental Shelf. The resulting information will support NEPA analyses, in validating models, and in Oil-Spill Risk Analysis. Additionally, these observations and improved description and understanding of biogeochemical and physical interactions will aid to improve the accuracy of model simulations and forecasts. Coordinated observational and modeling efforts will produce information that will be analyzed from different perspectives: a) ecosystem understanding and environmental protection, b) climate change and monitoring, and c) Oil-Spill Risk Analysis.

This partnership between BOEM, ONR, Shell, and USARC takes an integrated ecosystem approach to monitoring environmental change in the Arctic while coordinating the efforts of several Federal agencies. It is also responsive to the Interagency Arctic Research & Policy Committee (IARPC) 5-year plan (2017-2021) and research priorities, as well as recommendations from earlier MMS/BOEM studies.

Objectives:

- Identify and delineate areas of high biological productivity, as well as relative sensitivities and resiliencies to changes in environmental conditions within ecosystem components. This includes a detailed description of different trophic levels and their composition in terms of species abundance, distribution, and behavior in both ice free and ice covered habitat.
- Provide a qualitative and quantitative description of the biogeochemical-physical interactions and feedback processes in ice free and ice covered areas.
- Provide a detailed spatio-temporal description of ocean currents at different depths along the Beaufort continental shelf, including ice covered areas.

Methods: Proposed studies will emphasize an integrated, or ecosystems approach to data collection or synthesis. Each study will be based on the application of appropriate scientific methodologies, coordinating observational and modeling efforts, while focused on essential processes, functions and interactions among organisms and their environment. Proposed studies will recognize that humans, with their cultural diversity, are an integral component of ecosystems, and will accommodate appropriate methods of integration where possible, including access to traditional knowledge with active involvement of Alaska Natives in research planning and execution. Proposed studies will also seek to advance, where appropriate, the use of technology and instrumentation in monitoring and understanding complex ecosystem processes.

Specific Research Question(s):

1. What ecosystem changes are being observed in the Arctic?
2. How are different ecosystem components responding to these changes?

Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Study Area(s):	Beaufort Sea
Administered By:	Anchorage, Alaska Office
Title:	ANIMIDA III: Boulder Patch and Other Kelp Communities in the Development Area (AK-11-14a)

BOEM Information Need(s) to be Addressed: The Arctic Nearshore Impact Monitoring in Development Area (ANIMIDA) and continuation of ANIMIDA (cANIMIDA) have monitored the Boulder Patch Area of Special Biological Concern in the Beaufort Sea OCS. There is a continuing, ongoing need for this monitoring in the development area within the Beaufort Sea during the performance period of the study, which will coincide with continued production from Northstar, development and production from Liberty, and potential future delineation and development in Camden Bay. The information will support NEPA analysis and documentation for Beaufort Sea lease sales, EPs, and DPPs.

Total BOEM Cost: $647,661 **Period of Performance:** FY 2012-2020

Conducting Organization: CESU-University of Texas at Austin

BOEM Contact: Catherine Coon

Description:

Background: The ANIMIDA project started monitoring of the Boulder Patch in 2000. This and multiple other research projects on the Boulder Patch by BOEM, the National Science Foundation, and industry have allowed one of very few long-term monitoring records in the Arctic to be cobbled together, stretching from the late 1970s through the current decade.

The Liberty prospect adjoins the Boulder Patch. BOEM approved application for construction of a gravel island and production facility at Liberty (Hilcorp Alaska LLC). In addition, there is potential for exploration activity at active leases in the vicinity of Camden Bay, an area with known but poorly mapped kelp beds. Ongoing industry activities necessitate ongoing monitoring projects.

Objectives:

- Evaluate the potential impact from additional activities at the Liberty prospect on the Boulder Patch kelp community.
- Monitor the impact to the Boulder Patch community from increased summer turbidity and other oceanographic changes occurring with climate change.
- Estimate the importance of and extent of Camden Bay kelp patches.

Methods: The Boulder Patch kelp bed surveys and monitoring will be conducted using small vessel support in the open water season. Kelp production will be measured using established or comparable techniques. Oceanographic measurements shall include

ambient light intensity and total suspended solids using established or comparable techniques. Data will be combined with the existing long-term dataset. The extent of kelp in Camden Bay will be surveyed and GIS maps constructed of kelp and implied (boulder and or hard bottom) kelp beds in the study area.

Revised Date: October 1, 2019

Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	Microbial Biodegradation of Alaska North Slope Crude Oil in Arctic Marine Sediments (AK-13-03-24)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	Rick Raymond, richard.raymond@boem.gov
Conducting Organizations(s)	CMI, UAF
Total BOEM Cost	$174,931 plus Joint Funding ($174,931)
Performance Period	FY 2017-2020
Final Report Due	May 30, 2020
Date Revised	September 16, 2019
PICOC Summary	
Problem	Little is known about the oil biodegradation potential in the Arctic marine environment. Following an oil spill, microbial biodegradation is the main mechanism for removing petroleum from the marine environment. Understanding the oil biodegradation potential for ecosystems is important to assessing the fate and effects of oil contamination and for developing bioremediation strategies.
Intervention	This study will conduct laboratory incubation studies to investigate the biodegradation of fresh and weathered crude oil in sediments under both aerobic and anaerobic conditions in order to assess biodegradation rates.
Comparison	The results will provide an in-depth analysis of the crude oil biodegradation potential of Arctic marine sediments.
Outcome	The analysis will document biodegradation rates and identify oil-degrading microbes.
Context	Beaufort Sea

BOEM Information Need(s): BOEM needs additional information to facilitate evaluation of the fate of oil spilled in the Arctic marine environment. To better assess the fate of oil spilled in the Arctic marine environment, there is a need to understand the oil biodegradation potential in Arctic sediments. BOEM analysts and decision-makers can use this information in NEPA analysis and documentation for potential EPs and DPPs in the Beaufort Sea.

Background: Ice-covered waters are becoming more accessible to human activities, increasing the likelihood of anthropogenic disturbance and contaminant exposure through oil and gas development as well as increased commercial shipping and other activities. Because microbial biodegradation is the primary means through which petroleum is removed from the marine environment following a spill, knowing the oil biodegradation potential for each ecosystem compartment (i.e. shoreline, sea ice, sea surface, water column, and benthos) is important to evaluating the fate and effects of oil contamination and to developing cleanup strategies such as bioremediation. To date,

relatively little is known about the oil biodegradation potential of the Arctic marine environment, particularly in the benthos (sediment).

Oil in the benthos, although less visible than that on the surface or shoreline, can greatly impact the health of the marine system immediately following an oil spill for up to a decade or more, and can result in adverse effects on both benthic and pelagic food webs. Oil can be toxic or fatal to a multitude of demersal fishes and invertebrates and is persistent in the environment and the tissues of exposed organisms years after a spill event. Ten years following the Exxon-Valdez oil spill (EVOS), researchers discovered oil compounds both within marine sediments and at toxic levels within the tissues of organisms such as Pacific Halibut, mussels, and clams. In Arctic marine sediments, benthic fishes and invertebrates compose all or some of the diets of marine mammals including walruses, seals, and bowhead whales, which are also important for Alaska Native subsistence hunting. Thus, understanding the fate of oil in Arctic marine sediments is important to assessing the potential environmental and human health impacts of an oil spill in this ecosystem.

This study proposes to perform laboratory incubation studies to investigate the biodegradation of fresh and weathered crude oil in sediments under both aerobic and anaerobic conditions in order to assess biodegradation rates and to identify oil-degrading microbes, which can help to formulate projections regarding the fate of spilled oil in sediments.

Objectives:

- Assess the capacity for biodegradation of Alaska North Slope crude oil by indigenous microorganisms in subtidal Arctic marine sediments under aerobic and anaerobic conditions.
- Compare the biodegradation of fresh oil versus moderately weathered oil in Arctic sediments.
- Identify microorganisms involved in biodegradation of oil in Arctic marine sediments.
- Utilize taxonomic information from incubation studies to assess the distribution of putative oil-degrading microbes

Methods: Marine sediment samples will be collected approximately one km offshore on the Chukchi Sea, directly north and west of Point Barrow, AK in late summer (August-October) 2017. Laboratory incubation studies will be performed to investigate the biodegradation of fresh and weathered crude oil in sediments under both aerobic and anaerobic conditions to assess biodegradation rates and to identify oil-degrading microbes, which can facilitate evaluation of the fate of spilled oil in sediments. Following the identification of putative oil-degrading bacteria in incubation tests, queries will be conducted to existing microbial community datasets from sediments across the Beaufort Sea to assess the biodegradation potential present in indigenous sediment microbial communities across the region. Together, the findings will provide an in-depth analysis

of the crude oil biodegradation potential of Arctic marine sediments at growing risk of contamination.

Specific Research Question(s): How many microorganisms species are involved in biodegradation of oil in Arctic marine sediments?

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Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	Oil-Spill Occurrence Estimators for the Outer Continental Shelf in the Arctic (AK-16-04)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	Dr. Heather Crowley, heather.crowley@boem.gov
Conducting Organizations(s)	ABS Group
Total BOEM Cost	$262,821 (task orders to date)
Performance Period	FY 2017–2022
Final Report Due	Multiple reports expected
Date Revised	October 4, 2019
PICOC Summary	
Problem	The OCS spill occurrence rates used in non-Arctic BOEM NEPA analyses are based on historical platform, pipeline or tanker crude oil-spill rates, almost entirely from the Gulf of Mexico and Pacific OCS. For analyses in the Arctic BOEM has to consider differences in oil-spill occurrence factors between the Arctic and Gulf of Mexico OCS and Arctic-specific factors.
Intervention	Apply a Monte Carlo fault tree model to modify historical oil-spill occurrence rates from other OCS areas to develop oil-spill occurrence estimators for the Arctic OCS.
Comparison	Factors to be considered include: differences storm rates and vessel activity, as well as Arctic-specific factors such as ice gouging.
Outcome	Oil-spill occurrence estimates to support NEPA analyses for oil and gas lease sales or development projects in Arctic OCS areas.
Context	Beaufort Sea and Chukchi Sea Planning Areas

BOEM Information Need(s): The Oil-Spill-Risk Analysis (OSRA) is a cornerstone to BOEM EISes, EAs, and oil-spill contingency planning. Oil-spill issues constitute a substantial portion of public comments submitted on sale or development EISs in the Alaska Office. This study is necessary to develop oil-spill occurrence estimators for NEPA analyses for oil and gas lease sales or development projects in Arctic OCS areas.

Background: The OCS spill occurrence rates used in non-Arctic BOEM NEPA analyses are based on historical platform, pipeline or tanker crude oil-spill rates, almost entirely from the Gulf of Mexico and Pacific OCS. For analyses in the Arctic since 2002, the BOEM Alaska Office has incorporated a fault-tree approach, which considers 1) differences in oil-spill occurrence factors between the Arctic and Gulf of Mexico OCS and 2) Arctic-specific factors. Recent examples of such analyses include:

Bercha Group, Inc. 2014. Updates to Fault Tree Methodology and Technology for Risk Analysis Chukchi Sea Sale 193 Leased Area. OCS Study BOEM 2014 -774. Anchorage, AK: USDOI, BOEM, Alaska OCS Region. 109 pp.

Bercha Group Inc. 2013. Updates to Fault Tree for Oil Spill Occurrence Estimators, Update of GOM and PAC OCS Statistics to 2012. OCS Study BOEM 2013-0116. Anchorage, AK: Prepared by Bercha International Inc. for USDOI, BOEM, Alaska OCS Region. 35 pp. http://www.boem.gov/2013-0116/.

Bercha, F.G. 2011. Summary Final Report Alternative Oil Spill Occurrence Estimators for the Beaufort and Chukchi Seas - Fault Tree Method. OCS Study BOEMRE 2011-030. Anchorage, AK: Prepared by Bercha Group, Calgary, Alberta, for USDOI, BOEMRE, Alaska OCS Region. 48 pp. http://www.boem.gov/BOEM-Newsroom/Library/Publications/2011/2011-030.aspx.

Objectives:

- Update Gulf of Mexico and Pacific OCS historical oil-spill statistics.
- Provide analyses on topics relevant to oil-spill occurrence rates, spill sizes, oil-spill frequency distribution, and other parameters.
- Obtain fault tree spill occurrence rates and confidence intervals for NEPA analyses for any Arctic OCS Lease Sales or for OCS offshore oil and gas developments.

Methods: Task orders from this study will: 1) review and assimilate oil-spill occurrence reports, data and geohazard data from alternative sources and locations as needed to update Gulf of Mexico and Pacific OCS historical data; 2) conduct literature searches and analyses on relevant topics, such as potential causal factors of oil spills in Arctic regions and differences in oil-spill occurrence factors between the Arctic and Gulf of Mexico and Pacific OCS, assessing the relative importance of various causal factors and conducting sensitivity analyses, evaluating whether oil-spill sizes and frequency distributions vary as a function of annual oil production rates; 3) use these data together with measures of spill size and frequency variance to run the Monte Carlo fault tree model with these measures of variance; 4) provide fault tree analyses as needed for Arctic oil and gas lease sales based on BOEM-supplied exploration and development scenarios, generating life-of-field oil-spill occurrence rates and indicators; 5) provide fault-tree analyses as needed for site-specific oil and gas developments in the Arctic, taking into account site-specific geohazards and generating life-of-field occurrence indicators; 6) provide a formal report documenting each analysis, and 7) provide professional support to BOEM in regard to statistical issues of occurrence rates and estimator(s) related to this study and its results.

Specific Research Question(s): How can historical oil-spill occurrence rates from the Gulf of Mexico and Pacific OCS be adapted to provide oil-spill occurrence estimators for the Beaufort Sea and Chukchi Sea Planning Areas?

Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	Hydrocarbon Seeps in the Lower Cook Inlet, Gulf of Alaska, Chukchi Sea and Beaufort Sea OCS Planning Areas (AK-18-x11)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	Jenna Foreman, jennafer.foreman@boem.gov
Conducting Org(s).	UAF
Total BOEM Cost	$200,000
Performance Period	FY 2019–2020
Final Report Due	August 19, 2020
Date Revised	October 4, 2019
PICOC Summary	
Problem	Information regarding location and extent of natural hydrocarbon seeps on the OCS off Alaska is limited. Information that does exist is dispersed throughout the body of scientific literature, or held by government agencies and other entities.
Intervention	Currently available information about the locations, volumes, and chemical and weathering characteristics of hydrocarbon seeps on the Alaska OCS, as well as information regarding hydrocarbon-consuming organisms in the area will be identified, gathered, and analyzed. Recommendations for collection of additional field data will also be developed.
Comparison	This study will provide baseline information regarding natural hydrocarbon seeps on the OCS.
Outcome	Data about seeps will assist BOEM geoscientists in identifying locations of undiscovered oil and gas resources on the Alaska OCS and determining the fair market value of leased OCS blocks. Results from this project will also support analyses under NEPA by helping to quantify the associated contributions of hydrocarbons to the environment.
Context	All Alaska OCS Planning Areas

BOEM Information Need(s): Hydrocarbon seep composition, location and volume information is needed to address multiple aspects of BOEM's mission: 1) Hydrocarbon surface seeps can be a direct indicator of subsurface hydrocarbon prospects. Information about area seeps will inform BOEM geoscientists in estimating the undiscovered oil and gas resources of the Alaska OCS and determining the fair market value of leased OCS blocks. 2) Natural seeps represent a large portion of the petroleum input to the sea, providing natural background concentrations of hydrocarbons in the environment. Better knowledge of area seeps will provide insight into consideration of cumulative effects in agency NEPA analyses of exploration and development of hydrocarbon prospects in the Alaskan OCS. 3) Chemosynthetic communities have been shown to populate near hydrocarbon seeps. Evaluating these communities will provide further inform NEPA analyses on the effects of exploration and development activities in the Alaska OCS.

Background: Hydrocarbon seep locations and compositions have been used in prospecting for oil and gas fields. It has been observed that the compositions of hydrocarbon seeps can be a direct indicator of hydrocarbons filling a subsurface prospect. It has also been shown that the composition of gas seeps can be used to determine whether a hydrocarbon prospect is filled with oil or gas (Jones and Drozd, 1983). Whether a prospect is filled with oil or with gas has important implications for estimating undiscovered technically and economically recoverable oil and gas.

Limited information is available about the spatial extent or volume of release from natural hydrocarbon seeps on the Alaska OCS, or the disposition and residence time of the hydrocarbons in the environment. Some information about the location and extent of natural hydrocarbon seeps in the Chukchi and Beaufort OCS exists in the form of sniffer and shallow core surveys, but there is little data available for seeps in the Lower Cook Inlet and Gulf of Alaska.

We have little knowledge of the chemical properties of Alaska OCS hydrocarbon seeps, how seeped hydrocarbons are affected by weathering, or how they compare to known hydrocarbon types in other development areas. The presence of natural hydrocarbon seeps is indicative of organisms adapted to metabolize the hydrocarbons. These organisms in turn indicate the capacity for microbial remediation of hydrocarbons in the environment, or natural bioremediation through the means of reducing pollutants by way of resident oil-eating bacteria. Oil-eating, cold-water bacteria in the Gulf of Mexico waters were a major factor contributing to removal of spilled oil from the Macondo spill in 2010.

Objectives:

- Identify available geological, geophysical, and geochemical data that can provide insight into the location and extent of likely oil seeps in the Lower Cook Inlet, Gulf of Alaska, Chukchi and Beaufort OCS Program Areas
- Provide recommendations for future field-sampling efforts to augment the results and to facilitate estimation of seep volume, chemical characterization of oil (water column and/or sediment) samples, and identification of communities of hydrocarbon-associated organisms.

Methods: Researchers will search the available literature, including the large volume of information from the OCSEAP program of the 1980s and 1990s, to identify and gather any available information about the locations, volumes, and chemical and weathering characteristics of hydrocarbon seeps on the Alaska OCS, as well as information regarding hydrocarbon-consuming organisms in the area. A map of known seeps will be produced. Researchers and BOEM scientists will convene two to three meetings to discuss results of these efforts and suggest geographic areas for future field-sampling endeavors. Topics of discussion shall include, but not necessarily be limited to: additional geophysical survey data (e.g. multibeam echosounder and sub-bottom profiler data) needed to expand the spatial coverage; identification of prospective sites for coring and geochemical analysis; methodologies for evaluation of seep volume, chemical composition of oil, and microbial communities.

Specific Research Question(s):

1. What information is available regarding natural hydrocarbon seeps in the Lower Cook Inlet, Gulf of Alaska, Beaufort, and Chukchi Program Areas?
2. What is best approach for evaluating the volume of the natural hydrocarbon seeps and the variations in chemical composition?
3. What sampling is required to evaluate the type of microbes or other organisms populate the vicinity of the hydrocarbon seeps?

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Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	Oil Spill Occurrence Estimators for Onshore and Offshore Crude and Refined Oil Spills on the Alaska North Slope and Cook Inlet, Alaska (AK-18-x12)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	Dr. Heather Crowley, heather.crowley@boem.gov
Conducting Organizations(s)	Nuka Research and Planning Group, LLC
Total BOEM Cost	$224,658
Performance Period	FY 2019–2021
Final Report Due	October 2020
Date Revised	October 3, 2019
PICOC Summary	
Problem	Petroleum hydrocarbon spill data for analyses, including the number, volume, and likelihood of such petroleum hydrocarbon spills, is needed to support the assessment of potential impacts under the National Environmental Policy Act (NEPA).
Intervention	Disparate petroleum hydrocarbon spill data will be collected into a systematic collation of data for mathematical analyses.
Comparison	A suite of objective methodologies will provide estimates of petroleum hydrocarbon spills needed for NEPA analyses.
Outcome	This project will deliver regionally-specific estimates of the occurrence of small oil spills for the Beaufort and Chukchi Seas and Cook Inlet.
Context	Beaufort Sea, Chukchi Sea, Cook Inlet

BOEM Information Need(s): The oil-spill risk analysis is a cornerstone to BOEM Environmental Impact Statements (EISs), environmental assessments (EAs), and oil-spill-contingency planning. Oil-spill issues constitute a substantial portion of public comments submitted on lease sale or development and production EISes and exploration plan (EP) or geophysical and geological EAs in the Alaska Office. Oil spill occurrence rates specific to Alaska derived from this study will be used by Alaska Office staff to estimate small oil spill occurrence (<1,000 barrels [bbl]) in preparing NEPA documents for future Beaufort Sea, Chukchi Sea, or Cook Inlet lease sales, Exploration Plans (EPs), Development and Production Plans, and in reviewing oil-spill-contingency plans for Outer Continental Shelf (OCS) and coastal facilities.

Background: The Bureau of Ocean Energy Management (BOEM), Alaska Office uses various datasets and models to estimate the number, volume and likelihood of large (≥1,000 bbl) and small (<1,000 bbl) spills occurring. These estimates are used to evaluate potential oil spills from a proposed OCS action and derive an impact determination for NEPA analyses. The OCS spill occurrence rates used in non-Arctic BOEM NEPA analyses are based on historical Gulf of Mexico and Pacific OCS platform, pipeline, or worldwide tanker crude oil-spill rates (ABS Consulting Inc., 2016). Since

2000, the Alaska Office has incorporated Alaska North Slope spills (Robertson et al., 2013) in the analyses.

Objectives:

- Develop relative spill occurrence estimator(s) suitable for use for onshore and offshore small oil spills on the Alaska North Slope using an appropriate exposure variable.
- Develop relative spill occurrence estimator(s) suitable for use for onshore and State offshore for small and large oil spills in and adjacent to Cook Inlet using an appropriate exposure variable.

Methods: Investigators will conduct a preliminary meeting to discuss acceptable statistical methods in consideration of historical statistical approaches, BOEM rationales for estimating oil spill occurrence rates, and possible sources of variance. The discussion will include: methods for deriving historical spill frequencies from Alaska North Slope and Cook Inlet spill records; exposure variables for spill frequency such as pipeline miles, volume of throughput, age, and well years; implications for using different exposure variables; limitations of the spill records; and recommended standard data format for exposure variables and accident data.

The investigators will update oil spill occurrence estimates previously calculated for the North Slope (Robertson et al., 2013). They will collect, examine, and reconcile crude and refined oil spill records and cleanup reports for the North Slope for spills ≥1 bbl from industry, U.S. Coast Guard (USCG), Environmental Protection Agency (EPA), U.S. Department of the Interior (DOI), Bureau of Land Management (BLM), BOEM, Bureau of Safety & Environmental Enforcement (BSEE), U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration (USDOT, PHMSA), and Alaska Department of Environmental Conservation (ADEC) datasets through 2019. Exposure data for Alaska North Slope will be collected and the number of wells, flow, and pipeline miles by year provided when available. The investigators will also calculate accident frequencies for small spills and perform appropriate statistical analyses, including trend analysis. Results will be collated into an electronic database in a standard format.

Similarly, the investigators will collect, examine, and reconcile crude and refined oil spill records and cleanup reports for the onshore and offshore Cook Inlet region for spills ≥1 bbl from industry, USCG, EPA, DOI, BLM, BOEM, BSEE, U.S. Fish & Wildlife Service, USDOT PHMSA, and ADEC data sets through 2019.into an electronic database in a standard format. Exposure data for Cook Inlet region will be collected and the number of wells, flow, and pipeline miles by year provided when available. The investigators will also calculate accident frequencies for small spills and perform appropriate statistical analyses, including trend analysis. Results will be collated into an electronic database in a standard format.

Specific Research Question(s): What are the respective frequencies of oil spills on the Alaska North Slope and Cook Inlet?

Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	Oil Spill Effects Literature Synthesis: Crude Oil, Diesel, and Condensate Spills 500–20,000 bbls (AK-19-08)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	Dr. Heather Crowley, heather.crowley@boem.gov
Conducting Organizations(s)	Research Planning, Inc.
Total BOEM Cost	$199,915
Performance Period	FY 2019–2021
Final Report Due	September 2021
Date Revised	October 3, 2019
PICOC Summary	
Problem	BOEM NEPA analysts require reference information regarding the potential effects of moderately-sized spills on the physical, biological, social, or economic resources on the OCS. However, much of the literature regarding smaller spills of 500 to 20,000 barrels is buried in the gray literature or conference proceedings and not easily accessible to the analysts.
Intervention	A literature search focusing on small to medium size spills between 500 to 20,000 bbl in volume and their impacts on these environments would be very helpful to BOEM analysts for future National Environmental Policy Act (NEPA) analyses of the Outer Continental Shelf (OCS).
Comparison	Scaling of impacts from much larger oil spills may not provide an accurate representation to support analysis of effects from smaller spills.
Outcome	The project will identify available literature that defines the locations and impacts to human, physical, and biological environments of small to medium size spills.
Context	All OCS Planning Areas

BOEM Information Need(s): The Bureau of Ocean Energy Management (BOEM) needs information about oil spills, including particular oil types and volumes, and their impacts under specific environmental variables to allow NEPA analysts to make refined evaluations regarding potential impacts from large (≥500 bbl) spills of crude oil, diesel, or condensate.

Background: The relationship between BOEM Outer Continental Shelf (OCS) activity and oil spills is a common question; and public concern about oil spills is heightened due to the potential impacts on sensitive resources. However, many of the most well studied oil spills (e.g., *Exxon Valdez* and *Deepwater Horizon*) are orders of magnitude larger than the median OCS spill sizes which are used for NEPA impact assessment. Analysts must use these impacts and scale them to spills of much smaller volumes and duration. Much of the literature regarding smaller spills of 500 to 20,000 barrels is

buried in the gray literature or conference proceedings. Further, as new BOEM analysts begin their careers, the use of the older literature, although still valuable, is being lost to the archives.

Objectives:

- Synthesize documentation regarding impacts to various biological, social, or economic resources from spills of crude oil, diesel, or condensate ranging from 500–20,000 bbl in volume.
- Provide a systematic synthesis for use in impact assessment.

Methods: Researchers will conduct a careful literature compilation of all relevant information on spills of crude oil, diesel, or condensate of 500–20,000 bbl in size since approximately 1970. Sources consulted will include not only formally published scientific literature but also so-called "gray literature", information available from the Internet, and information developed through limited appropriate personal contacts. After conducting an extensive and thorough review of the peer-reviewed and gray literature, researchers will prepare an annotated bibliography of information regarding effects and impacts of spills of crude oil, diesel, or condensate ranging from 500–20,000 bbl in size. Products will include a written synthesis of impacts and degree of recovery from spills of crude oil, diesel, or condensate 500–20,000 bbl in size discussing environmental and physical variables derived through the extensive review.

Specific Research Question(s): What is the range of environmental effects from spills of crude oil, diesel, or condensate ranging from 500–20,000 bbl in size?

Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	Collaboration with North Pacific Research Board (NPRB) Arctic Marine Research Program (AK-16-02)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	Rick Raymond, richard.raymond@boem.gov
Conducting Organizations(s)	North Pacific Research Board
Total BOEM Cost	$1,000,000
Performance Period	FY 2016-2021
Final Report Due	December 2021
Date Revised	June 3, 2019
PICOC Summary	
Problem	This study will build upon available synthesis projects to examine areas where collaborative studies can help enhance informed decision-making on the sustainable use of resources in Arctic marine environment.
Intervention	BOEM enhance existing working relationships with NPRB, NOAA, USGS, AOOS, industry and others by establishing financial cooperation, coordinated Request for Proposals, data sharing agreements, and logistical support agreements.
Comparison	BOEM and NPRB will partner on collaborative research, leveraging expertise across several partners and funding sources, including NGOs, Federal agencies, Universities, NSB, industry and others in the Chukchi and Beaufort seas.
Outcome	This project will support mutually identified information needs on the physical, biological and social processes in the Arctic marine environment.
Context	Bering, Chukchi and Beaufort seas

BOEM Information Need(s): BOEM needs to leverage funding for updated environmental data collection as significant opportunities arise. The National Science Foundation and the North Pacific Research Board have worked together programmatically and scientifically through the Bering Sea Project since 2007 (http://bsierp.nprb.org). Based on this successful collaboration, BOEM and NPRB plan to partner on new collaborative research in the Arctic, leveraging expertise across several partners and funding sources, including BOEM, NSF, NPRB, NOAA, Alaska Ocean Observing System (AOOS), USGS, ONR, NASA, North Slope Borough, Northwest Arctic Borough, industry and others, specifically in the Chukchi and Beaufort seas. Research from this collaboration will support mutually identified information needs on the physical, biological and social processes in the Arctic marine environment.

Background: The Alaska Office has a long history of supporting multidisciplinary research, beginning with the Outer Continental Shelf Environmental Assessment Program (OCSEAP) surveys conducted between the 1970s and early 1990s and the Beaufort Sea Monitoring Program in the 1980s. The Arctic Nearshore Impact

Monitoring in Development Area (ANIMIDA) program and its continuation (cANIMIDA) started in 1999 to provide baseline data and monitoring results for chemical contamination, turbidity, and subsistence whaling in the vicinity of Northstar and Liberty development sites. This work continues today with the studies ANIMIDA III: Boulder Patch and Other Kelp Communities in the Development Area, begun in 2012, and the recently awarded ANIMIDA III: Contaminants, Sources, and Bioaccumulation, which has been expanded to include Camden Bay.

Since 2007, the Alaska Office has also developed a new suite of studies in the Chukchi Sea, leveraging more than $70 million (through FY 2015) to conduct interim baseline research and monitoring in all the following fields of interest: meteorology, ice dynamics and basic oceanography, benthic fauna and sedimentation, marine mammals (including whales, walrus, seals, and polar bear), fish, birds, and social systems. Most of the projects exhibit complex, multilateral collaborations, with explicit inter-disciplinary linkages between the physical and biological sciences, and many of them also provide a role for active participation by Alaska Native residents and input from sources of traditional knowledge. Most of them pursue multi-year data collection efforts on a regional scale, with careful attention to inter-annual variability and ecosystem processes. The newly funded Arctic Marine Biodiversity Observation Network (AMBON) in the Chukchi Sea is a prime example.

Objectives: BOEM seeks to build upon existing working relationships with NPRB, NOAA, USGS, AOOS, industry and others by establishing financial cooperation, coordinated Request for Proposals, data sharing agreements, and logistical support agreements. The foundation for such partnerships will be based on BOEMs Annual Studies Planning Process.

Methods: BOEM, NPRB and other funding partners will build upon newly available synthesis projects (such as Synthesis of Arctic Research [SOAR] and the Pacific Marine Arctic Regional Synthesis [PacMARS] to examine areas where collaborative studies could help enhance informed decision-making on the sustainable use of resources. This collaborative study will be guided by an oversight committee formed of senior scientists and accomplished through an annual request for proposals (RFP). Recommendations for select studies would be based on program development goals. After BOEM review of RFP responses, subgroups of interdisciplinary scientists will work together with NPRB to select specific task orders for BOEM funding. Targeted areas for new research in the Chukchi Sea would include, but are not limited to: influence of sea ice dynamics and advection on the phenology, magnitude and location of primary and secondary production; distribution and life history of upper trophic predators in response to availability of lower trophic prey resources; and improving knowledge about rates of consumption, growth, and reproduction of benthic and pelagic organisms. Deliverables from this study will include final reports, published papers, and synthesis workshops to integrate multi-disciplinary datasets that will include participation of several BOEM-funded PIs.

Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	Alaska Coastal Marine Institute (AK-19-02)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	Dr. Heather Crowley, heather.crowley@boem.gov
Conducting Organizations(s)	CMI, UAF
Total BOEM Cost	$750,213 plus Joint Funding ($750,213)
Performance Period	FY 2019-2022
Final Report Due	March 2022
Date Revised	October 3, 2019
PICOC Summary	
Problem	The BOEM Environmental Studies Program needs applied scientific studies to provide information for making responsible decisions for managing energy and marine mineral resources on the U.S. Outer Continental Shelf (OCS).
Intervention	Scientific information collected for leasing, exploration, and development decisions tends to be more readily accepted by the local and regional populace if the studies are conducted by well-known and scientifically respected local experts and institutions.
Comparison	Through the Coastal Marine Institute (CMI) BOEM will obtain high quality scientific research to meet the shared goals of BOEM and the State of Alaska at substantial savings due to the one-to-one cost match requirement.
Outcome	The CMI program will use the highly qualified, scientific expertise at local levels to collect and disseminate environmental information needed for OCS oil and gas and renewable energy decisions; address local and regional OCS related environmental and resource issues of mutual interest; and strengthen the BOEM-State partnership in addressing OCS oil and gas information needs.
Context	All Alaska OCS Planning Areas.

BOEM Information Need(s): This cooperative agreement supports improved leasing decisions and National Environmental Policy Act (NEPA) analyses pertinent to potential oil and gas-related actions on the Outer Continental Shelf (OCS). Final reports will be available for lease sales and post-sale decisions; interim data products and inputs will be used to address information needs. Topical areas to be addressed under the Coastal Marine Institute (CMI) have been identified through the Alaska Annual Studies Planning process and a set of identified Framework Issues. The CMI, which operates on a five-year funding cycle, also will develop information and public products for various audiences that address public concerns raised during outreach efforts.

Background: The CMI is cooperative program between BOEM and the University of Alaska, with State of Alaska participation, began in 1993 with the goals of updating and expanding our understanding of OCS environmental information and addressing future

needs related to the offshore oil and gas program in Alaska. This large program of scientific research is guided by framework issues related to potential future lease sales and other oil and gas-related actions in the Alaska Office. Beginning in 2016, the CMI instituted a program of Student Research Awards, which provide up to $25,000 in funding for up to three student-led projects each year. Through an established cost-sharing arrangement, the CMI is expected to leverage additional scientific results and logistics capability at levels comparable to the BOEM contribution of up to $1,000,000 per year. Typically, five to seven new projects are funded each year.

Objectives: The Framework Issues which guide the CMI are:

- Scientific studies for better understanding marine, coastal, or human environments affected or potentially affected by offshore oil and gas or other mineral exploration and extraction on the OCS.
- Modeling studies of environmental, social, economic, or cultural processes related to OCS oil and gas activities in order to improve scientific predictive capabilities.
- Experimental studies for better understanding of environmental processes, or the causes and effects of OCS activities.
- Projects which design or establish mechanisms or protocols for sharing data or scientific information regarding marine or coastal resources or human activities in order to support prudent management of conventional energy resources and potential development of renewable energy and marine mineral resources on the OCS offshore the State of Alaska.
- Synthesis studies of scientific environmental or socioeconomic background information relevant to the OCS oil and gas program.

Methods: A proposal process is initiated each year with a request for letters of intent to address one or more of the Framework Issues from university researchers and other scientific researchers in State agencies. The letters of intent are reviewed by BOEM scientists and a Technical Steering Committee (TSC), made up of scientific representatives of the cooperators, to identify which submissions merit submission of a full-length proposal. BOEM scientists and the TSC then evaluate the proposals' research concepts, methodology, and cost effectiveness to inform funding decisions. External peer reviews may be requested for new projects. Each CMI project produces a final report that is publicly disseminated through the BOEM website. Principal investigators also give presentations at a scheduled annual CMI Science Review, scientific conferences, and various public meetings.

The structure of the CMI not only promotes extensive input from BOEM's academic partners in Alaska, but it allows for a great deal of flexibility to rapidly address priority information needs as they arise. Furthermore, the requirement for matching funds at a one-to-one level facilitates extensive leveraging and partnership arrangements for the projects.

Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	Synthesis of Current Environmental Literature for OCS Planning Areas in the Northern Gulf of Alaska (AK-19-04)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	TBD
Conducting Organizations(s)	TBD
Total BOEM Cost	TBD
Performance Period	FY 2019–2021
Final Report Due	TBD
Date Revised	October 3, 2019
PICOC Summary	
Problem	Collation of available environmental information would support analyses under the National Environmental Policy Act (NEPA), Endangered Species Act (ESA), etc. for potential future lease sales and other activities regulated by BOEM in the northern Gulf of Alaska.
Intervention	This study will complete a regionally-based literature search and synthesis of environmental information for the OCS Planning Areas in the northern Gulf of Alaska.
Comparison	Results from this award will provide a resource to help guide BOEM NEPA analysts in locating the reference information they will need.
Outcome	The project would produce an annotated bibliography of relevant literature and a summary report documenting the current environment for various resources.
Context	Gulf of Alaska, Kodiak, and Shumagin OCS Planning Areas

BOEM Information Need(s): Potential future lease sales that could be scheduled in the Gulf of Alaska, Kodiak, and Shumagin OCS Planning Areas would require NEPA analyses of the existing environment and potential impacts from possible future oil and gas exploration and development activities. The last lease sale in the Gulf of Alaska Planning Area occurred in 1981, and no lease sales have occurred in the Kodiak and Shumagin Planning Areas. BOEM requires updated information to support NEPA analysis and documentation for the proposed lease sales in these areas.

Research in the northern Gulf of Alaska by a broad array of organizations—including the National Oceanic & Atmospheric Administration (NOAA), Alaska Department of Fish & Game, Exxon Valdez Oil Spill Trustee Council (Gulf Watch) and academia—has produced an extensive body of literature that can be synthesized to support NEPA analysis for potential future lease sales in the Shumagin, Kodiak, and Gulf of Alaska OCS Planning Areas.

Background: The northern Gulf of Alaska exhibits a productive ecosystem supported by a dynamic ocean circulation that disperses marine life and nutrients from deeper

waters across the continental shelf. The diverse biological communities support some of the most productive fisheries in the United States. Bays and estuaries represent important nursery habitats for young fishes, and feeding grounds for seabirds and marine mammals.

This region is rapidly changing due to climate warming. Sea temperatures have been anomalously warm, and process studies have provided data that illustrates sustained periods of warming can change the trophic structure of the ecosystem, reducing energy to upper trophic level juvenile fishes, leading to increased winter mortality. Recent and ongoing field work and modeling by NOAA and others suggests that the manifestations of warming in the Gulf of Alaska ("The Blob", El Niño, toxic algal blooms, small-copepod-dominated community, cetacean die-offs, and temperate and tropical fish species collected off Alaska's coasts) will continue highlighting the need for continued research and monitoring of conditions and emergent events.

Objectives: Describe the current environmental understanding of the northern Gulf of Alaska.

Methods: Researchers will conduct a careful literature search and compilation of all relevant information on the environment and resources of the Gulf of Alaska, Kodiak, and Shumagin Planning Areas in the northern Gulf of Alaska.

Specific Research Question(s): What is the current status of physical, biological, social, and economic resources in the northern Gulf of Alaska?

Title	Underwater Sound Signatures and Propagation for OCS Activities Permitted by BOEM (AK-19-06)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	TBD
Conducting Organizations(s)	TBD
Total BOEM Cost	TBD
Performance Period	FY 2019–2022
Final Report Due	TBD
Date Revised	October 7, 2019
PICOC Summary	
Problem	Newer, more accurate acoustic harassment criteria for marine mammals requires greater accuracy in NEPA analyses. No standardized source of noise spectra characteristics that links with accompanying datasets is available.
Intervention	This study would collate baseline information regarding noise from sources associated with human activities, especially oil and gas exploration and development. A search will be conducted of white and gray literature produced by government, private sector, non-governmental, and academic entities.
Comparison	The results will support analyses to discriminate anthropogenic noise sources and noise generated by the natural environment and biological sources.
Outcome	The project will produce a dataset of sound metrics for noises from a variety of sources associated with oil and gas exploration and development activities.
Context	The results will be relevant to all Outer Continental Shelf (OCS) Planning Areas.

BOEM Information Need(s): BOEM needs information about noise from sources associated with oil and gas exploration and development activities to inform noise impacts analyses that meet the newer noise impact thresholds criteria issued by NMFS in 2016. Results will support noise impacts analyses at all levels of NEPA, and in Endangered Species Act (ESA) Section 7 consultations.

Background: Newer, more accurate acoustic harassment criteria for marine mammals requires greater accuracy in NEPA analyses. Historically, the sound metric of decibels (dB re 1 µPa) has been used in NEPA analyses, without serious consideration of the frequencies involved, or if marine mammals were capable of detecting such noises. These relationships are now being addressed in newer NEPA documents produced by BOEM; however, no standardized source of noise spectra characteristics is available that links with accompanying datasets.

Objectives: The goal of this study will develop a consolidated source of information that provides BOEM analysts with a basic tool to analyze the effects of anthropogenic noise on marine mammals in the Alaska OCS in support of NEPA.

Methods: Researchers will collect existing noise production data found in journal publications and gray literature reports produced by government, private sector, non-governmental, and academic entities. Efforts will focus on noises from different types of seismic surveys and drilling; anchor handling; vessel, aircraft and hovercraft traffic; on-ice activities; ancillary activities; sub-sea pipeline installation; etc. Specifically, collected data will include the metrics of frequency, dB re 1 µPa, and dB SEL24, etc., and any other relevant metrics to support analysis of potential impacts from noise to marine mammals and other biota. Results will be presented in a final report, with the accompanying datasets in tabular format.

Specific Research Question(s):

1. What information is available regarding noise from sources associated with oil and gas exploration and development activities?
2. Given the existing knowledge on increased vessel traffic, what is the associated increase in anthropogenic noise?
3. What is the associated ecosystem response, in particular marine mammals?

Current Status: Planned new start

Publications Completed: None

Affiliated WWW Sites:

http://www.boem.gov/akstudies/

Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	Measuring Wave Forces along Alaska's Coastal Sea Ice (AK-13-03-17)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	Dr. Heather Crowley, heather.crowley@boem.gov
Conducting Organizations(s)	CMI, UAF
Total BOEM Cost	$311,392 plus Joint Funding ($311,392)
Performance Period	FY 2016–2020
Final Report Due	December 15, 2020
Date Revised	October 4, 2019
PICOC Summary	
Problem	Landfast ice is used as a platform for subsistence hunting and potentially for wintertime activities related to oil and gas exploration and development in the Beaufort Sea and Chukchi Sea. To ensure the safe use of landfast ice as a platform, BOEM needs a better understanding of the mechanical properties of sea ice within the landsfast ice zone and the stresses that cause breakout events.
Intervention	This project will design, fabricate, and field test portable sensors that measure the 3D acceleration of the landfast ice to measure acceleration of the landfast ice and estimate the stresses imparted into the ice.
Comparison	The study will evaluate the relationship between variations in infragravity waves in the landfast and ice destabilization events.
Outcome	The development of portable sensors of ice movement that can be monitored in real-time could allow for prediction of landfast ice breakout events, leading to early warnings and improved ice safety.
Context	Beaufort Sea, Chukchi Sea

BOEM Information Need(s): This study will provide a better understanding of the stresses that cause breakout events associated with landfast ice along the Chukchi and Beaufort coasts from wind, waves, coastal waves, and storm surges. The results from the sensor measurements will be used to better understand the mechanical properties of sea ice within the landsfast ice zone. Information will provide supporting data to improve our understanding of ice safety and marine navigation during the spring months. Information could also be utilized in NEPA documents to assess the risk of landfast ice to proposed exploration and production activities.

Background: Landfast ice stability is extremely important to the Alaska Native subsistence hunters along the Chukchi coast. During the spring hunt for bowhead whales the subsistence hunters use landfast ice as a stable hunting platform. Breakout events occur when there is a sudden detachment of the landfast ice platform from the coast. In some years, large breakout events have stranded subsistence hunters offshore on drifting sea ice. Climate change may cause earlier and more frequent breakout events due to longer periods of open water causing greater exposure of the ice edge to

the forces of waves and storm surges. A set of inertial motion units (IMUs) sensors will be designed and deployed to measure ice acceleration due to waves propagating through the landfast ice off Barrow, Alaska. These types of measurements will improve ice safety by understanding how propagating waves impacts landfast ice stability and fragmentation along the coast. These measurements will also help to achieve a better understanding on the processes associated with larger breakout events that occur on an annual basis along the Chukchi coast. The experiment of measuring wave propagation into the landfast ice has been tested in Norway with success. This study plans to reproduce a similar experiment along the coast of the Chukchi Sea to measure those wave forces in the landfast ice near Barrow, Alaska.

Objectives: The overall goal of this project is to improve ice safety by understanding wave energy propagation into sea ice, and determine its effect on landfast ice stability along the Chukchi coast. Specific objectives include:

- Improving the ability to detect infragravity waves at the fast ice edge and directly measure ice acceleration, wave period and arrival time.
- Developing estimates of wave velocity and amplitude and propagation direction.
- Gaining a better understanding of wave origin, propagation path and attenuation and their relationship to the mechanical properties of ice.
- Estimating the stresses imparted into landfast ice.
- Evaluating the relationship between infragravity waves and landfast ice destabilization events.
- Assessing the effect of ice topography and heterogeneity of wave propagation.

Methods: This project will design, fabricate, and field test portable sensors that measure the 3D acceleration of the landfast ice. Year one field testing will be conducted in Fairbanks, Alaska. During year two, the researchers will build three IMU wave sensors for full deployment during the spring months on the landfast ice edge off of Barrow, Alaska. In year three, the IMU wave sensors will be deployed away from the landfast ice edge to test the feasibility of measuring wave attenuation and estimate along path ice thickness.

Specific Research Question(s):

1. How is energy from wind, waves, coastal waves, and storm surges transmitted through landfast ice?
2. How do variations in these factors impact landfast ice breakout events?
3. Can breakout events be predicted through measurements of infragravity waves in landfast ice?

Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	High-frequency Characterization of the Physicochemical Parameters of Cook Inlet, Alaska (AK-13-03-23)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	Dr. Heather Crowley, heather.crowley@boem.gov
Conducting Organizations(s)	CMI, UAF
Total BOEM Cost	$120,094 plus Joint Funding ($120,094)
Performance Period	FY 2017–2020
Final Report Due	July 31, 2020
Date Revised	October 3, 2019
PICOC Summary	
Problem	Ocean acidification can have detrimental effects on marine ecosystems, but it is difficult to determine the natural and anthropogenic influences on ocean pH variability based on the limited data currently available.
Intervention	This study will deploy two sensors capable of measuring pH, temperature, conductivity (to calculate salinity) and oxygen concentration along the freshwater gradient in Cook Inlet, Alaska.
Comparison	Researchers will examine pH variability based on multiple factors, including: diurnal, seasonal and annual cycles; different water mass movements and changes in temperature and salinity; and increased freshwater input.
Outcome	Verification of a pH gradient across Cook Inlet will provide a unique framework for biological studies investigating aspects of ocean acidification tolerance and local adaptation and will further our understanding of complex, near-shore acidification dynamics.
Context	Cook Inlet

BOEM Information Need(s): Results from this study will support analysis of cumulative effects in NEPA documents for future Cook Inlet lease sales, and for future EPs and DPPs that may result from Cook Inlet Lease Sale 244 (2017) or from future Cook Inlet lease sales.

Background: Measuring ocean acidification (OA), the addition of anthropogenic atmospheric CO_2 to the surface oceans, is increasingly important to aid understanding of how marine ecosystems will respond to global ocean change. With few long-term and baseline ocean pH records in place, it is difficult to determine the natural and anthropogenic influences on ocean pH variability. With recent developments in pH sensor technology, monitoring networks are growing along the west coast of the United States. This study will deploy two sensors capable of measuring pH, temperature, conductivity (to calculate salinity) and oxygen concentration along the freshwater gradient in Cook Inlet, Alaska. Utilizing this new technology can vastly improve understanding of nearshore carbonate chemistry and help tease apart the source of current pH variability. Conductivity measurements will facilitate identification of the

intensity of freshwater input as well as improve calculations of pCO_2 levels. Due to oxygen's role in photosynthesis and respiration, oxygen concentration measurements will provide insight to the relative impact that biological processes have on the carbonate system, although it does not directly impact pH or pCO_2. Verification of a pH gradient across Cook Inlet will provide a unique framework for biological studies investigating aspects of OA tolerance and local adaptation. Including temperature, conductivity and oxygen concentration measurements will further our understanding of complex, near-shore OA dynamics.

Objectives:

- Establish baseline high-frequency pH, temperature, conductivity (salinity) and dissolved oxygen time-series measurements from two near-shore sites in Cook Inlet, AK.
- Quantify the sources of pH variability, including those associated with biological processes, tides and currents, and freshwater (riverine) input.

Methods: This project will deploy oceanographic SeapHOx sensors at two sites along the freshwater gradient found in Cook Inlet, Alaska. Sensors will be deployed in summer 2017 via scuba in lower Cook Inlet and Kachemak Bay. Sensor maintenance will be conducted and calibration samples collected at six-month intervals over two years. Descriptive statistics and basic time-series analyses will be used to describe the range, frequencies, and mean conditions measured at each site. Site-specific correlation and regression analyses will be employed to explore variation between sites and among measured parameters. Spectral analyses will be used to identify periodicities and correlation among parameters across different frequencies. Low pass and high pass filters will identify sources of short-term, event-scale and seasonal pH variability (if present) will be investigated and described through simultaneous analysis of oxygen, salinity, and temperature.

Specific Research Question(s): What are the sources of pH variability in lower Cook Inlet?

Title	Wave and Hydrodynamic Observations and Modeling in the Nearshore Beaufort Sea (AK-17-01)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	Dr. Heather Crowley, heather.crowley@boem.gov
Conducting Organizations(s)	University of Alaska Fairbanks; USGS Western Region
Total BOEM Cost	$2,123,903
Performance Period	FY 2017–2022
Final Report Due	May 2022
Date Revised	October 3, 2019
PICOC Summary	
Problem	BOEM needs a better understanding of the physical processes related to wave conditions within Stefansson Sound, Beaufort Sea, the bottom conditions and depth-induced wave breaking conditions and their effects.
Intervention	Develop a high-resolution wave model and hydrodynamic model, including a field observation campaign to support model validation.
Comparison	Evaluate effects that climate change may have on sea ice, wind, and wave conditions, changes in sedimentation rates, and ice pile-up events.
Outcome	Documentation of current sediment transport conditions and forecasted changes due to higher waves, stronger currents, and diminished sea ice.
Context	Stefansson Sound in the Beaufort Sea Planning Area

BOEM Information Need(s): BOEM needs validated high-resolution wave and hydrodynamic model outputs to assess current and future wave conditions, their impacts on offshore oil and gas structures, and potential changes in sedimentation patterns and coastal erosion within Stefansson Sound and the nearshore areas of the Beaufort Sea. Specifically, BOEM needs information on the impacts that climate change may have on sea ice, wind, and wave conditions, changes in sedimentation rates, and ice pile-up events during the expected timeframe of the Liberty Development Project (~2020-2050). Coordinated field observations are needed for model validation because wave observations are quite limited in the central Beaufort Sea. Results from this study will inform monitoring activities associated with the planned Liberty Development Project and support NEPA analyses for future lease sales, EPs and DPPs.

Background: The shallow shelf area in Stefansson Sound is capable of modifying large wave events as they propagate shoreward. Depth refraction, shoaling, and dissipation processes due to shallow water bathymetric effects are difficult to represent in shallow water wave models. The area within Stefansson Sound and Foggy Island Bay are difficult to model due to the scarcity of wind and wave information, the complex shallow bathymetry and coastal topography, and the highly variable and mobile sea ice conditions. The 100-year return wave height and wave period are important

considerations for the design of offshore fixed structures to support the topside oil and gas facilities. Likewise, rapidly changing climate conditions such as warmer temperatures, stronger winds, and reduced ice cover can adversely impact those shore based facilities through larger, more persistent waves, thawing of permafrost, and increased coastal erosion.

Objectives

- Obtain a better understanding of the physical processes related to wave simulations within Stefansson Sound, Beaufort Sea, the bottom conditions and depth-induced wave breaking conditions and their effects.
- Assess offshore wave and meteorological conditions within Stefansson Sound and compare those measurements to model results.
- Produce a 20-year wind and wave hindcast reanalysis dataset and document the minimum, mean, and maximum wind-wave events.
- Characterize wave conditions in Stefansson Sound over a 2, 5, 10, 20, and 30 year period based upon the model results and potential reduced sea ice conditions due to climate change.
- Develop a coupled wave-hydrodynamic-sediment transport model to document current sediment transport conditions; forecast changes due to higher waves, stronger currents and diminished sea ice.
- Through field observations, document wave, ice, and erosional conditions within Stefansson Sound and their impacts on offshore and coastal oil and gas facilities during the two years of field effort and compare to past assessments since the 1970s.

Methods: This study will produce high resolution wave output in the nearshore region to assess the impacts of waves on sea ice and offshore structures. A coordinated field effort will collect offshore observations using fixed moorings and buoys for validation of the proposed wave model for the Beaufort Sea. Additional field effort will be conducted to map ice pile-up events within Stefansson Sound. The study will develop a new wave model or enhance an existing wave model (e.g., the Simulating Waves Nearshore or SWAN model) to better simulate near shore wave conditions within the Beaufort Sea. Researchers will validate the model against field-deployed moorings that measure site-specific wave conditions over a two-year field season. The developed wave model will be coupled to a hydrodynamic model to evaluate potential nearshore impacts or changes in sedimentation rates or sites of deposition or erosion related to changes in current and wave energy resulting from construction of a gravel island for oil and gas production on the OCS. This work is intended to be coordinated with ongoing and future research funded by BSEE and BOEM to investigate the dynamics of sea ice freeze-up.

Specific Research Question(s):

1. What are the existing sea ice, wind, wave, and sediment transport conditions in Stefansson Sound?
2. How might these be affected by climate change?

Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	Western Beaufort and Chukchi Sea Surface Current Analysis (AK-19-02-04)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	Dr. Heather Crowley, heather.crowley@boem.gov
Conducting Organizations(s)	CMI, UAF
Total BOEM Cost	$77,640, plus Joint Funding ($77, 640)
Performance Period	FY 2019–2022
Final Report Due	January 2022
Date Revised	October 3, 2019
PICOC Summary	
Problem	A substantial amount of high-frequency radar (HFR) data was collected in the western Beaufort Sea and northeastern Chukchi Sea from 2015 to 2018. Effort is required to process and archive these data to facilitate its use in analyses of ocean circulation.
Intervention	Process and analyze previously collected data from high-frequency radars to evaluate the relationship between surface currents measured by the HFR systems and subsurface currents as measured by seasonal and year-round oceanographic moorings, and assess the relation between the wind and the surface flow field structure and evolution.
Comparison	This study will develop a new understanding of surface circulation in the western Beaufort Sea from Point Barrow to Smith Bay, as well as surface-to-subsurface relationships throughout the study area.
Outcome	Results from the study will help to improve understanding of the complex oceanic flow field in the vicinity of Barrow Canyon.
Context	Western Beaufort and Northeastern Chukchi Sea region

BOEM Information Need(s): Improving BOEM's understanding of the regional circulation is directly related to identifying potential effects of offshore drilling. The results can help improve existing oil spill trajectory models, risk assessment, and emergency planning.

Background: This study will develop a new understanding of surface circulation in the western Beaufort Sea from Point Barrow to Smith Bay, as well as surface-to-subsurface relationships throughout the greater western Beaufort and northeastern Chukchi Sea region. Though initially part of BOEM study 2017-065 (Weingartner, et al., 2017), since 2015, real-time HFR surface current observations have been collected in the Chukchi and Beaufort Seas with support from the Alaska Ocean Observing System (AOOS), the North Slope Borough (NSB), and Shell Oil. However, no funding was available for quality control, data analysis, or peer-review.

Improving our understanding of the regional circulation will help to better interpret the observed environmental change in the U.S. Arctic. With record low sea ice cover in

recent years, there are longer periods of open water. These changes directly affect the livelihood of local communities and their relationship with the marine environment and could potentially cause changes in marine mammal and seabird behavior. Past measurements of surface currents using HFR and satellite-tracked drifters in the western Beaufort Sea have captured westward currents near the Beaufort coast which often converge with northeastward currents flowing past Point Barrow.

Objectives:

- Process and quality control surface HFR current data from 2015-2018 and archive the data with ISO compliant metadata.
- Explore the connection between regional winds and circulation patterns over the western Beaufort Sea and Barrow Canyon.
- Compare surface currents with subsurface mooring derived currents from previous deployments in the western Beaufort and northeastern Chukchi Seas.
- Summarize the findings in a project report and one peer-reviewed publication.

Methods: For this study, real time HFR backscattered spectra data will undergo both visual and initial processing steps. Further processing will ready the data for higher level analysis. This analysis will consist of general statistics and the self-organized mapping technique (Liu, et al., 2006) to define major circulation patterns along with their wind conditions, similar to Fang et al. (2017). Wind data from two sources will be used for the current/wind analyses. The complete record of the National Weather Service Station data from the Wiley Post Will Roger Memorial Airport in Utqiagvik and hindcasts from the European Centre for Medium-Range Weather Forecast (ECMWF) ERA-5 atmospheric reanalysis.

Moored ADCP data overlapping HFR surface velocity fields both temporally and spatially will be used for comparison. Surface and subsurface datasets will be compared using correlation analysis to determine flow concordance throughout the water column. Other surface data collected in 2014 in the Alaskan Arctic include GPS fixes of 1-m drogued satellite-tracked oceanographic drifters. A number of these drifters were deployed in the northeastern Chukchi Sea and in the central Beaufort Sea (in Camden Bay). When concurrent in space and time these data will be included in the analysis of the surface currents in the western Beaufort Sea.

Analysis of current data will include the computation of flow statistics on an inter-annual basis. Metrics will include mean and net speed and direction, variance, principle axis of variation, and eccentricity. These will be computed at each HFR grid point and for the ADCP depth bins in the underlying water column. Time-lagged correlation analysis will provide the basis for relating the flow field variations to the wind conditions. Findings will be grouped based on primary modes of system behavior. When available, visible, sea ice, sea surface temperature, and chlorophyll-a satellite imagery will be overlaid to provide further context. Satellite tracked oceanographic drifters will provide some Lagrangian points for comparison against the HFR surface field.

Specific Research Question(s):

1. What is the relation between winds and circulation patterns in the western Beaufort Sea and Barrow Canyon
2. What is the relationship between surface and subsurface currents in the western Beaufort and northeastern Chukchi Seas?

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Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	Changing Relationships among Climate Variables and Cumulative Climate Stress on the Gulf of Alaska Ecosystem (AK-19-02-06)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	Dr. Heather Crowley, heather.crowley@boem.gov
Conducting Organizations(s)	CMI, UAF
Total BOEM Cost	$149,440 plus Joint Funding ($149,440)
Performance Period	FY 2019–2021
Final Report Due	June 2021
Date Revised	October 3, 2019
PICOC Summary	
Problem	The Gulf of Alaska (GOA) ecosystem is currently experiencing an extended climate anomaly that challenges existing understanding of the factors regulating population variability in commercially and ecologically important fish species. More information is needed about the possible ecological responses to changing relationships among basic oceanographic variables such as temperature, salinity, and stratification.
Intervention	This study will evaluate the ecological consequences of nonstationary environmental relationships through analysis of spawner-recruit dynamics for wild populations of pink, sockeye, and chum salmon throughout the GOA.
Comparison	The project will test the hypothesis that relationships among environmental variables have changed in ways that must be accounted for in any analysis of system dynamics under climate change.
Outcome	This research will improve understanding of the cumulative effects of change in multiple physical variables and contribute to the scientific knowledge of the GOA ecosystem.
Context	The northern Gulf of Alaska and Cook Inlet.

BOEM Information Need(s): BOEM needs an improved understanding of the ecological implications of observed increases in climate variability and changing relationships among oceanographic parameters. This information will improve understanding and provide insight to support cumulative effects analyses for NEPA assessments related to lease sales and potential exploration plans and development and production plans in Cook Inlet.

Background: Since 2014 the Gulf of Alaska (GOA) ecosystem has experienced unprecedented warm temperature anomalies, both on the surface and at depth (Walsh et al. 2018). These warm conditions are part of a North Pacific heatwave that began in 2014 and which, in terms of spatial scope, temporal duration, and magnitude of observed warm anomalies, is the largest marine heatwave ever observed (Hobday et al. 2018). Persistent warm anomalies outside the envelope of pre-2014 conditions have

continued through at least March 2019. The extent and magnitude of this warm event suggest the potential for strong and potentially long-lasting effects on GOA populations. Initial responses to the warm event included extreme mortality events for whales and seabirds, and unprecedented outbreaks of neurotoxin-producing dinoflagellates and pelagic tunicates. In addition to these acute responses, a number of potentially more persistent effects have become apparent as affected cohorts begin recruiting to populations of a variety of commercially-important fish species.

Recent observations suggest that relationships between SST and other ecologically-important environmental variables may have strengthened. Density profiles, stratification, and alongshore transport in the Alaska Coastal Current are largely driven by coastal freshwater discharge and water column salinity (Stabeno et al. 2004, Weingartner et al. 2005), and these processes are in turn linked to survival and productivity in a number of economically/ecologically important fish populations (Mueter et al. 2002, Doyle et al. 2009). Further, statistical effects of temperature on GOA populations, and the cumulative level of stress from multiple environmental processes, may be increasing.

Objectives:

- Examine evolving effects of changing environmental conditions on biological resources throughout the Gulf of Alaska (GOA) using statistical models of changing patterns of association among ecologically-important GOA climate processes.
- Evaluate the cumulative climate stresses on economically important salmon populations in the GOA by testing the hypothesis that increasing (decreasing) collinearity among climate variables predicts increasing (decreasing) strength of biological responses to primary climate variables, such as SST.

Methods: Researchers will collaborate with Gulf Watch Alaska (GWA) to examine changing collinearity among climate variables and impacts on a restricted set of populations. Physical (temperature, salinity, density, fluorescence, freshwater discharge, sea level pressure, wind stress, etc.) and biological (spawner-recruit time series for wild runs of pink, sockeye, and chum salmon) data from the 1970s through the present will be analyzed using standard approaches to understand basin-scale atmosphere-ocean interactions, such as regression of sea level pressure and wind stress fields onto GOA SST values, and empirical orthogonal function analysis to elucidate leading axes of spatial and temporal variability in atmospheric drivers of GOA physical variability.

Specific Research Question(s):

1. Is the collinearity of environmental parameters in the Gulf of Alaska changing over time?
2. What are the ecological effects of such changes?

Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	Landfast Ice Climatology in the Beaufort and Chukchi Seas (AK-19-03)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	Caryn Smith, caryn.smith@boem.gov
Conducting Organizations(s)	University of Alaska, Fairbanks
Total BOEM Cost	$1,699,293
Performance Period	FY 2019–2023
Final Report Due	September 2023
Date Revised	October 2, 2019
PICOC Summary	
Problem	Landfast ice is used as a platform for subsistence hunting and potentially for wintertime activities related to oil and gas exploration and development in the Beaufort Sea and Chukchi Sea. Understanding of the extent, stability, and seasonality of landfast ice is important for its safe use, but available data is quite old and conditions have been changing rapidly in recent years. Updated information about landfast ice extent and duration is also needed to validate coupled ice-ocean models used in BOEM's Oil Spill Risk Analysis (OSRA).
Intervention	This study will analyze landfast ice data interpreted by the National Weather Service (NWS) for the U.S. Arctic and produce improved estimates of minimum, mean, and maximum extents over time. Contributions of physical forcing mechanisms to changes in landfast ice will also be evaluated.
Comparison	The results will document changes in landfast ice cover over time.
Outcome	The analysis will document the role of physical forcing mechanisms on landfast ice extent and duration, offer information for validation of coupled ice-ocean circulation models, and improve understanding of the existing environment to support National Environmental Policy Act (NEPA) analyses.
Context	Beaufort Sea, Chukchi Sea

BOEM Information Need(s): Improved understanding of changes in landfast ice extent and stability is needed to provide context for interpretation of changing subsistence patterns and inform reviews and decision-making regarding oil and gas exploration and development plans involving on-ice activities. In addition, BOEM needs information about under ice circulation, including the influence of local freshwater river discharges, and the extent of landfast ice over time to validate coupled ice-ocean circulation models used to support OSRA.

Background: Offshore landfast ice can be used as a platform during potential winter oil and gas exploration or development, as well as subsistence activities. Ongoing environmental change in the Arctic has altered the extent, stability, and seasonality of the landfast ice along the U.S. Arctic coast and updated information is needed to

facilitate planning and ensure the safety of on-ice activities. The monthly minimum, mean, and maximum landfast ice extents along the Beaufort Sea coast were last quantified by Mahoney *et al.* (2012), but these data were collected up to 2008 and are more than 10 years old. Landfast ice extent is interpreted by the National Ice Center on a weekly basis (U.S. National Ice Center, 2018), whereas the NWS Alaska Sea Ice Program (ASIP) interprets landfast ice extent on the shelf areas surrounding Alaska on a daily basis (National Weather Service, 2018). The higher spatial and temporal resolution of these products will provide better understanding of ice stability and how storms and other physical processes influence landfast ice extent.

Documentation of the extent of landfast ice will also support validation of results from coupled ice-ocean circulation models used to support trajectory analyses for OSRA. In the Arctic, the oil-spill trajectory analysis must adequately represent how the movement of oil would be influenced by the presence of fixed, landfast ice.

Previous work by Weingartner and Kasper (2011) used idealized analytical and numerical models to examine the effects of spatially variable landfast ice cover on under-ice circulation. The results demonstrate that circulation under landfast ice cover is profoundly different from ice-free shelf circulation. Buoyancy forced experiments also showed that a landfast ice cover alters the behavior of a buoyant plume considerably, spreading it further offshore than in the ice free scenario. A recent publication by Weingartner *et al.* (2017) found similar results in their analysis of observations collected between 1999 and 2006 in Stefansson Sound. Results from this new study will provide additional context to these findings.

Objectives:

- Assess and document the landfast ice extent in the Beaufort Sea and Chukchi Sea at a higher temporal resolution and determine how it has changed over time.
- Evaluate how changes in landfast ice relate to local and regional changes in temperature, pressure, and major storms, as well as to global climate shifts.

Methods: Researchers will compile a time-series of landfast ice data for the Beaufort Sea and Chukchi Sea from interpreted sea ice data available from the NWS Alaska Sea Ice Program from 2008 through 2021. Results will be analyzed to produce a climatology that includes daily, weekly, monthly minimum, mean, and maximum landfast ice extent and to evaluate the changes in landfast ice over time. Sea Ice Mass Balance Buoys and Acoustic Doppler Current Profilers (est. 4–5) will measure themodynamics, temperature, salinity, ice thickness, and ice velocities, mostly beneath the landfast portion of the sea ice. Researchers will use these data to examine the physical forces that drive changes in seasonal and interannual landfast ice extents, including large breakout events. Local and traditional knowledge from coastal communities along the Beaufort and Chukchi Sea will be used to identify conditions associated with freeze-up, formation of landfast ice, major breakouts linked to storm events and changes in subsistence harvest.

Specific Research Question(s):

1. How has landfast ice extent in the Beaufort Sea and Chukchi Sea changed over time?
2. How has the stability and seasonal duration of landfast ice in the U.S. Arctic been altered in recent decades and what can be inferred about its use as a platform for on-ice activities, including subsistence hunting and oil and gas exploration and development?
3. How is landfast ice affected by physical forcings, including the winter and springtime under-ice circulation in the central Beaufort Sea, freshwater discharges from rivers in the area, variations in hydrography, and storms? Is this relationship changing over time?

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Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Study Area(s):	Beaufort Sea, Chukchi Sea
Administered By:	Anchorage, Alaska Office
Title:	Satellite Tracking of Bowhead Whales: Habitat Use, Passive Acoustic and Environmental Monitoring (AK-12-02)

BOEM Information Need(s) to be Addressed: This project will extend ongoing research to provide more information on the locations and use of bowhead whale feeding areas, the variability of those locations from year to year, and the environmental factors that can be used to project where bowhead whales will concentrate. This information can be used for developing mitigation options for OCS oil and gas activities in the Beaufort and Chukchi Seas. Information on the vocal behavior of bowhead whales under various environmental conditions is needed to interpret the habitat use and call behavior being collected on many passive acoustic recorders currently in use. Information from this study will support ESA Section 7 consultations and NEPA documentation.

Total BOEM Cost: $2,699,857 **Period of Performance:** FY 2012-2019

Conducting Organization: ADF&G

BOEM Contact: Heather Crowley

Description:

Background: A previous BOEM study using satellite telemetry has greatly added to the knowledge of bowhead whale movements, concentration areas, and the timing of both. Multiple years of tracking during this study has begun to provide information regarding the inter-annual variability in movements and concentration areas. Continued tracking will provide a better understanding of this variability and will allow us to estimate the timing and location of bowhead concentration areas making mitigation measures more directly applicable and useful.

Satellite-linked transmitters are a valuable tool for tracking bowhead whales and they have been effective at documenting movements of large and small whales of both sexes, and the timing and locations of concentration areas. Another tool, of increasing use, is the passive acoustic recorder deployed near areas of interest to record marine mammal vocalizations. Recorded bowhead vocalizations indicate that a bowhead was present at the time of vocalization, but an absence of calls could mean bowheads are present but not vocalizing. Bowhead whale vocalization rates related to various behaviors (e.g., feeding and travelling) or potential disturbances (e.g., boat traffic, seismic operations, and drilling) are needed to interpret the information being collected by passive acoustic recorders. Sensors for monitoring environmental conditions such as temperature and salinity have been developed and are in use on large whales, including bowheads in Greenland.

Objectives: To better understand interannual variation in bowhead whale feeding concentrations and to interpret call counts and calling rates collected by passive acoustic recorders.

Methods: This study will track the movements and document the behavior of bowhead whales using satellite telemetry to compare among years emphasizing new tagging locations such as St. Lawrence, Island, Pt. Hope and Canada. Bowhead whale vocalization rates and ambient noise levels will be documented using an acoustic tag to develop analysis of call rates relative to behavior and disturbance. Tags equipped with environmental sensors will be deployed to monitor, summarize, and transmit ambient oceanographic conditions as bowheads migrate. Limited numbers of individuals of other species of large whales (Gray, Humpback, Fin) may be tagged and tracked as opportunities arise as a pilot study for future work.

This study also will continue collaborations between individual whaling captains, AEWC, NSB, ADF&G, NMFS, BOEM, DFO-Canada, and Natural Resources Greenland and develop additional collaborations with oil companies and consultants collecting acoustic data to accomplish this project. Satellite transmitters with environmental and passive acoustic monitoring capabilities will be deployed on bowhead whales near Native communities in the Beaufort, Chukchi, and Bering Seas. Plots of whale tracks will be made available weekly and location data compared among years to determine inter-annual variability of movements and concentrations. Acoustic data will be analyzed to determine individual whale calling rates relative to whale behavior and disturbance factors. This study will be coordinated with AEWC and local whaling captains' associations go prevent any interference with subsistence whaling and hunting. All necessary research and access permits will be obtained by the PI.

Revised Date: October 3, 2019

Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Study Area(s):	Beaufort Sea, Chukchi Sea, Northern Bering Sea
Administered By:	Anchorage, Alaska Office
Title:	Ice Seal Movements and Foraging: Village-based Satellite Tracking of Ringed and Bearded Seals (AK-12-05)

BOEM Information Need(s) to be Addressed: More information is needed on seal movements and feeding areas relative to areas of interest for oil and gas leasing, exploration and development. Additional information would be particularly useful to evaluate potential interaction between industrial development and anticipated effects of diminished summer sea ice in much of their habitat. Data can be used to design monitoring and mitigation measures and will support NEPA environmental analyses. Since ice seals have been petitioned for listing under the ESA, information from this study may be useful for future ESA Section 7 consultations.

Total BOEM Cost: $1,174,994 **Period of Performance:** FY 2013-2019

Conducting Organization: ADF&G

BOEM Contact: Heather Crowley

Description:

Background: Considerable effort has been expended since the 1980s to document the distribution, abundance and behavior of ice seals in the Beaufort and Chukchi Seas. However, most of that effort involved aircraft surveys and analysis of prey from stomachs collected by biologists or in subsistence harvests. Some satellite telemetry studies of ringed, bearded, and spotted seals movements have been conducted (funded by MMS and others) showing large scale movements by all species and age classes. One highly successful project was conducted from 2004-2010 near Kotzebue in which local hunters were trained for capture and tagging. Seals tagged near Kotzebue ranged farther north than Barrow and south to Bristol Bay. Overall, because of the proximity to the tagging most of the locations are in the southern Chukchi Sea near Kotzebue. Additional tagging locations are needed to better understand the range of movements and use patterns. Tagging near Pt. Lay, Wainwright, and Barrow may show a greater use of the Chukchi Sea and the Beaufort Sea than use by seals tagged near Kotzebue. On the other hand, if seals tagged near Kotzebue go to the Yukon-Kuskokwim area and Bristol Bay, seals tagged in the Bering Sea may also use the Chukchi and Beaufort Seas.

Adult ringed seals are the most ice adapted and are known to use the heaviest ice concentrations throughout winter and spring, and it was assumed that juveniles occupied similar habitats in winter. Movements of adult and juvenile ringed seals tagged near Kotzebue, however, showed juveniles travelling to and wintering near the ice edge in the Bering Sea while adults wintered in heavy ice in the northern Bering and Chukchi Seas. It is likely that other similar patterns of use by species or sex/age classes will be documented during this tagging study.

Objectives: To better understand movements and habitat use of ice seals in the Beaufort, Chukchi, and northern Bering Seas.

Methods: Using the tagging project conducted in Kotzebue Sound by the Native Village of Kotzebue (Kotzebue IRA) as a model, develop similar collaborations between local Village Councils, seal hunters, the Ice Seal Committee, NSB, ADF&G, NMFS, BOEM, to establish seal tagging projects near several Native communities selected for their importance in provided missing seal movement information. Biologists have trained hunters in seal capture and tag deployment and provide weekly maps of seal tracks to the hunters and their communities. Movement data will be analyzed relative to ice edge, ice concentration, bathymetry, and residence times.

Revised Date: October 3, 2019

Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	Aerial Surveys of Arctic Marine Mammals (ASAMM) – Personnel and Aircraft Needs (AK-16-01)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	Rick Raymond, richard.raymond@boem.gov
Conducting Organizations(s)	NOAA-MML; USDOI National Business Center
Total BOEM Cost	$11,437,309 plus Joint Funding (~$420,000)
Performance Period	FY 2016–2020
Final Report Due	Annual report due June 2020
Date Revised	October 7, 2019
PICOC Summary	
Problem	Information is needed about distributions and relative densities of bowhead whales and other marine mammals to support NEPA analyses related to oil and gas exploration and development activities in the Beaufort and Chukchi Seas.
Intervention	Aerial surveys are conducted in the Chukchi Sea and Beaufort Sea Planning Areas from mid-July to the end of October to observe the fall migration of the bowhead whales.
Comparison	Past surveys are available for comparison with new data to assess whether changes in distribution or abundance have occurred since the earlier surveys were completed.
Outcome	This continuation of long-term monitoring activities provides updated information about distribution and abundance of bowheads and other marine mammals in the U.S. Arctic areas.
Context	Beaufort Sea, Chukchi Sea

BOEM Information Need(s): This study will maintain long-term monitoring information about potential impacts to marine mammals from OCS oil and gas-related activities and subsequent leasing in the Chukchi and Beaufort Seas. The information will assist BOEM in NEPA analyses for lease sales, EPs, and DPPs, ESA Section 7 consultations, and decision-making in the Beaufort and Chukchi Seas.

Background: Bowhead whales *(Balaena mysticetus*), gray whales (*Eschrichtius robustus*), beluga whales (*Delphinapterus leucas*), Pacific walrus (*Odobenus rosmarus divergens*), polar bears (*Ursus maritimus*), bearded seals (*Phoca fasciata*), and several other species of ice seals are known to occupy the Chukchi Sea, at least during some seasons. All of these species are subject to changes in environmental variables such as oceanographic currents, sea temperature, sea ice cover, prey availability, and anthropogenic impacts. Moreover all of these species are used for subsistence both in Russia and the U.S. and form an important part of the diet and cultural base for most people in communities along the Beaufort and Chukchi coasts. Having a good understanding of the seasonal distribution, relative abundance, and habitat use of

marine mammals in the Beaufort and Chukchi Seas is fundamentally important to evaluating the potential environmental impacts associated with oil and gas exploration and development and other anthropogenic activities. Reliable, up-to-date information of this type is needed for estimating marine mammal populations. Aerial surveys of marine mammals are an efficient tool because they offer quick coverage of large marine areas. Past surveys are available for comparison with new data to assess whether changes in distribution or abundance have occurred since the earlier surveys were completed.

Aerial surveys of the fall migration of the bowheads have been conducted annually since 1979, initially by the Bureau of Land Management and subsequently by MMS, now BOEM. This is one of the longest-maintained monitoring programs of a biological phenomenon and has produced an invaluable baseline of the distribution and habitat use of the bowheads. The baseline can be used to observe changes in distribution and habitat use that may occur due to changing atmospheric and oceanic climates and to OCS oil and gas development activities. This investigation will continue the aerial observations of the fall migration for evidence of these changes. Since the beluga whales and other marine mammals seasonally or otherwise resident in the Beaufort and Chukchi Seas are often sighted during the bowhead whale aerial surveys, their occurrence will also be part of the acquired data.

Objectives:

- Document the distributions and relative densities of marine mammals in the Chukchi Sea and Beaufort Sea Planning Areas.
- To the extent possible, delineate the areas that are most important to marine mammals during critical seasons of their annual life history cycles such as calving and feeding.
- Define the annual fall migration of bowhead whales, significant inter-year differences, and long-term trends in the distances from shore and water depths at which whales migrate.
- Monitor temporal and spatial trends in the distribution, relative abundance, habitat, and behaviors (especially feeding) of whales in arctic waters.
- Provide real-time data to BOEM and NMFS on the general progress of the fall migration of bowhead whales across the U.S. Beaufort and Chukchi Seas for use in protection of this Endangered Species, if needed.
- Provide an objective wide-area context for management understanding of the overall fall migration of bowhead whales and site-specific study results.
- Document the spatial and temporal distribution of beluga and gray whales, and other marine mammal species as sighted.

Methods: This Interagency Agreement between NMFS and BOEM will fly aerial line-transect surveys in the Chukchi Sea and Beaufort Sea Planning Areas from mid-July to the end of October to observe the fall migration of the bowhead whales, continuing the decades-long set of observations. For surveys in both seas, the observational and data recording methodology shall follow protocols used by the BOEM in the past surveys of

the bowhead fall migration. The scientists will be responsible for the management of this project, all necessary training of support personnel, providing all needed field equipment, conducting all logistical tasks, acquiring all necessary permits, and insuring the safety of all people involved.

The necessary aircraft services (planes, fuel, maintenance, pilots, etc.) to pursue the science objectives will be supported via Interagency Agreement between the National Business Center's Office of Aviation Services and BOEM.

Specific Research Question(s):

1. What are the distribution and relative abundance of bowhead whales in the U.S. Arctic?
2. Can aerial survey results provide a population estimate for bowhead whales in the U.S. Arctic?

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Title	Evaluating Novel Assessment Approaches for Coastal Ice Seal Haulout Areas and Behavior in the Alaskan Beaufort Sea (AK-19-02-05)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	Rick Raymond, richard.raymond@boem.gov
Conducting Organizations(s)	CMI, UAF
Total BOEM Cost	$204,990 plus Joint Funding ($204,990)
Performance Period	FY 2019–2021
Final Report Due	July 2021
Date Revised	June 18, 2019
PICOC Summary	
Problem	The spotted seal (*Phoca largha*) and bearded seal (*Erignathus barbatus*; listed as Threatened under the ESA) are two ice-associated pinnipeds that could be affected by environmental change and oil and gas development in the Beaufort Sea OCS. Understanding the environmental conditions and anthropogenic factors affecting the distribution, abundance, and behavior of ice-seals are important to understanding the health of the marine ecosystem, coastal communities, and management of coastal environments.
Intervention	This study will evaluate the potential of emerging technologies, specifically small Unmanned Aircraft Systems (sUAS) and time-lapse cameras, to assess the seasonal presence, behavior, and numbers of spotted and bearded seals at known summer-fall coastal haulouts.
Comparison	Study sites represent a range of human disturbance levels relevant across the broader Beaufort Sea OCS, which provides context for an area of increased interest for oil and gas exploration and extraction, notably with recent major oil discoveries by the oil and gas industry near the study area.
Outcome	Project outcomes will include an understanding of utility of novel ice-seal monitoring techniques (including behavioral disturbance and influence of local environmental conditions), several scientific as well as locally-relevant outreach products, and explicit coordination and capacity-building opportunities for Alaskan Native hunters.
Context	Beaufort Sea

BOEM Information Need(s): BOEM needs information to understand the environmental conditions and anthropogenic factors affecting the distribution, abundance, and behavior of Arctic ice-seals (specifically the spotted and bearded seals). An understanding of ice-seal movements, location and timing of important feeding areas will support National Environmental Policy Act (NEPA) analyses, Endangered Species Act (ESA) Section 7 consultations, and development of mitigation measures related to future lease sales in the Beaufort Sea Planning Area, as well as potential exploration and development on existing leases.

Background: Both spotted and bearded seals are important species residing in the Arctic marine environment. Their extensive seasonal migrations make these seals valuable as cultural and spiritual resources for coastal Indigenous people across northern, western, and southwestern Alaska. Presently, information is needed for both species, including poorly known abundance, distribution, phenology, and habitat use as well as response information to human activities. To obtain ice-seal information, sUAS along with time-lapse cameras in tandem have been identified as technologies that could transform the way both aerial and ground surveys for ice-seals are conducted in order to collect information on their distribution, density, and abundance. This emerging technology have less disturbance potential than more traditional and costly approaches, and could be more broadly applied to monitoring surveys for seal responses across their marine range, including areas affected by oil and gas exploration and development.

Objectives: The goals of this project are to clarify environmental and anthropogenic factors that affect late summer-fall haulout patterns of ice seals in two coastal regions of the Beaufort Sea OCS through a collaborative approach involving environmental observations by Indigenous Experts, time-lapse camera data, and short-duration focused surveys by sUAS. The specific objectives include:

- Test and refine remote camera and sUAS survey methods to assess counts, presence/absence, and behavior of ice seals at haulout sites.
- Quantify the effects of environmental conditions on ice seal summer-fall haulout behavior.
- Assess combined effects of environmental conditions and human disturbance on counts and behavioral responses of hauled out ice seals.
- Quantify disturbance effects of sUAS to hauled out ice seals.
- Assess the feasibility of using sUAS to survey ice seal abundance and coastal haulouts.
- Engage Indigenous communities and hunters in ice seal research.
- Build capacity for scientific operations, specifically sUAS surveys, by Indigenous communities and hunters.

Methods: Small Unmanned Aircraft Systems will be tested to survey ice seal numbers and behavioral responses in conjunction with paired time-lapse cameras at specific coastal sites to examine ice-seal haulout behavior and responses to anthropogenic disturbances at summer-fall coastal haulouts near Utqiaġvik in Dease Inlet. Ultimately, this study will build an improved understanding of the combination of environmental factors and human disturbances that can influence seal distribution and behavior.

Specific Research Question(s):

1. How can sUAS and time-lapse camera technologies be best used to survey ice seals and examine their haulout behavior and responses to disturbance and environmental factors?
2. How do environmental and anthropogenic factors influence ice seal haulout site selection and occupancy?

Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	NOAA-BOEM Partnership: Range-Wide Distribution of Cook Inlet Beluga Whales (*Delphinapterus leucas*) in the Winter
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	Catherine Coon, catherine.coon@boem.gov
Conducting Organizations(s)	NOAA / DOI AQD
Total BOEM Cost	$276,000 plus Joint Funding ($92,000)
Performance Period	FY 2018–2021
Final Report Due	TBD
Date Revised	October 1, 2019
PICOC Summary	
Problem	There is much uncertainty regarding the current spatial and temporal distribution of the critically endangered Cook Inlet Beluga Whale (CIBW) population. In particular, the most recent information regarding the winter range of the CIBW population is more than 15 years old.
Intervention	A wide-ranging aerial survey for CIBW in winter that could be augmented with passive acoustic monitoring (PAM) recorders to aid in winter detections of beluga whales.
Comparison	NOAA Fisheries conducts biennial summer surveys for this species, but the last winter aerial survey for CIBW was flown in 2002 (Rugh et al. 2004).
Outcome	This project will produce updated information regarding the winter range of the CIBW population.
Context	Cook Inlet Planning Area

BOEM Information Need(s): Updated information on the wintering locations of CIBW will aid BOEM in developing more effective and precise spatial and temporal mitigation measures to help minimize potential impacts from oil and gas activities on the Outer Continental Shelf (OCS) in Cook Inlet. Results from this effort will support National Environmental Policy Act (NEPA) analyses for Cook Inlet Lease Sale 258 (2021) and other future Cook Inlet lease sales, as well as for future exploration plans (EPs) and development & production plans (DPPs) that may result from Cook Inlet Lease Sales 244 (2017) and 258 (2021).

Background: CIBW may be adversely affected by routine operations associated with oil and gas exploration and development, including seismic surveys, drilling, production, and shipping (Small et al. 2017). The areas leased in Cook Inlet Lease Sale 244 at least partially overlap with CIBW critical habitat and some are in the vicinity of major anadromous streams which are important foraging areas for.

There is much uncertainty regarding the current spatial and temporal distribution of the critically endangered Cook Inlet Beluga Whale (CIBW) population. NOAA Fisheries conducts biennial summer surveys for this species, but the last winter aerial survey for CIBW was flown in 2002 (Rugh et al. 2004). There has been a considerable contraction in the summer range (Shelden et al. 2015), as aerial surveys and satellite-tagging studies have shown the majority of whales now occupy the areas of upper Cook Inlet in the summer. Satellite tagging studies on 18 animals (Shelden et al. 2015), together with presence/absence PAM (Castellote et al. 2016), show CIBW appear to still occur within the OCS historic range for this species in the winter.

The most recent abundance estimate of 340 CIBW (CV = 0.08, 95% CI 291-398, Nmin = 318) in June 2014 (Shelden et al. 2015) falls within the range of abundance estimates from the last 10 survey years (278 – 375 whales). This is down from an historical estimate of 1,300 in 1979. NOAA Fisheries designated the CIBW population as depleted under the MMPA in 2000, subsequently listing this population as an endangered species in 2008 under the ESA.

Objectives:

- Identify distribution and hot spots for CIBW throughout their winter range.
- Assess winter spatial and temporal extent of CIBW in Cook Inlet, including OCS areas.
- Make recommendations on precise spatial and temporal mitigation measures for CIBW.

Methods: NOAA Fisheries is conducting a four year (2018-2021) winter aerial survey program in upper Cook Inlet. BOEM has partnered with NOAA Fisheries to expand these winter aerial surveys to lower Cook Inlet. Winter surveys through upper and Lower Cook Inlet will occur two times a year, in Fall (October, November) and Spring (March, April) in 2018-2021. The lower Cook Inlet survey extends from East Forelands south to Homer on the east side and from West Forelands south to Kamishak Bay on the west side, as Nikiski (in close proximity to the Forelands) and Homer were identified as operating bases for exploration and development activities for Cook Inlet Lease Sale 244, and would cover the historic range of this species. At least initially, lower levels of OCS-related activity are expected during December and January, and the available daylight is limited, thus surveys are not planned during those months. Protocols for aerial surveys of CIBW have been well developed (Shelden et al. 2013) and will be followed using a twin-engine, high-wing platform with bubble windows at the right- and left-forward observer positions and a 6 to 8-hour flying time. Surveys may be augmented by deploying PAM moorings strategically placed throughout Cook Inlet with locations based on prior studies (Castellote et al. 2016), as funding permits.

Specific Research Question(s): What is the current winter range of the critically endangered Cook Inlet Beluga Whale population?

Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	Traditional Knowledge Implementation: Accessing Arctic Community Panels of Subject Matter Experts (AK-15-05)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	Dr. Jeffrey Brooks, jeffrey.brooks@boem.gov
Conducting Organizations(s)	Department of Wildlife Management (DWM), North Slope Borough
Total BOEM Cost	$359,470
Performance Period	FY 2016–2022
Final Report Due	January 31, 2023
Date Revised	October 9, 2019
PICOC Summary	
Problem	BOEM applies traditional knowledge (TK) to help it responsibly develop the nation's offshore resources. BOEM needs to proactively apply TK in research to enhance shared knowledge of environmental conditions.
Intervention	Organize TK Panels in North Slope communities to closely work with scientists to improve the research process and application of results.
Comparison	Researchers are better informed when guided by TK Panels, and TK holders meaningfully contribute to research and management.
Outcomes	The outcomes are an enhanced understanding of the environment, responsible management of energy resources, meaningful engagement of TK holders, and proactive application of TK.
Context	Scientific research in the North Slope to support BOEM's mission

BOEM Information Need(s): This project identifies and organizes Traditional Knowledge (TK) subject matter experts from Arctic communities into recognized panels of experts. The panels allow TK holders to become more widely accessible to research scientists and to function with authority on TK domains. This project actively advances prospects for TK application to scientific research sponsored by BOEM and other funding organizations. Any BOEM-funded study on the North Slope could be a candidate for TK Panel consultation and collaboration.

Background: Discussions about TK are often preoccupied with integration of TK data rather than with integration of TK experts into a collaborative research process. In the North Slope, research needs to be meaningful for both indigenous communities and scientists. This study identifies key individuals in North Slope communities who are locally recognized for their expertise on specific resources and available to serve on one or more TK Panels. External scientists funded by BOEM or other organizations consult TK Panels. Communities and the DWM pre-authorize TK Panels to speak with authority on specific topics, including ocean currents, ice movements, changing environmental conditions, and nearshore or offshore subsistence activities and harvest patterns. With the exception of some active co-management commissions in place, formalized local panels of TK holders do not yet exist to serve this capacity.

Objectives: The successful integration of TK into research processes requires intensive collaboration between scientists and local communities. The objectives include:

- Define a process with consistent methods for selecting and vetting TK panelists and linking them with relevant research projects; demonstrate a good match between knowledge and the focus of a study.
- Enhance TK authority and application in scientific research by promoting co-production of knowledge and dissemination of TK to external scientists through direct involvement of TK holders with conventional scientists.
- Develop and provide rosters of TK experts and guidance for external scientists to effectively access those experts and apply TK on a systematic basis for North Slope projects.
- Enhance dialogue about science through exchange of information between external scientists and the communities.
- Enhance the understanding of environmental change in the Arctic through proactive application of TK and better-informed scientific research.
- Achieve more efficient research timelines; currently, some researchers have to substantially delay studies while they seek local counsel and garner community support.

Methods: The DWM is developing panels of experts with intimate knowledge of research topics. Working closely with BOEM, the DWM will select specific studies for the TK Panels to review and discuss. The DWM will choose the panelists after discussions with and guidance from City and Tribal Councils and elders. TK Panels will not exceed nine persons. The DWM will work with the relevant researchers to draft specific questions for the TK panelists to address while allowing them flexibility to identify and discuss their understandings of the topic. The TK Panels will host and hold discussions with scientists and managers associated with the specific study. Panelists will receive honoraria in recognition of their service.

Specific Research Question(s): How can decision-makers most effectively incorporate TK into scientific research in the North Slope of Alaska?

Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Title	Community Based Monitoring in Arctic and Cook Inlet Coastal Zone, Extension of the Local Environmental Observer (LEO) Network (AK-16-05)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	James T. Lima, Ph.D., james.lima@boem.gov
Conducting Organizations(s)	Alaska Native Tribal Health Consortium, Inc. (ANTHC)
Total BOEM Cost	$400,000
Performance Period	FY 2016–2021
Final Report Due	July 2021
Date Revised	September 30, 2019
PICOC Summary	
Problem	Coastal Alaska is undergoing changes that affect subsistence harvests on the land and at sea.
Intervention	Collect and analyze frontline observations by residents of rural communities including Alaska Native subsistence harvesters, who can readily identify abnormalities in local habitat, prey availability, species composition, and seasonal timing of ecological processes.
Comparison	Evaluate observations of unexpected conditions against that expected based on traditional/local ecological knowledge and Western scientific knowledge.
Outcome	Documenting and dissemination of information of changing conditions in the Alaska and Northern Hemisphere Arctic and subarctic areas.
Context	Arctic and Cook Inlet communities

BOEM Information Need(s): BOEM needs the most up-to-date information on a variety of environmental variables to effectively conduct environmental analyses against a backdrop of changing environmental conditions. BOEM is collaborating with the ANTHC, on an established environmental observation network to enhance its utility for documenting changing environmental conditions and to assess the range of implications for human communities.

Background: LEO is a volunteer program of mostly tribal environmental professionals who share information about environmental events where they live, post observations on public sites and coordinate with technical experts to identify appropriate actions. The purpose is to increase understanding about climate change and other drivers of environmental conditions to facilitate development of appropriate adaptation strategies. ANTHC serves as the hub for the LEO Network.

Members self-enroll via the LEO Network website. Since the program was initiated in January 2012, more than 800 individuals in 234 communities have enrolled across Alaska. They receive training on how to be effective observers and use of the tools

available through the LEO Network. Posted observations are reviewed in monthly webinars and annual conferences and updates are communicated through social media and a weekly e-news to network members and a list-serve of over 1500 subscribers.

Dozens of State, Tribal and Federal agencies and academic institutions provide technical consultation support to LEO based on their topical expertise. Most of these communities are coastal, but there is growing participation in interior Alaska as well. The Network maintains a database of community based observations on a wide range of topics including extreme weather, floods, erosion, ice changes, permafrost thaw, invasive species, infrastructure damage, environmental contamination, and changes in the health, range, and behavior of fish, insects, birds and wildlife.

Objectives:

- Identify and promote pathways for incorporating observations and real time documentation in the coastal Arctic and Cook Inlet regions.
- Increase understanding about environmental change;
- Enhance tools available at the community and regional level to assess impacts;
- Improve communication and collaboration among communities, State of Alaska and Federal government, and other institutions;
- Facilitate development of healthy and effective adaptation strategies.
- Document community-based valuations of environmental resources.

Methods: 1) Enroll and train new members in the observation network protocols. 2) Manage and evaluate observation content. 3) Transfer observation content to data systems. 4) Connect observers with technical experts in partner organization to evaluate observations. 5) Distribute new observations via Google maps, LEO network, website and social media. 6) Hold monthly webinars to review observations. 7) Synthesize data for dissemination through the Alaska One Health System.

Specific Research Question(s): What are the circumstances or observed indications of unexpected environmental change in Alaska.

Title	Monitoring the Cross Island Subsistence Whale Hunt for Effects from Liberty Development and Production, Central Beaufort Sea, Alaska (AK-19-05)
Administered by	Anchorage, Alaska Office
BOEM Contact(s)	TBD
Conducting Organizations(s)	TBD
Total BOEM Cost	TBD
Performance Period	FY 2019–2024
Final Report Due	TBD
Date Revised	October 9, 2019
PICOC Summary	
Problem	Iñupiaq traditional knowledge states that bowhead whales deflect from anthropogenic noise. Nuiqsut hunters engage in subsistence harvest of bowhead whales at Cross Island, which is downstream from the proposed Liberty development. Whalers are concerned that noise associated with construction activities and vessel and aircraft traffic at the site will cause bowheads to deflect from Cross Island since they potentially will encounter anthropogenic noise from Liberty when they migrate from east to west. This could result in lower than usual success in harvesting, more difficulties in whaling, and negatively affect cultural practices, sharing networks, and important community celebrations where bowhead is primarily served to elders and other residents.
Intervention	This study will monitor the annual bowhead whale hunt at Cross Island, identify any source of disturbance, and identify whaling hunters' scouting tracks and locations of strikes and landings. In addition, the study will document the harvest and processing of whales, the hunters' traditional and local knowledge (TK/LK), and other external drivers such as weather, wind, sea states, and ice conditions.
Comparison	Whaling at Cross Island has been documented through collection of Global Positioning System (GPS) data since 1999. Results from this study will be evaluated against that baseline.
Outcome	This study will provide documentation of any changes in number and distribution of bowhead whales available for harvest, as well as changes in the whales' behavior (specifically increased skittishness).
Context	The area surrounding Cross Island in the Beaufort Sea Planning Area

BOEM Information Need(s): The Bureau of Ocean Energy Management (BOEM) has a continuing, ongoing need to monitor Cross Island whaling activities for potential impacts from oil and gas-related activities on the Outer Continental Shelf (OCS). Information obtained from this study will inform BOEM and BSEE about potential temporal and special conflicts between subsistence use and activities associated with proposed oil and gas development activities at Liberty, including marine vessel passage,

excavation, drilling and construction. The information will also inform future National Environmental Policy Act (NEPA) analysis and documentation related to potential future lease sales, as well as potential future exploration plans and development and production plans (DPPs). This information includes new data on potential effects of anthropogenic noise on subsistence whaling activities, TK/LK regarding migrating bowhead whale behavior, and possible effects of presence or absence sea ice on the whale hunt.

Background: The DPP for the Liberty Development Project proposes an offshore gravel island with a pipeline to land. The facility will be constructed southeast of Cross Island, where Iñupiat subsistence bowhead whale hunters launch their annual fall hunt for bowhead whales. Subsistence whalers have expressed concerns about potential effects to the bowhead whale hunt, due to the potential disturbance of the bowheads as they migrate from the east to the west in the fall. The concern, based on TK/LK, is that anthropogenic noise emanating from the Liberty site will affect the whales, causing them to deflect and reduce their prospects for successful harvests. This study will renew the long-term BOEM-funded ethnographic monitoring effort of subsistence whaling activities, incorporating TK/LK about bowhead whales and real-time information about proximity of sea ice to GPS recorded whaling tracks. The study will build upon prior efforts to document the effects of the development at Northstar on Cross Island subsistence conducted between 2001 and 2012 under the multi-disciplinary Arctic Nearshore Impact Monitoring in Development Area (ANIMIDA) project and its continuation (cANIMIDA) (Galginaitis, 2014).

Objectives:

- Evaluate variation in Cross Island subsistence whaling over time
- Assess whether OCS oil development activities at Liberty are likely to result in changes to bowhead whale subsistence hunting practices, or to hunting success at Cross Island

Methods: This study continues the methods established during the ANIMIDA and cANIMIDA projects. It calls for systematic observations and discussions with local informants about: a) number of whales taken; b) GPS location of whale sightings and strikes, with direction and distance from Cross Island; c) number of crews, composition of crews, total number of crew; d) periodic "census" of whaling participants on Cross Island; e) duration of whaling season by active days; f) timing of whaling; g) length of trips and area searched while whaling; h) records of catch per unit effort; i) observations of whaling participants; j) real time records of the location of sea ice relative to Cross Island; k) collection of TK/LK regarding bowhead whale and hunting practices; and l) weather, wind, and sea states. Recorded data will be presented in an annual report using tabular information on harvest levels and locations of subsistence resources taken on or near Cross Island, with hard copy maps showing the locations of subsistence whaling activities.

This study will leverage multiple recently completed and ongoing projects supported by the State of Alaska, North Slope Borough, and private industry.

Specific Research Question(s):

1. Would subsistence whaling activity and whale behaviors in the vicinity of Cross Island be affected by offshore oil and gas development at Liberty?
2. If so, in what ways?
3. Do the whales become skittish and more difficult to harvest, and if so, what behaviors comprise "skittishness" and how long does it take for whales to resume normal behavior?
4. Do the whales dive or deflect, and if so, for how long and how far? How long does it take for whales to resume normal behavior?
5. Did these alterations in behavior increase the level of effort or seem to limit the ability to harvest the quota of whales? Did it result in placing whalers in hazardous conditions? Please describe.
6. What TK can be documented regarding typical whale migratory whale behavior?

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Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Study Area(s):	Beaufort Sea, Chukchi Sea
Administered By:	National Program
Title:	WALRUS - Walrus Adaptability and Long-term Responses; Using multi-proxy data to project Sustainability (ArcSEES; NT-13-x11)

BOEM Information Need(s) to be Addressed: BOEM needs reliable estimation of long-term trends in walrus feeding ecology, foraging location, and population demographics. NSF's Arctic Science, Engineering and Education for Sustainability (ArcSEES) program is an is a multi-year, interdisciplinary program, supported by an international partnership among BOEM, NSF, USGS, USFWS, EPA, and a consortium of French agencies, that seeks to evaluate the sustainability of the Arctic's human-environmental system and to provide community-relevant sustainability pathways and engineering solutions. BOEM's participation in the ArcSEES program will facilitate a better understanding the complex feedbacks that control the overall evolution of the Arctic system for timescales ranging from a few days to several years. Findings from this and other ArcSEES projects will support NEPA analyses for potential future lease sales, review of EPs, DPPs and other reviews for BOEM decision-making and mitigation.

BOEM Contribution: $200,000 plus Joint Funding

Period of Performance: FY 2013-2020

Conducting Organization: NSF, ArcSEES

BOEM Contact: Dr. John Primo

Description:

Background: In the last seven years there has been a rapid decline in spatial extent of summer sea-ice in the Arctic Ocean. At the same time, striking changes in Pacific walrus (*Odobenus rosmarus divergens*) foraging and haul-out locations have been observed. Marine mammals are considered sentinels of climate change in the Arctic as they are long-lived, occupy higher trophic levels, and many depend on sea-ice habitat. Walruses are also a significant component of the Alaska Native subsistence way of life, so information exchange based on traditional ecological knowledge (TEK) and scientific findings is pivotal to communities relying on these iconic animals. A substantial threat to walruses is the current warming and associated loss of sea-ice during the summer months, which can result in increased mortality due to decreases in prey within range of coastal haulouts and an increase in disturbance events. Despite impressive data from in-depth studies of Pacific walruses over the last 40-50 years, that timeframe is too short to capture adaptation to large-scale warming and change, making sustainability projections difficult. Management decisions are currently based on numerical population assessments, which can be somewhat unreliable, and instead advocated for decision-making processes based on ecological needs and observed ecological change.

Objectives: The goal of this study is to correlate changes in genetic diversity and effective population size (DNA), foraging locations (element analyses) and accessibility (TEK), and changes in overall diet (stable isotope analysis) and health (steroid hormones) of walrus populations in Alaska with known periods of climate change and differing anthropogenic pressures (TEK, published records).

Methods: This study will track changes in walrus trophic position, foraging location, and genetic structure and diversity over the past 2500 years using multi-proxy datasets. The researchers will test correlations between these changes and large-scale climate and anthropogenic forces and will develop projections about how walruses would respond to or perceive varied stresses. The project will involve students from high school to graduate levels to promote sustainability education within affected communities. The results will be compiled and disseminated to assist communities currently planning for a sustainable walrus subsistence harvest within the parameters of a rapidly changing Arctic.

Revised Date: October 4, 2019

Environmental Studies Program: Alaska Annual Studies Plan FY 2020

Study Area(s): Beaufort Sea

Administered By: National Program

Title: Cumulative Effects of Arctic Oil Development – Planning and Designing for Sustainability (ArcSEES; NT-13-x11)

BOEM Information Need(s) to be Addressed: BOEM needs information on the effects of oil and gas infrastructure and climate change to support future planning and decision-making. NSF's Arctic Science, Engineering and Education for Sustainability (ArcSEES) program is an is a multi-year, interdisciplinary program, supported by an international partnership among BOEM, NSF, USGS, USFWS, EPA, and a consortium of French agencies, that seeks to evaluate the sustainability of the Arctic's human-environmental system and to provide community-relevant sustainability pathways and engineering solutions. BOEM's participation in the ArcSEES program will facilitate a better understanding the complex feedbacks that control the overall evolution of the Arctic system for timescales ranging from a few days to several years. Findings from this and other ArcSEES projects will support NEPA analyses for potential future lease sales, review of EPs, DPPs and other reviews for BOEM decision-making and mitigation.

BOEM Contribution: $300,000 plus Joint Funding

Period of Performance: FY 2013-2020

Conducting Organization: NSF, ArcSEES

BOEM Contact: Dr. John Primo

Description:

Background: Further development of oil and gas resources and associated infrastructure in the Arctic is possible, and BOEM, other agencies, and the private sector need more information on the infrastructural effects of such activity, and particularly on the thawing of permafrost. This vital component of the arctic ecosystem plays a substantial role in supporting system processes; including subsistence activities in the region.

Additional information is needed so that current international initiatives related to the Arctic may better address cumulative effects of extensive networks of infrastructure needed for resource development. This is important as local people are directly impacted by the effects of oil and gas development and associated infrastructure. The opening of arctic lands and seas to transportation and development is occurring against a backdrop of sea-ice loss, dwindling resources elsewhere in the world, and competing geopolitical interests. It is inevitable that considerably more infrastructure than presently exists will be required to develop these areas.

Objectives: The overarching goal of this study is to better understand the cumulative environmental and social effects of developing oil and gas resources in the Arctic, and to support the creation of a comprehensive adaptive planning approach toward

infrastructural development. In doing so, the study aims to meet the following objectives:

- An enhanced understanding of the infrastructure-related permafrost/landform/ vegetation succession in terrain undergoing thermokarst formation
- The creation of an arctic infrastructure action group to develop adaptive management strategies that address the unique issues related to networks of infrastructure in arctic permafrost environments
- The development of future arctic scientists with an understanding of the effects of industrial development and the potential for adaptive management

Methods: This study will include an examination of infrastructure and landscape change at multiple scales, an evaluation of adaptive management planning for infrastructure in northern Alaska and cumulative effects studies associated with the Iñupiat village of Nuiqsut. The study will also support several workshops bringing a diversity of scientists and local people together to develop adaptive management strategies that address issues related to the effects of infrastructure development in arctic permafrost environments. Lastly, training for students on arctic systems and on issues related to industrial development and adaptive management will be administered through a college course.

Revised Date: October 4, 2019

SECTION 3.0 TOPICAL AREAS FOR FUTURE RESEARCH

This section presents a general forecast of significant topical issues and concerns to be addressed by studies for FY 2022 and beyond. In general, these topics conform with the research themes of the ESP. Due to the great differences existing between Alaskan environments and other OCS areas, the uniqueness of issues in Alaska has dictated the need to anticipate new topical areas for implementation. These projects will focus on BOEM mission needs within the context of varying industry interest in OCS exploration, development and production, as well as potential trends in a changing environment.

In addition to the ongoing information needs relating to existing leases in the Beaufort Sea and Cook Inlet, a lease sale is currently scheduled for 2021. In addition, a future *Outer Continental Shelf Oil and Gas Leasing Program* could lead to increased levels of oil and gas activities in the Beaufort Sea, the Chukchi Sea, and Cook Inlet. This would expand BOEM's information needs in these areas, as well as in other Alaska OCS Planning Areas that could be impacted by the additional actions.

3.1 Environmental Change

In recent years, the extent, duration, and thickness of summer ice cover in the Arctic region have decreased to record historical lows. The loss of ice cover is causing changes to both physical oceanography and ecosystem productivity and has substantial ramifications for marine mammals, birds and fish species that live on, below, or near the ice.

Oceanic current patterns in the Arctic, especially in nearshore regions, are strongly influenced by climatological factors such as winds, river runoff and sea ice coverage. The rapid changes in each of these factors that are now occurring could lead to drastic alterations of the surface current fields. Oil-spill trajectory analyses performed by BOEM are based on surface current data derived from ocean circulation hindcast models. As climate change continues, oil-spill trajectory modeling may need to be updated on a more frequent basis.

Climate change is also associated with altered water chemistry, particularly a reduction in pH, which will likely produce substantial habitat stresses for calcifying marine organisms (Mathis and Cross 2014). In addition, the duration and extent of seasonal sea ice, seawater temperature, and water mass structure are critical controls on water column production, organic carbon cycling, and pelagic-benthic coupling. The recently observed changes in these factors have the potential to alter the current benthic-based food web to one more dominated by pelagic trophic transfers (Grebmeier and Cooper 2012). More research is needed to better understand the implications of such a shift, such as whether conditions may become less favorable for krill and arctic copepods, the preferred prey of bowhead whales.

Climate change also entrains many socio-economic issues. Some immediate concerns include: increased shoreline erosion and permafrost melt that threatens arctic villages and infrastructure; changes in distribution and availability of hunted subsistence species; and potential changes in commercial and subsistence fisheries as commercial

species such as salmon move north. In consideration of such basic transition, scientists are challenged to project how climate change effects will interact with OCS activities in the Arctic over the next 25-50 years.

3.2 Air Quality

In December 2011, Congress transferred jurisdiction and authority for the regulation of oil and gas-related air emissions on the OCS adjacent to the North Slope Borough from the EPA to BOEM. While implementing this authority, BOEM will need air quality monitoring information to assess the cumulative air quality impact of OCS Arctic oil and gas activity and to support compliance with the OCSLA and environmental justice initiatives. In particular, more information is needed to evaluate how high levels of substances such as black carbon and methane might impact climate change, as well as human health, in the region.

3.3 Physical Oceanography

An ongoing challenge in Alaska is the need for better, finer scale circulation and oil-spill models and higher resolution data. This need is underscored by the rapidly changing conditions in the Arctic. Continued development and application of state-of the-art circulation models is important for future OSRA-based EIS analyses.

Improvements are also needed in sea ice aspects of the modeling. The resolution of ice models and ice data needs to be increased to address the propagation of fine scale, non-random interactions across hundreds of miles of pack ice, as evidenced by ice leads and extensive break-out events seen in satellite images in recent years.

A better understanding of the first order physics controlling regional circulation and ice conditions within the U.S. Beaufort and Chukchi Seas, as well as interactions with the Arctic basin and Canadian Beaufort, would inform and improve regional analyses for NEPA documents, and review of oil-spill response planning documents. In particular, more information is needed to assess the impact of ice on the nature and amplitude of the upwelling/downwelling, to evaluate influences of Atlantic water and other water masses, and to gain a better understanding of the dynamics associated with river outflow plumes, especially under ice.

3.4 Fate and Effects

The Alaska Office has been collecting baseline biological and chemical monitoring data in the Beaufort Sea since the 1980s, first under the BSMP and more recently through the suite of ANIMIDA studies. Similar monitoring work has been ongoing in the Chukchi Sea since 2008, through the component projects of the COMIDA program. The need for additional monitoring will continue to be re-evaluated as oil and gas exploration and development on the OCS off Alaska evolves.

Available information about input of hydrocarbon to the environment through natural oil seeps across the OCS off Alaska is limited. The ESP is initiating a study to collate and synthesis currently available data regarding seeps offshore of Alaska, and to develop

recommendations for future field research. Identification of the location and extent of these seeps, as well as information on the chemical composition and weathering characteristics of these oils, would provide additional insight for analysis of potential effects from oil spills. The presence of natural oil seeps is indicative of organisms adapted to metabolize the hydrocarbons. More information is needed about hydrocarbon-consuming organisms resident in the Arctic.

3.5 Marine Mammals and Protected Species

Oil and gas-related activities, including development and production at the Liberty site and other potential sites, may lead to risks of oil spills from buried pipelines, other discharges, noise from various industrial and support activities, and increased human interaction with arctic offshore species. Species protected under the ESA, MMPA and the Migratory Bird Treaty Act are of particular concern if impacted by such factors. Study of the effects of oil and gas-related activities on protected mammals and the need for monitoring of endangered species are expected to continue. Related to this is the need for assessment of how any changes in the bowhead whale migration's distance from shore could relate to subsistence success (see below). Future bowhead whale studies are expected to continue to explore use of satellite tagging for information on bowhead whale residence times in development areas and advancement of UAS technologies also will lead to expanded research opportunities for bowhead whales.

As benthic feeders with a preference for bivalves, walruses are especially vulnerable to climate change or ecosystem shifts (Berchok et al. 2015). Walruses characteristically will haul out onto sea ice to rest, with the advantage that the ice can carry them to new feeding grounds. The summer distribution of walruses has been changing as a result of changes in summer pack ice, however, with large numbers of walruses observed to haul out on land along the Chukchi coast during most years in the past decade. A notable exception is 2012, when some ice persisted over the shelf. Information is needed to more fully understand how this shift to land-based haulouts affects walrus foraging behavior, diet, and energetic needs.

Other key subsistence species for which behavioral or monitoring studies may be needed include polar bears, beluga whales, ringed seals, ribbon seals and bearded seals. The impacts of sea ice loss and other environmental change on both ice seals and polar bears are high priority information needs. The status of the critically endangered Cook Inlet population of beluga whales and potential effects from future oil and gas activity is also of ongoing concern. Furthermore, BOEM will continue to develop specific information on the hearing capabilities of baleen whales and other marine mammals with the goal of better understanding their behavior in response to industrial noise.

3.6 Marine Fish Migrations, Recruitment and Essential Fish Habitat

BOEM needs information to assess and manage the potential environmental effects of OCS development on marine fish. More detailed information about the biology and ecology of many marine fish species inhabiting areas of potential oil and gas activity would be especially useful. The highest priority BOEM information needs include

species presence, distribution, abundance and potential effects of oil spills, particularly during periods when ice is present. As a result of the Magnuson-Stevens Fishery Conservation and Management Act, effects on Essential Fish Habitat must also be evaluated. More information is needed to evaluate Essential Fish Habitats and to clarify environmental assessment and mitigation needs.

Alaska Natives are concerned that OCS activities will affect subsistence fish populations and reduce availability for subsistence harvest. Consequently, additional research on arctic fisheries and recruitment to nearshore feeding populations are an important consideration. In addition, more information is needed regarding the effects of seismic exploration on the health, behavior, distribution, and migration of the numerous important fish species of the Beaufort and Chukchi seas.

A need for more information on the forage fish resources and their relation to apex predators on the OCS is also indicated. A good understanding of the seasonal distribution, abundance, and habitat use of forage fish, including the effects of changing temperatures and prey availability, is fundamentally important to monitoring the potential environmental impacts associated with OCS development. Understanding of key spawning and migration events that quickly transfer large amounts of energy to upper trophic levels is also important.

3.7 Subsistence and Socio-economics

Residents of the North Slope coastal communities frequently express concern about cumulative impacts of offshore and onshore developments, as well as climate change, on their subsistence way of life. Some of the concerns of the Iñupiat include diminished access to hunting and fishing areas around oil industry infrastructure, reduced harvests, increased hunter efforts, increased hunter cost and general food security. How, and to what degree, subsistence activities have been affected by industry infrastructure and industry activity, or may be in the future, are concerns that will continue to be further addressed by additional research. Consideration of cumulative impacts is an important issue for BOEM in preparing NEPA documents.

Aggregate effects research also encompasses a broader set of issues concerning how the Iñupiat society has been potentially affected. Relevant issues include a wide range of topics, such as the changing relationship between the cash economy and household subsistence activities, changing sources of anxiety and stress at multiple levels of organization, potential changes in sharing of subsistence resources and in the recruitment of youth into subsistence activities. Social indicators should be maintained to serve as a basis for estimating long-term aggregate impacts.

Furthermore, additional information is needed regarding contaminant levels in the marine mammals and fish species of Cook Inlet and other OCS areas off Alaska. Of particular concern is the potential impact of contamination or perception of tainting in relation to subsistence, commercial, and recreational fishing activities.

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APPENDIX 1: U.S. ARCTIC RESEARCH PLAN: Intersection with BOEM Environmental Studies

This table is organized to display recent BOEM-directed research as it supports relevant Research Goals and Objectives outlined in IARPC's *Arctic Research Plan: 2017-2021* released in December 2016.

BOEM Study	BOEM Partner(s)	BOEM Funding	Study Duration	Relationship to IARPC Performance Element
Research Goal 1: Enhance Understanding of Health Determinants and Improve the Well-being of Arctic Residents				
Research Objective 1.1: Support integrative approaches to human health that recognize the connections among people, wildlife, the environment, and climate.				
Performance Element 1.1.2: In collaboration with the ANTHC, support community-based monitoring and Indigenous Knowledge and Local Knowledge by maintaining and strengthening the Local Environmental Observer (LEO) Network to help describe connections between climate change, environmental impacts, and health effects.				
AK-16-05 Community Based Monitoring: LEO Network	ANTHC	$400,000	2016-2021	Supports continued maintenance and expansion of the LEO network to improve reporting from the North Slope and Cook Inlet and enhance the quality, rigor, and consistency of data collection.
Performance Element 1.1.4: Increase understanding of how both natural climate change and the effects of human activities are affecting the ecosystem by documenting observations of changing sea ice conditions, with implications for development and subsistence.				
AK-13-03-16 Northern Alaska Sea Ice Project Jukebox OCS Study BOEM 2018-027	UAF-CMI	$60,663	2016-2018	Documented personal observations and traditional knowledge about ice near Barrow and Kotzebue to assess what has changed and how the Iñupiat are adapting to the changes.
Research Goal 3: Enhance Understanding and Improve Predictions of the Changing Arctic Sea Ice Cover				
Research Objective 3.1: Conduct coordinated/integrated atmosphere-ice-ocean observations and research to understand the processes that determine the spatial and temporal variation of the thickness, extent, and volume of sea ice and their effects on atmosphere-ice-ocean interactions and feedbacks over multiple time scales (hourly, daily, weekly, seasonal, inter-annual, decadal).				
Performance Element 3.1.1: Support investigator-driven observations and process studies of the pack ice (e.g., ice thickness distribution, topography/surface roughness and strength; ice motion and deformation; snow depth distribution and melt pond characteristics; surface albedo and energy balance) and landfast ice (e.g., extent, stability, and break-up).				
AK-13-03-07 Development and Testing of a Low-Cost Satellite-Tracked Ice Drifter for Arctic Waters OCS Study BOEM 2017-079	UAF-CMI	$243,286	2014-2018	Deployed drifters on landfast and mobile pack ice to develop new information on the fate of landfast ice in the Chukchi and Beaufort seas.
AK-13-03-17 Measuring Wave Forces along Alaska's Coastal Sea Ice	UAF-CMI	$311,392	2016-2020	Improve understanding of wave energy propagation into sea ice, and determine its effect on landfast ice stability along the Chukchi coast.
Performance Element 3.1.5: Use multiple remote sensing data sets to: (1) investigate sea ice properties and processes and atmosphere-ice-ocean interactions; and (2) develop algorithms for automated ice edge detection and delineation of the marginal ice zone, landfast ice extent, ice classification (e.g., age/type of ice, melt ponds, floe size), and ice motion and deformation.				

BOEM Study	BOEM Partner(s)	BOEM Funding	Study Duration	Relationship to IARPC Performance Element
AK-19-03 Landfast Ice in the Beaufort and Chukchi Seas	UAF	$1.70M	2019-2023	Developing protocols to analyze satellite data and create and maintain a landfast ice climatology database for the Beaufort and Chukchi seas.
AK-20-xx Update of River Overflood on Sea Ice and Strudel Scour Database			2020-2022	This new study will document maximum river overflood boundaries and collate industry acquired strudel scour data from Smith Bay to Camden Bay between 2008 and 2019
Performance Element 3.1.6: Develop and deploy new technologies that enable persistent data collection on a variety of environmental variables using mobile platforms and sensors operating above, on, in, and under the Arctic sea ice cover to support a framework of observations that will improve forecasting and prediction of sea ice.				
AK-13-03-17 Measuring Wave Forces along Alaska's Coastal Sea Ice	UAF-CMI	$311,392	2016-2020	Improve understanding of wave energy propagation into sea ice, and determine its effect on landfast ice stability along the Chukchi coast.
AK-19-03 Landfast Ice in the Beaufort and Chukchi Seas	UAF	$1.70M	2019-2023	Developing protocols to analyze satellite data and create and maintain a landfast ice climatology database for the Beaufort and Chukchi seas.
AK-20-xx Update of River Overflood on Sea Ice and Strudel Scour Database			2020-2022	This new study will document maximum river overflood boundaries and collate industry acquired strudel scour data from Smith Bay to Camden Bay between 2008 and 2019
Performance Element 3.1.7: Investigate Arctic Ocean processes, interactions and feedbacks that affect the dynamics and thermodynamics of the sea ice cover, including ocean circulation and stratification, turbulence and mixing, horizontal and vertical heat transport, and freshwater transport and storage.				
NT-13-05 Marine Arctic Ecosystems Study (MARES): A Multi-Agency NOPP Partnership	NOPP	$5.42M	2015-2020	Describing ocean currents at different depths along the Beaufort Sea continental shelf, including the biogeochemical-physical interactions and feedback processes in ice free and ice covered areas.
AK-12-03a Characterization of the Circulation on the Continental Shelf Areas of the Northeast Chukchi and Western Beaufort Seas OCS Study BOEM 2017-065	CESU-UAF	$5.06M	2012-2018	Characterized the flow regimes and surface water exchange among areas of the inner and outer Chukchi shelf and the western Beaufort shelf under varying conditions of wind forcing and sea ice coverage.
AK-17-01 Wave and Hydrodynamic Modeling in the Nearshore Beaufort Sea	CESU-UAF; USGS	$2.12M	2017-2022	Using observations and a coupled ocean-wave model to obtain a better understanding of the physical processes related to wave conditions and their effects within Stefansson Sound in the Beaufort Sea.
AK-19-03 Landfast Ice in the Beaufort and Chukchi Seas	UAF	$1.70M	2019-2023	Evaluating how changes in landfast ice relate to local and regional changes in temperature, pressure, and major storms.
AK-19-02-04 Western Beaufort and Chukchi Sea Surface Current Analysis	UAF-CMI	$77,640	2019-2022	Assessing the relation between the wind and the surface flow field structure and evolution.
AK-20-xx Update of River Overflood on Sea Ice and Strudel Scour Database			2020-2022	This new study will document maximum river overflood boundaries and collate industry acquired strudel scour data from Smith Bay to Camden Bay between 2008 and 2019

BOEM Study	BOEM Partner(s)	BOEM Funding	Study Duration	Relationship to IARPC Performance Element
Research Objective 3.2: Improve models for understanding sea ice processes and for enhanced forecasting and prediction of sea ice behavior at a range of spatial and temporal scales.				
Performance Element 3.2.1: Support investigator-driven modeling studies designed to understand and parameterize key sea ice properties and processes, including ice thickness distribution, topography, and strength; ice motion, deformation and mechanics; snow depth distribution and melt pond characteristics; surface albedo and energy balance; and biogeochemistry.				
AK-15-02 Development of a Very High-resolution Regional Circulation Model of Beaufort Sea Nearshore Areas OCS Study BOEM 2018-018; OCS Study BOEM 2018-007	CESU-Rutgers University; UAF	$489,735	2015-2018	Developed an updated coupled ice-ocean circulation model of the Arctic Ocean, including nested domains for high-resolution computations on the Beaufort Sea shelf.
AK-19-03 Landfast Ice in the Beaufort and Chukchi Seas	UAF	$1.70M	2019-2023	Producing data that will support verification and validation of sea ice models.
AK-17-01 Wave and Hydrodynamic Modeling in the Nearshore Beaufort Sea	CESU-UAF; USGS	$2.12M	2017-2022	Using observations and a coupled ocean-wave model to obtain a better understanding of the physical processes related to wave conditions and their effects within Stefansson Sound in the Beaufort Sea.
Performance Element 3.2.2: Enhance operational sea ice forecasting and research-oriented prediction capabilities through improvements to model physics (explicit and parameterized); initialization techniques; assimilation of observations, including newly available and future data sources such as VIIRS, AMSR2, CryoSat-2, SMOS, and ICESat-2; model evaluation and verification; evaluation of model skill, post-processing techniques and forecast guidance tools used in operational forecasts and decision support.				
AK-15-02 Development of a Very High-resolution Regional Circulation Model of Beaufort Sea Nearshore Areas OCS Study BOEM 2018-018; OCS Study BOEM 2018-007	CESU-Rutgers University; UAF	$489,735	2015-2018	Contributed to advancement of predictive capabilities for sea ice in ocean circulation models.
Research Goal 4: Increase Understanding of the Structure and Function of Arctic Marine Ecosystems and Their Role in the Climate System and Advance Predictive Capabilities				
Research Objective 4.1: Increase knowledge on the distribution and abundance of Arctic marine species across all trophic levels and scales, including an improved understanding of the formation and maintenance of biological hotspots and proximate causes of shifts in range.				
Performance Element 4.1.1: Continue distribution and abundance surveys of Arctic marine species, for example, concurrent monitoring of polar bears and their ice seal prey.				
AK-11-05 Synthesis of Arctic Research (SOAR): Physics to Marine Mammals in the Pacific Arctic OCS Study BOEM 2018-017	NOAA-PMEL	$1.79M	2011-2018	Used a synthesis approach to increase scientific understanding of the relationships of oceanographic conditions, lower trophic prey species and marine mammal distribution and behavior in the Pacific Arctic. The project included development of the Arctic Marine Pulses (AMP) model was developed that depicts seasonal biophysical 'pulses' across a latitudinal gradient by linking processes across contiguous ecological domains.
AK-12-04 U.S.-Canada Transboundary Fish and Lower Trophic Communities OCS Study BOEM 2017-034	UAF; DFO Canada	$5.19M	2012-2018	Documented baseline fish and invertebrate species presence, abundance, distribution and biomass.

BOEM Study	BOEM Partner(s)	BOEM Funding	Study Duration	Relationship to IARPC Performance Element
AK-12-07 Arctic Whale Ecology Study (ARCWEST): Use of the Chukchi Sea by Endangered Baleen and Other Whales OCS Study BOEM 2018-022; OCS Study BOEM 2019-024	MML	$4.60M	2012-2017	Assessed spatial and temporal patterns of use of the Chukchi Sea by endangered bowhead, fin and humpback whales, and beluga and gray whales and evaluated ecological relationships for the species.
AK-13-02 Chukchi Acoustic, Oceanography and Zooplankton Study: Hanna Shoal (Extension of CHAOZ) OCS Study BOEM 2018-008; OCS Study BOEM 2019-024	MML	$3.93M	2013-2019	Assessed the spatial and temporal distribution of marine mammals near Hanna Shoal and the extent that environmental conditions such as sea ice, oceanic currents, water temperature and salinity, and prey abundance influence whale distribution and relative abundance.
AK-13-06 Walrus Seasonal Distribution and Habitat Use in the Eastern Chukchi Sea	USGS	$1.69M	2013-2018	Evaluating seasonal abundance, distribution, and habitat use of walruses in the Chukchi Sea.
AK-16-07 Arctic Integrated Ecosystem Survey, Phase II	NOAA; UAF; USFWS	$2.50M	2017-2022	Quantifying the distribution, abundance, and condition of fishes, shellfishes, and seabirds throughout the U.S. shelf waters of the Chukchi Sea and Western Beaufort Sea.
AK-17-03 Marine Bird Distribution and Abundance in Offshore Waters	USFWS	$500,000	2017-2021	Using long-term surveys to determine seabird spatial distribution, species composition, and seasonal changes in species abundance in the Arctic.
AK-16-01 Aerial Surveys of Arctic Marine Mammals (ASAMM) OCS Study BOEM 2018-023	MML	$11.44M	2016-2019	Long-term surveys to document the distributions and relative densities of marine mammals in the Chukchi Sea and Beaufort Sea Planning Areas.
AK-16-06 Estimation of Abundance and Demographic Rates of Pacific Walruses Using a Genetics-based Mark-Recapture Approach OCS Study BOEM 2019-059	USFWS	$250,000	2016-2019	Estimating annual abundance of walruses for evaluation of population status and trends by applying mark-recapture analytical techniques to biopsy samples.
AK-19-02-03 Utilization of the Under-ice Habitat by Arctic Cod in the Western Arctic Ocean: A Multidisciplinary Collaborative Study	UAF-CMI	$258,539	2019-2022	Conducting under-ice surveys of Arctic cod to obtain better understanding of the under-ice associations of Arctic cod life history and key under-ice habitat locations.
AK-19-02-05 Evaluating Novel Assessment Approaches for Coastal Ice Seal Haulout Areas and Behavior in the Alaskan Beaufort Sea	UAF-CMI	$204,990	2019-2021	Evaluating the potential of small UAS and time-lapse cameras to assess the seasonal presence, behavior, and numbers of spotted and bearded seals at known summer-fall coastal haulouts.
Performance Element 4.1.2: Continue studies to document Arctic marine species biodiversity (e.g. Arctic Marine Biodiversity Observation Network—AMBON—and programs that monitor loss of sea ice) and habitat use in the Arctic.				
AK-15-01 Initiating an Arctic Marine Biodiversity Observing Network (AMBON) for Ecosystem Monitoring	NOPP; NOAA; UAF	$1.75M	2015-2020	Examining influences of sea ice dynamics on the phenology, distribution, and life history of upper trophic predators in response to availability of lower trophic prey resources; and improving knowledge about rates of consumption, growth, and reproduction of benthic and pelagic organisms.

BOEM Study	BOEM Partner(s)	BOEM Funding	Study Duration	Relationship to IARPC Performance Element
AK-16-02 Collaboration with North Pacific Research Board (NPRB) Arctic Marine Research Program	NPRB	$1.00M	2016-2021	Provides support for NPRB's Arctic Integrated Ecosystem Research Program, including coordination among the ASGARD and Arctic IES (AK-16-07) components.
AK-16-07 Arctic Integrated Ecosystem Survey, Phase II	NOAA; UAF; USFWS	$2.50M	2017-2022	Quantifying the distribution, abundance, and condition of fishes, shellfishes, and seabirds throughout the U.S. shelf waters of the Chukchi Sea and Western Beaufort Sea.
AK-19-01 Impacts of Sedimentation and Drivers of Variability in the Boulder Patch Community, Beaufort Sea	UT-Austin; UAF	$750,000	2019-2024	Conducting a monitoring program to examine long-term drivers of community variability during Liberty development activities.
AK-19-02-02 Kelp Restoration in the Boulder Patch	UAF-CMI	$138,884	2020-2023	Evaluating the value of artificial reefs as a mitigation tool for potential disturbances to foundation kelp in the Boulder Patch.
AK-19-07 Model-based Essential Fish Habitat (EFH) Descriptions for Arctic Cod, Saffron Cod and Snow Crab in the Alaskan Arctic	UAF	$125,000	2019-2021	Identifying habitat characteristics most important to distributions and habitat suitability of larval (if data is available), juvenile and adult Arctic cod, saffron cod and snow crab.
AK-20-xx Early Detection Plan for Marine Non-native Species on the Arctic Outer Continental Shelf			2020-2023	Establishing a monitoring scheme for detection of marine non-native species in the Arctic.
Performance Element 4.1.3: Assess winter distributions of key Arctic species, via passive acoustic sampling and satellite tagging for marine mammals to include further development of autonomous, unmanned surface and underwater vehicles equipped with sensors capable of recording marine mammal vocalizations.				
AK-12-02 Satellite Tracking of Bowhead Whales: Habitat Use, Passive Acoustic and Environmental Monitoring	ADF&G	$2.70M	2012-2019	Deployed satellite transmitters with environmental and passive acoustic monitoring capabilities to track the movements and document the behavior of bowhead whales.
AK-12-07 Arctic Whale Ecology Study (ARCWEST): Use of the Chukchi Sea by Endangered Baleen and Other Whales OCS Study BOEM 2018-022 ; OCS Study BOEM 2019-024	MML	$4.60M	2012-2017	Used passive acoustic monitoring to assess spatial and temporal patterns of use of the Chukchi Sea by endangered bowhead, fin and humpback whales, and beluga and gray whales.
AK-13-02 Chukchi Acoustic, Oceanography and Zooplankton Study: Hanna Shoal (Extension of CHAOZ) OCS Study BOEM 2018-008 ; OCS Study BOEM 2019-024	MML	$3.93M	2013-2019	Used passive acoustic monitoring to assess spatial and temporal distribution of marine mammals near Hanna Shoal.
Research Objective 4.3: Advance the understanding of how climate-related changes, biophysical interactions, and feedbacks at different scales in the marine ecosystems impact Arctic marine resources and human communities that depend on them.				
Performance Element 4.3.1: Continue Distributed Biological Observatory (DBO) sampling in regions 1-5 and make data publicly available through upload of metadata to the Earth Observing Laboratory/DBO data portal.				
AK-16-07 Arctic Integrated Ecosystem Survey, Phase II	NOAA; UAF; USFWS	$2.50M	2017-2022	Quantifying the distribution, abundance, and condition of fishes, shellfishes, and seabirds throughout the U.S. shelf waters of the Chukchi Sea and Western Beaufort Sea.

BOEM Study	BOEM Partner(s)	BOEM Funding	Study Duration	Relationship to IARPC Performance Element
Performance Element 4.3.4: Continue research and make simultaneous observations of biological, chemical, and physical variables to examine linkages among marine species, oceanographic and sea ice conditions, and climate change to understand the mechanisms that affect performance and distribution. Quantify feedbacks and interactions of bottom-up and top-down processes that regulate production.				
AK-11-03 Hanna Shoal Ecosystem Study OCS Study BOEM 2016-047	CESU-UT	$5.69M	2011-2018	Examined important chemical, physical and biological interactions with the unique ecological regime in the highly productive area of Hanna Shoal.
AK-13-02 Chukchi Acoustic, Oceanography and Zooplankton Study: Hanna Shoal (Extension of CHAOZ) OCS Study BOEM 2018-008 ; OCS Study BOEM 2019-024	MML	$3.93M	2013-2019	Assessed the spatial and temporal distribution of marine mammals near Hanna Shoal and the extent that environmental conditions such as sea ice, oceanic currents, water temperature and salinity, and prey abundance influence whale distribution and relative abundance.
AK-16-02 Collaboration with North Pacific Research Board (NPRB) Arctic Marine Research Program	NPRB	$1.00M	2016-2021	Provides support for NPRB's Arctic Integrated Ecosystem Research Program, including coordination among the ASGARD and Arctic IES (AK-16-07) components.
AK-16-07 Arctic Integrated Ecosystem Survey, Phase II	NOAA; UAF; USFWS	$2.50M	2017-2022	Quantifying the distribution, abundance, and condition of fishes, shellfishes, and seabirds throughout the U.S. shelf waters of the Chukchi Sea and Western Beaufort Sea.
AK-19-01 Impacts of Sedimentation and Drivers of Variability in the Boulder Patch Community, Beaufort Sea			2019-2022	Conducting a monitoring program to examine long-term drivers of community variability during activities at the Liberty Development.
AK-19-02-02 Kelp Restoration in the Boulder Patch	UAF-CMI	$138,884	2020-2023	Evaluating the value of artificial reefs as a mitigation tool for potential disturbances to foundation kelp in the Boulder Patch.
NT-13-x11 WALRUS – Walrus Adaptability and Long-term Responses; Using multi-proxy data to project Sustainability	NSF	$200,000	2013-2019	Tracking changes in walrus trophic position, foraging location, and genetic structure and diversity over the past 2500 years using multi-proxy datasets.
Performance Element 4.3.7: Continue development, testing, and runs of prognostic models that use Intergovernmental Panel on Climate Change (IPCC) scenarios in a regional context to explore current understanding of biophysical interactions and feedbacks, such as perturbations across several modeled food webs from the subarctic to the Arctic to estimate relative ecosystem sensitivities and rates of change.				
AK-11-05 Synthesis of Arctic Research (SOAR): Physics to Marine Mammals in the Pacific Arctic OCS Study BOEM 2018-017	NOAA-PMEL	$1.80M	2011-2018	This synthesis project included a component that examined sea-ice cover timing in the Pacific Arctic based on IPCC scenarios.
Research Goal 8: Strengthen Coastal Community Resilience and Advance Stewardship of Coastal Natural and Cultural Resources by Engaging in Research Related to the Interconnections of People, Natural, and Built Environments				
Research Objective 8.1: Engage coastal communities in research to advance knowledge on cultural, safety, and infrastructure issues for coastal communities.				
Performance Element 8.1.1: Engage coastal community members in research by seeking cooperative opportunities between community members, IK holders, and/or LK holders, and researchers in knowledge co-production research processes. Employ IK and/or LK to jointly conceive of and plan research activities and to report research results back to communities.				

BOEM Study	BOEM Partner(s)	BOEM Funding	Study Duration	Relationship to IARPC Performance Element
AK-15-05 Traditional Knowledge Implementation: Accessing Arctic Community Panels of Subject Matter Experts	NSB-DWM	$359,470	2016-2020	Develops panels of subject matter experts to systematically incorporate Traditional (Indigenous) Knowledge from community members through co-production of knowledge and sharing with western scientists.
AK-20-xx Early Detection Plan for Marine Non-native Species on the Arctic Outer Continental Shelf			2020-2023	Capturing LK related to marine invertebrates and introductions of non-native species. Local citizens will be involved with field surveys and plans to establish a long-term monitoring scheme.
Performance Element 8.1.2: Engage coastal community members in research by supporting community-based monitoring focused on measuring physical and biotic information by strengthening initiatives led by groups such as the Arctic-focused LCCs, BOEM, NOAA, and FWS.				
AK-19-05 Monitoring of the Cross Island Subsistence Whale Hunt for Effects from Liberty DPP			2019-2024	Engaging with Alaska Native hunters to monitor the annual bowhead whale hunt at Cross Island and document the hunters' IK/LK.
AK-17-01 Wave and Hydrodynamic Modeling in the Nearshore Beaufort Sea	CESU-UAF; USGS	$2.12M	2017-2022	Involving local community members in collecting ocean observations.
AK-20-xx Subsistence Harvest and Iñupiaq Knowledge of Beluga Whales for Kaktovik, Alaska			2020-2023	Documenting how the people of Kaktovik hunt belugas and how beluga is processed and examining the cultural importance of belugas and beluga harvest for Kaktovik.
Research Goal 9: Enhance Frameworks for Environmental Intelligence Gathering, Interpretation, and Application toward Decision Support				
Research Objective 9.4: Enhance availability, discoverability, understanding, and interoperability of Arctic data and tools across Federal data centers.				
Performance Element 9.4.4: Advance agile situational awareness and decision support for Arctic operators through efforts like ADAC's Arctic Information Fusion Capability28, ERMA, and NASA ACE project.				
AK-12-03b Arctic Tracer Release Experiment (ARCTREX): Applications for Mapping Spilled Oil in Arctic Waters OCS Study BOEM 2017-062	BSEE; UAF	$1.25M	2013-2018	Tested the ability of available observational technology to sample a simulated oil spill in the Chukchi Sea and to transmit data to NOAA's Arctic Environmental Response Management Application (ERMA).

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APPENDIX 2: RECENT OCS STUDY REPORTS: 2015—2019

BOEM 2019-059	Estimation of abundance and demographic rates of Pacific walruses using a genetics-based mark-recapture approach
BOEM 2019-031	Coastal Community Vulnerability Index and Visualizations of Change in Cook Inlet, Alaska
BOEM 2019-030	Identifying sources of organic matter to benthic organisms in the Beaufort and Chukchi outer continental shelves
BOEM 2019-024	Chukchi Sea Acoustics, Oceanography, and Zooplankton Study: Hanna Shoal Extension (CHAOZ-X) and Arctic Whale Ecology Study (ARCWEST) Supplemental Report
BOEM 2019-009	Marine ARctic Ecosystem Study (MARES): Moorings on the Beaufort Sea shelf, 2016-2017
BOEM 2019-005	Coastal Marine Institute (CMI) Annual Report 25: Calendar Year 2018
BOEM 2018-064	University of Alaska Coastal Marine Institute, Program Administration 2013-2017
BOEM 2018-059	Migration Trends for King and Common Eiders and Yellow-billed Loons past Point Barrow in a Rapidly Changing Environment
BOEM 2018-058	CMI Graduate Student Projects: Volume 2: Functional Diversity of Epibenthic Communities on the Chukchi and Beaufort Sea Shelves; Using Trace Elements in Pacific Walrus Teeth to Track the Impacts of Petroleum Production in the Alaskan Arctic
BOEM 2018-048	Oil-Spill Occurrence Estimators: Fault Tree Analysis for One or More Potential Future Beaufort Sea OCS Lease Sales
BOEM 2018-037	ShoreZone Imaging and Mapping along the Alaska Peninsula
BOEM 2018-032	US Outer Continental Shelf Oil Spill Causal Factors Report (2018)
BOEM 2018-027	Northern Alaska Sea Ice Project Jukebox: Phase III
BOEM 2018-024	Marine Arctic Ecosystem Study—Biophysical and Chemical Observations From Glider and Benthic Surveys in 2016
BOEM 2018-023	Distribution and Relative Abundance of Marine Mammals in the Eastern Chukchi and Western Beaufort Seas, 2017 Annual Report
BOEM 2018-022	Arctic Whale Ecology Study (ARCWEST): Use of the Chukchi Sea by Endangered Baleen and Other Whales (Westward Extension of the BOWFEST)

BOEM 2018-021	CMI Graduate Student Projects: Characterizing Bacterial Communities in Beaufort Sea Sediments in a Changing Arctic; Chukchi-Beaufort Seas Storms and Their Influence on Surface Climate; Using Genotyping-by-Sequencing (GBS) Population Genetics Approaches to Determine the Population Structure of Tanner Crab (*Chionoecetes bairdi*) in Alaska
BOEM 2018-020	Arctic Air Quality Impact Assessment Modeling Study: Final Project Report
BOEM 2018-018	Development of a Very High-Resolution Regional Circulation Model of Beaufort Sea Nearshore Areas
BOEM 2018-017	Synthesis of Arctic Research (SOAR): Physics to Marine Mammals in the Pacific Arctic
BOEM 2018-016	Development of an Autonomous Carbon Glider to Monitor Sea-Air CO2 Fluxes in the Chukchi Sea
BOEM 2018-008	Chukchi Sea Acoustics, Oceanography, and Zooplankton Study: Hanna Shoal Extension (CHAOZ-X)
BOEM 2018-007	Technical Manual for a Coupled Sea-Ice/Ocean Circulation Model (Version 5)
BOEM 2018-006	US Outer Continental Shelf Oil Spill Statistics
BOEM 2017-087	Crude Oil Infiltration and Movements in First-Year Sea Ice; Impacts on Ice-Associated Biota and Physical Constraints
BOEM 2017-080	U.S.-Canada Northern Oil and Gas Research Forum Final Report
BOEM 2017-078	Distribution and Relative Abundance of Marine Mammals in the Eastern Chukchi and Western Beaufort Seas, 2016 Annual Report
BOEM 2017-077	Arctic Ecosystem Integrated Survey Final Report on Distribution of Fish, Crab, and Lower Trophic Communities in the Northeastern Bering Sea and Chukchi Sea
BOEM 2017-076	IceTrackers: Low-Cost Tracking of Sea Ice in Remote Environments
BOEM 2017-072	Alaska Monitoring and Assessment Program (AKMAP) Survey of Estuaries within the National Petroleum Reserve - Alaska
BOEM 2017-066	Genomics of Arctic Cod
BOEM 2017-065	Characterization of the Circulation on the Continental Shelf Areas of the Northeastern Chukchi and Western Beaufort Seas
BOEM 2017-062	Arctic Tracer Release Experiment (ARCTREX), Applications for Mapping Spilled Oil in Arctic Waters
BOEM 2017-055	Demographic Composition and Behazvior of Polar Bears Summering on Shore in Alaska

BOEM 2017-043	Siku Sea Ice Discrete Element Method Model
BOEM 2017-040	Arctic Air Quality Impact Assessment Modeling - Evaluation of the Exemption Thresholds
BOEM 2017-035	Social Indicators in Coastal Alaska: Arctic Communities
BOEM 2017-034	US-Canada Transboundary Fish and Lower Trophic Communities
BOEM 2017-033	Central Beaufort Sea Marine Fish Monitoring
BOEM 2017-032	Arctic Nearshore Impact Monitoring in Development Area III (ANIMIDA): Contaminants, Sources and Bioaccumulation
BOEM 2017-029	Arctic Air Quality Modeling Study - Final Near-Field Dispersion Modeling Report
BOEM 2017-020	Demography and Behavior of Polar Bears Summering on Shore in Alaska (USFWS)
BOEM 2017-019	Distribution and Relative Abundance of Marine Mammals in the Eastern Chukchi and Western Beaufort Seas, 2015 Annual Report
BOEM 2017-017	Marine Arctic Ecosystem Study - Pilot Program: Marine Mammals Tagging and Tracking
BOEM 2017-011	Seasonality of Seabird Distribution in Lower Cook Inlet
BOEM 2017-004	Seabird Distribution and Abundance in the Offshore Environmental Final Report
BOEM 2016-079	Distribution and Abundance of Select Trace Metals in Chukchi and Beaufort Sea Ice
BOEM 2016-078	Evaluating Chukchi Sea Trace Metals and Hydrocarbons in the Yukon River Delta, Alaska
BOEM 2016-077	Abundance Estimates of Ice-Associated Seals: Bering Sea Populations that Inhabit the Chukchi Sea During the Open-Water Period
BOEM 2016-076	Arctic Air Quality Modeling Study - Final Photochemical Modeling Report
BOEM 2016-075	Sea Level Measurements Along the Alaskan Chukchi and Beaufort Coasts
BOEM 2016-066	Distribution and Habitat Use of Fish in the Nearshore Ecosystem in the Beaufort and Chukchi Seas
BOEM 2016-064	Sensitivity to Hydrocarbons and Baselines of Exposure in Marine Birds on the Chukchi and Beaufort Seas
BOEM 2016-062	Physical and Chemical Analyses of Crude and Refined Oils: Laboratory and Mesoscale Oil Weathering

BOEM 2016-053	Pinniped Movements and Foraging: Village Based Walrus Habitat Use Studies in the Chukchi Sea
BOEM 2016-052	Final Report: Updates to Fault Tree Methodology and Technology for Risk Analysis -- Liberty Project
BOEM 2016-051	Testing the Use of Unmanned Aircraft Systems for Intertidal Surveys
BOEM 2016-048	Alaska Arctic Marine Fish Ecology Catalog
BOEM 2016-047	Chukchi Sea Offshore Monitoring in Drilling Area (COMIDA): Hanna Shoal Ecosystem Study
BOEM 2016-037	Technical Manual for a Coupled Sea-Ice/Ocean Circulation Model (Version 4)
BOEM 2015-050	Cook Inlet Circulation Model Calculations.
BOEM 2015-049	Arctic Air Quality Modeling Study Meteorological Model Performance Evaluation: 2009-2013 BOEM Arctic WRF Dataset
BOEM 2015-045	Sediment Characteristics and Infauna of Deltaic Mudflats Along the Alaskan Beaufort Sea
BOEM 2015-041	Biodegradation and Transport of Crude Oil in Sand and Gravel Beaches of Arctic Alaska
BOEM 2015-040	Distribution and Relative Abundance of Marine Mammals in the Eastern Chukchi and Western Beaufort Seas, 2014 - Annual Report
BOEM 2015-039	Arctic Currents: A Year in the Life of a Bowhead Whale
BOEM 2015-034	Final Report of the Chukchi Sea Acoustics, Oceanography and Zooplankton Study
BOEM 2015-029	Population Assessment of Snow Crab, Chionoecetes Opilio, in the Chukchi and Beaufort Seas Including Oil and Gas Lease Areas
BOEM 2015-023	Subsistence Sharing Networks and Cooperation: Kaktovik, Wainwright, and Venetie, Alaska
BOEM 2015-022	Satellite-tracked Drifter Measurements in the Chukchi and Beaufort Seas

APPENDIX 3: RECENT PUBLICATIONS AND PRESENTATIONS DERIVED FROM OCS STUDIES: 2015—2019

2019

Barton, M. B., S. Y. Litvin, J. J. Vollenweider, R.A. Heintz, B. L. Norcross, and K. M. Boswell. 2019. Implications of Trophic Discrimination Factor Selection for Stable Isotope Food Web Models of Low Trophic Levels in the Arctic Nearshore. Marine Ecology Progress Series. 613: 211-216.

Biddlecombe, B., A. Derocher, E. Richardson, and I. Stirling. 2019. Behaviour and Characteristics of Mating Polar Bears (*Ursus Maritimus*) in the Beaufort Sea, Canada. Polar Biology. First Published Online 12 March 2019.

Brooks, J. J., H. A. Crowley, C. C. Coon, and J. J. Kendall. 2019. Traditional Knowledge & Ocean Research. The Journal of Ocean Technology. 14(1) 49-58.

Carothers, C., T. L. Sformo, S. Cotton, J. C. George, and P. A. Westley. 2019. Pacific Salmon in the Rapidly Changing Arctic: Exploring Local Knowledge and Emerging Fisheries in Utqiaġvik and Nuiqsut, Alaska. Arctic. 72(3): 273-288.

Clark, C. T., L. Horstmann, and N. Misarti. 2019. Lipid Normalization and Stable Isotope Discrimination in Pacific Walrus Tissues. Scientific Reports. 9(1): 5843.

Clark, C. T., L. Horstmann, A. de Vernal, A. M. Jensen, and N. Misarti. 2019. Pacific Walrus Diet Across 4000 Years of Changing Sea Ice Conditions. Quaternary Research. 1-17.

Crance, J. L., C. L. Berchok, D. L. Wright, A. M. Brewer, and D. F. Woodrich. 2019. Song Production by the North Pacific Right Whale, *Eubalaena Japonica*. The Journal of the Acoustical Society of America. 145(6): 3467-3479.

Divine, L. M., F. J. Mueter, G. H. Kruse, B. A. Bluhm, S. C. Jewett, and K. Iken. 2019. New Estimates of Weight-at-Size, Maturity-at-Size, Fecundity, and Biomass of Snow Crab, *Chionoecetes Opilio*, in the Arctic Ocean Off Alaska. Fisheries Research. 218: 246-258.

Durell, G. S. and J. M. Neff. 2019. Effects of Offshore Oil Exploration and Development in the Alaskan Beaufort Sea: Long-term Patterns of Hydrocarbons in Sediments. Integrated Environmental Assessment and Management. 15(2): 224-236.

Ershova, E., R. Descoteaux, O. Wangensteen, K. Iken, R. Hopcroft, C. Smoot, J. M. Grebmeier, and B. A. Bluhm. 2019. Diversity and Distribution of Meroplanktonic Larvae in the Pacific Arctic and Connectivity with Adult Benthic Invertebrate Communities. Frontiers in Marine Science. 6: 490.

Frouin-Mouy, H., X. Mouy, C. L. Berchok, S.B. Blackwell, and K. M. Stafford. 2019. Acoustic Occurrence and Behavior of Ribbon Seals (*Histriophoca Fasciata*) in the Bering, Chukchi, and Beaufort Seas. Polar Biology. 42(4): 657-674.

Grebmeier, J. M., S. E. Moore, L. W. Cooper, and K. E. Frey. 2019. The Distributed Biological Observatory: A Change Detection Array in the Pacific Arctic – an

Introduction. Deep Sea Research Part II: Topical Studies in Oceanography. 162: 1-7.

Iken, K., F. Mueter, J. M. Grebmeier, L. W. Cooper, S. L. Danielson, and B. Bluhm. 2019. Developing an Observational Design for Epibenthos and Fish Assemblages in the Chukchi Sea. Deep Sea Research Part II: Topical Studies in Oceanography. First Published Online 18 November 2018.

Kędra, M., L. W. Cooper, M. Zhang, D. Biasatti, and J. M. Grebmeier. 2019. Benthic Trophic Sensitivity to on-Going Changes in Pacific Arctic Seasonal Sea Ice cover–Insights from the Nitrogen Isotopic Composition of Amino Acids. Deep Sea Research Part II: Topical Studies in Oceanography. First Published Online 10 April 2019

Kuletz, K. J., D. Cushing, E. E. Osnas, E. A. Labunski, and A. Gall. 2019. Representation of the Pacific Arctic Seabird Community within the Distributed Biological Observatory Array, 2007–2015. Deep Sea Research Part II: Topical Studies in Oceanography. First Published Online 10 April 2019.

Lewis, B. J. and J. K. Hutchings. 2019. Leads and Associated Sea Ice Drift in the Beaufort Sea in Winter. Journal of Geophysical Research: Oceans. 124(5): 3411-3427.

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