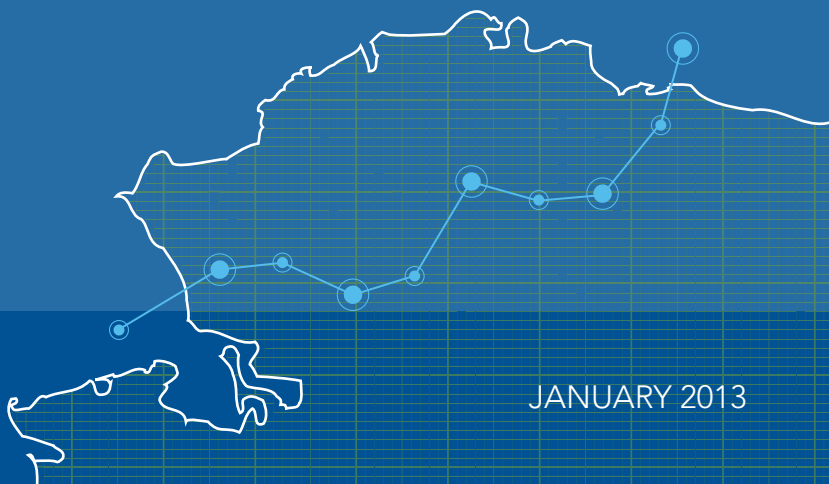
EVALUATION OF

BUREAU OF OCEAN ENERGY MANAGEMENT

ALASKA ANNUAL STUDIES PLAN



Prepared by Robert Spies for The Pew Charitable Trusts and Ocean Conservancy

JANUARY 2013

Cover Photo

U.S. Geological Survey marine biologists study Pacific walrus in the Chukchi Sea.

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Prepared for The Pew Charitable Trusts' U.S. Arctic Program
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SUMMARY AND RECOMMENDATIONS

The Bureau of Ocean Energy Management's (BOEM) fiscal year 2012 Alaska Annual Studies plan is evaluated and a number of overarching issues are discussed, including monitoring, integration of science, documenting cumulative effects and building development scenarios. In addition, selected specific topics are evaluated, including walrus, bowhead whales and noise, subsistence, Arctic cod and small fishes, and birds.

The major findings and recommendation are summarized as follows:

1. **MONITORING THE MARINE ENVIRONMENT.** There is still no comprehensive, long-term, integrated monitoring program for the Beaufort and Chukchi seas. BOEM needs to support efforts, such as the Distributed Biological Observatory, in order to track changes in the Arctic Ocean as industrialization and climate change impact these ecosystems. There is no plan yet in place to track ecological changes over decades, the scale at which significant changes are most likely to become apparent. The funding cycles for research, usually up to five years for individual projects, are at odds with the decadal scales on which marine ecosystems change.

2. **INTEGRATION OF SCIENCE.** There are many organizations and agencies sponsoring scientific research in the Arctic Ocean. BOEM and other sponsors would greatly benefit from more integration of these research and monitoring efforts. Some efforts at integration are under way, such as participation in joint planning, which might lead eventually to integration in other areas, such as logistics, obtaining geographic completeness, data sharing and synthesis. The BOEM study plans for the Arctic should be presented and rationalized with respect to other major efforts in the Arctic marine environment.

3. **DOCUMENTING CUMULATIVE EFFECTS.** Despite more than 30 years of oil and gas activity, as well as military activity, in the Arctic, there is no clear picture—or even attempted analysis—of the cumulative effects of these activities in the U.S. Arctic Ocean and coastal zone. The instigation of a comprehensive long-term monitoring program informed by development scenarios, as indicated below, would help make this possible.

4. **BUILDING POTENTIAL DEVELOPMENT SCENARIOS.** To design appropriate monitoring strategies and document cumulative effects, BOEM should

create likely scenarios for developing infrastructure, extractive processes, and associated transport and staging of equipment and personnel and other operations.

5. **USING SCIENCE IN DECISION-MAKING.** If decision-making processes on offshore oil and gas development are to be designed to minimize harm, then it must be clear how the results of scientific studies are being incorporated into such decisions. For example, science should more clearly inform decisions about where drilling should and should not take place.

6. **WALRUS.** A renewed effort needs to be made to count the entire Pacific walrus population. More needs to be done to understand the sources and thresholds of disturbance from anthropogenic activities. Maximum use should be made of animals harvested for subsistence purposes to collect tissues for key physiological measurements of wild animals.

7. **EFFECTS OF NOISE ON BOWHEAD WHALES.** Further efforts should be directed toward establishing inventories and databases of anthropogenic noise and to integrate data on noise sources and whale movements.

8. **ARCTIC COD AND OTHER FORAGE SPECIES.** While BOEM is initiating much new work on Arctic cod and similar forage species, and this is to BOEM's credit, we do not yet understand the basic life histories of these species (e.g., their reproductive biology and critical habitat for various life history stages).

9. **ARCTIC SEABIRDS.** Planned BOEM studies do a reasonably good job of addressing research needs for Arctic seabirds. However, it would be beneficial if some of the existing seabird colony data from the coast of the Chukchi Sea were published in the peer-reviewed scientific literature.

10. **SUBSISTENCE.** A synthesis is needed of what has been learned from more than 30 years of subsistence studies in the U.S. Arctic. There also needs to be a more systematic approach to incorporating traditional knowledge into BOEM-sponsored projects.

11. **USE OF TRADITIONAL KNOWLEDGE.** An evaluation of how traditional knowledge has been used in the decision-making process is needed to see where improvements might be made and decisions potentially improved.

INTRODUCTION

The Bureau of Ocean Energy Management (BOEM) develops an annual plan to describe studies needed to assess the ecological and sociological impact of offshore energy development on the continental shelves of Alaska. The rationale for the studies is that the information gathered is needed to assess and manage environmental impacts, predict impacts from chronic low-level pollution or large oil spills, and help guide policy and management decisions. Ideas for studies are submitted to BOEM by the public as well as by its staff. Input is also made via the Science Advisory Committee for the Outer Continental Shelf (OCS) Environmental Studies Plan. It is not entirely clear what role the committee plays in selecting study topics. The Alaska region competes with other regions in the country for research funds from the national office, and not all of the studies it proposes are funded.

The BOEM plan addresses the need to better understand the Beaufort and Chukchi seas' marine ecosystems and to support decisions about oil and gas exploration and extraction.

At the request of Ocean Conservancy and The Pew Charitable Trusts, an independent evaluation of the BOEM *Alaska Annual Studies Plan FY 2012* (BOEM, 2011) was carried out. This review was undertaken with particular reference to recent recommendations from the U.S. Geological Survey (USGS) in Circular 1370, *An Evaluation of the Science Needs to Inform Decisions on Outer Continental Energy Development in the Chukchi and Beaufort Seas* (USGS, 2011), but also incorporated insights from a previous review carried out by Spies (2011) for The Pew Charitable Trusts.

The ongoing and proposed studies in the BOEM science plan address the need for an investment of scientific effort to better understand the marine ecosystems of the Beaufort and Chukchi seas and support decisions about further offshore oil and gas exploration and extraction. Industrial development of the Arctic Ocean has the potential to harm these ecosystems, which are already adjusting to radical changes due to global warming and ocean acidification.

There is an important distinction to be made when evaluating the adequacy of the BOEM scientific effort: the large difference between a good effort under the limitations of working in the Arctic and the effort needed to actually answer pressing questions about the management and protection of the Arctic ecosystem. The Arctic Ocean is a difficult place to conduct scientific research due to severe weather, lack of support facilities, ice cover

for nine months or more a year, expense of research operations, and the movements and other characteristics of key species. All of these factors make it very challenging to answer important questions about the Arctic. In many cases there is a gap between the best science possible at this time and the science that is needed to fully understand and support decisions about the resources. The organizations sponsoring this review recognize that BOEM works hard to produce quality scientific results at a pace that is relevant to policy decisions about energy development and that it does so with a limited budget. Notwithstanding these limitations, Ocean Conservancy and Pew will continue to press BOEM and other government agencies to obtain the greatest possible value from their environmental studies programs in order to obtain the understanding necessary to properly support decisions about, and ultimately protect, Arctic ecosystems. Both organizations will press Congress for larger studies budgets when needed to obtain these goals.

The following evaluation considers the BOEM plan's adequacy for answering essential scientific questions.

The following evaluation is based on BOEM's Alaska Annual Studies Plan FY 2012 and considers its adequacy for answering essential scientific questions. There were not sufficient resources to investigate other research programs, whether by other US government agencies, industry, academia, or foreign governments. Our inability to evaluate the whole range of effort in Arctic marine science related to energy development is both a shortcoming of this effort as well as those of BOEM and other entities, for it points to a lack of overall planning, coordination, and synthesis that should be taking place regularly on national, if not international, levels.

This evaluation is presented on two levels: general and specific. The evaluation of general issues addresses coordination, synthesis, monitoring, cumulative effects, scenario building, and adaptive management. The evaluation of specific issues was limited to walrus, bowhead whales and noise, Arctic cod and other forage fishes, seabirds, and subsistence.

CONTENT OF THE 2012 STUDY PLAN

The BOEM annual studies plan consists of four major sections. The first section is a programmatic overview that outlines the background, the region, and the partnerships with other agencies in the program. It also describes the USGS report (USGS, 2011) on science needs and how these needs will be addressed both in the planning process for studies and the projected OCS activities for the Beaufort Sea, Chukchi Sea, and Cook Inlet planning

areas. The second section provides profiles of the studies that are ongoing, start in 2012, and start in 2013. The third section presents topical areas for studies that will be carried out in 2014, including climate change, physical oceanography, fate and effects of contaminants, endangered and protected species, and fish migration, recruitment and essential habitat. The fourth section provides the literature citations.

LEGAL CONTEXT

To better understand and evaluate the content of BOEM's study plan, the context of the guiding environmental laws must be considered. A variety of federal laws require government agencies, including BOEM, to collect and use scientific and other information to inform their planning and management decisions. Many federal statutes come into play when addressing OCS oil and gas activities, but the following focuses on the most pertinent examples, including requirements imposed by the Outer Continental Shelf Lands Act (OSCLA), the Oil Pollution Act of 1990 (OPA), and the National Environmental Policy Act (NEPA).

Outer Continental Shelf Lands Act

OCSLA is the principal statute governing offshore oil and gas activities in federal waters (see 43 U.S.C. §§ 1331-1356a). Although the statute does not mention specific federal agencies by name, BOEM, the Bureau of Safety and Environmental Enforcement, and the Office of Natural Resources Revenue are tasked with implementing many of OCSLA's provisions.

It is necessary to consider the plan in the context of the pertinent environmental laws.

OCSLA requires the federal government to collect and consider certain information when making planning, leasing, and management decisions. For example, Section 20 requires BOEM to study the areas included in lease sales "to establish information needed for assessment and management of environmental impacts on the human, marine, and coastal environments of the outer Continental Shelf and coastal areas" (43 U.S.C. § 1346(a)(1)). To the extent practicable, BOEM's studies must "be designed to predict impacts on the marine biota which may result from chronic low level pollution or large spills" and other impacts (43 U.S.C. § 1346(a)(3)). After an area has been leased or developed, OCSLA requires additional studies "to establish environmental information," as well as monitoring "designed to provide time-series and data trend information" to detect "any significant changes in the quality and productivity of" the area (43 U.S.C. § 1346(b)).

OSCLA also requires BOEM to consider scientific and other information when making

certain decisions. In general, OCSLA requires BOEM to "consider available relevant environmental information in making decisions" about a variety of oil and gas activities on the outer continental shelf (43 U.S.C. § 1346(d)). To give a more specific example, when BOEM develops a five-year offshore leasing program, OCSLA requires the agency to consider "existing information concerning the geographical, geological, and ecological characteristics" of offshore areas (43 U.S.C. § 1344(a)(2)(A)). BOEM also must consider the "relative environmental sensitivity and marine productivity" and the "environmental and predictive information" for different areas of the outer continental shelf (43 U.S.C. § 1344(a)(2)(G)-(H)).

Oil Pollution Act of 1990

OPA, including certain amendments to the federal Clean Water Act, sets forth a series of requirements that govern planning and response related to oil spills in marine waters (33 U.S.C §§ 2701-2762). A range of federal agencies, including BOEM, are involved in the implementation of this statute.

Like OCSLA, OPA and its implementing regulations require federal agencies to collect and use certain information concerning the environment. For instance, with respect to pre-spill preparation and planning, OPA requires the development of "Area Contingency Plans" (33 U.S.C. § 1321(j)(4)(B)(i)). These plans must, among other things, identify areas of special economic or environmental importance (33 U.S.C. § 1321(j)(4)(C)(i); see also 40 C.F.R. § 300.210(c)). After an oil spill, OPA may require federal officials to conduct a Natural Resource Damage Assessment (NRDA) (see 33 U.S.C. § 2706(c)(1)(A); see also 15 C.F.R. Part 990). The NRDA process requires the collection and analysis of information to evaluate the nature and extent of injuries resulting from a release of oil, as well as a determination of the restoration actions necessary to return injured natural resources and services back to their pre-spill state (see generally 15 C.F.R. § 990.30).

National Environmental Policy Act

NEPA is the "basic national charter for protection of the environment" (40 C.F.R. § 1500.1(a)). It applies to all federal agencies and was designed to ensure that federal decision-makers "will have available, and will carefully consider, detailed information concerning significant environmental impacts" (Dept. of Transp. v. Pub. Citizen, 541 U.S. 752, 768 (2004)). It also requires "that relevant information will be made available to the public" (Pub. Citizen, 541 U.S. at 768). Although NEPA is often described as a procedural statute, it "plays a unique role in injecting consideration of environmental effects in what would otherwise be single resource-driven decisions (Searles, 2008).

Although NEPA does not necessarily require federal agencies to collect new information, it does require agencies to assess existing information before committing to a certain course (see 42 U.S.C. § 4332(2)(C)). NEPA also requires agencies to "study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources," and to "initiate and utilize ecological information in the planning and development of resource-oriented projects" (42 U.S.C. § 4332(2)(E)& (H)).

When proposing major federal actions significantly affecting the quality of the human environment, NEPA requires agencies to prepare an environmental impact statement (EIS) that details the environmental effects of the proposed action (42 U.S.C. § 4332(2)(C)). The EIS should "provide full and fair discussion of significant environmental impacts and ... inform decision-makers and the public of the reasonable alternatives which would avoid or minimize adverse impacts or enhance the quality of the human environment" (40 C.F.R. § 1502.1). An EIS must discuss, among other things, the environmental impacts of the proposed action, adverse environmental effects that cannot be avoided, alternatives to the proposed action, and "the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity" (42 U.S.C. § 4332(2)(C)(i)-(iv)). An EIS does not require an agency to adopt any particular alternative, but it should inform the decision-making process (40 C.F.R. § 1502.14).

GENERAL ISSUES

MONITORING

The USGS report (USGS, 2011) identified the need for a comprehensive, long-term monitoring program to understand the effects of industrialization of the Arctic Ocean in the face of rapid changes in climate (recommendations 3.03-3.07). Such a program is also crucial to identifying the cumulative effects of development. The absence of comprehensive long-term monitoring has limited the ability to assess the cumulative effects of the industrialization that has taken place on the North Slope since the 1970s (NRC, 2003). Concern about these cumulative and interactive changes is a core issue that remains unanswered.

Many potential components of a comprehensive, long-term monitoring program are being carried out with funding for research projects that generally last five or fewer years. Some governmental entity, such as the Interagency Arctic Research Policy Committee (IARPC),

should take the lead in initiating and coordinating a long-term comprehensive program, as described below. BOEM should be a major part of that effort and seek budget authority to contribute substantial continuing funding to a comprehensive monitoring program.

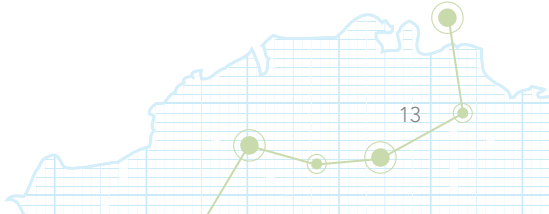
An interagency-funded committee of the best Arctic scientists from academia, government, and the private sector should be commissioned to design a program to account for spatial and temporal changes in the Arctic Ocean ecosystem at various scales, and should include recommendations on where and when to sample to characterize long-term trends. A conceptual model of the Arctic Ocean should be developed to provide the initial basis for the monitoring program. Adaptive management principles should be used periodically to revise the conceptual model as new information becomes available through synthesis of existing information, analysis of the results of the monitoring program, and short-term research projects.

The monitoring program should include, at a minimum: climate, physical oceanography, ice dynamics, phytoplankton and zooplankton abundance and timing, forage species (euphausiids and small fishes), sea bottom communities, larger fishes (including subsistence and commercial species), shorebirds and seabirds, marine mammals (gray, beluga, and bowhead whales; polar bears; walrus; ringed and bearded seals), and subsistence harvest of resources. To capture long-term trends, consistent, comparable data need to be collected in the same manner and at the same times and places at a series of primary or core stations. The locations of the core stations should not change through the life of the program.

BOEM should fund a comprehensive, long-term monitoring program to capture trends.

There should be interactions between long-term monitoring and shorter-term research activities in the Arctic, so that one informs the other. Research results could then be used to adjust the monitoring program, for example to add non-core stations and measurements if important findings indicate the need to supplement monitoring done at core stations.

Planning for the Distributed Biological Observatory supported by NOAA and IARPC incorporates some of the above-mentioned features. Additional interagency efforts such as this should be supported in the future.



INTEGRATION AND SYNTHESIS OF SCIENCE

In addition to research sponsored by BOEM, there is also related Arctic scientific planning and activity being undertaken by multiple entities, including: the Alaska Ocean Observing System, the National Academy of Sciences' Polar Research Board, the National Science Foundation, IARPC, the Pacific Arctic Group, the North Pacific Research Board, the North Pacific Marine Science Organization (PICES), NOAA Pacific Science Center, Scott Polar Research Institute, the US Army's Cold Regions Research and Engineering Laboratory, the Arctic Council and its working groups, the Russian-American Long-term Census of the Arctic, NOAA National Snow and Ice Data Center, the International Arctic Science Committee/Marine Working Group, the Arctic Research Consortium, the Barrow Arctic Science Consortium, and the Smithsonian's Arctic Science Center, to name only a few. Industry, particularly Shell and ConocoPhillips, also has sponsored intensive monitoring and research efforts in support of oil and gas exploration at Chukchi Sea lease sites. In addition, a variety of oil companies have carried out research in the Beaufort Sea.

BOEM needs to improve its efforts to work jointly with other organizations to form an overall picture of Arctic research.

Clearly, there is much ecosystem-related research occurring in the Arctic. BOEM is beginning to link the studies it sponsors to some of these other programs, which is commendable, and it is also apparently constructing a study planning matrix with NOAA. However, the BOEM annual science plan for Alaska does not present its ongoing and proposed program within the context of the overall research effort in the Arctic. BOEM needs to improve its efforts to work jointly with other organizations to formulate an overall picture of Arctic research, and the BOEM plan for research should be presented and rationalized within this larger framework.

BOEM's Synthesis of Arctic Research (SOAR) project is a good start on synthesizing existing findings and could serve as a jumping-off point for an up-to-date database that would track all significant ecosystem research being carried out in the Beaufort and Chukchi seas.

Identifying all research being done in the Beaufort and Chukchi seas and making results available to all interested parties is only the first step in better integrating ecosystem science in the Arctic. Achieving geographic completeness is another significant goal of integration. In addition, ensuring comparability of data and access to data from different sources in a

common computing environment are extremely important goals that are far from being realized. Of course, it would be a huge step forward if a common, shared conceptual model(s) of the Beaufort and Chukchi seas was also available.

Beyond some references to ongoing industry-sponsored projects, contracting with the USGS, the Alaska Department of Fish and Game, and the U.S. Fish and Wildlife Service (USFWS), and the SOAR synthesis, there is little in the present BOEM plan that indicates commitment to or major progress toward integration and synthesis of Arctic marine research and monitoring. More active participation in efforts to coordinate research under the leadership of other agencies and boards is also recommended. This point was noted in previous evaluations of Arctic science in support of energy development (Spies, 2011).

It appears from justifications given for particular research projects in the FY 2012 plan (e.g., the project entitled "The Study of Sharing Networks to Assess the Vulnerabilities of Local Communities to Oil and Gas Impacts in Arctic Alaska" [AK-05-04a]) that BOEM gives high priority to producing scientific information that can be used to inform decisions about exploration or development activities by BOEM (e.g., in application of OCSLA and NEPA assessments). While OCSLA and NEPA are very important, there may be tension between providing the science necessary to comply with applicable statutes and supporting permitting decisions, on the one hand, and providing the science necessary to best inform decision-making in an ecosystem-based framework, on the other hand. It should be possible and is highly desirable to do both: that is, to comply with applicable statures and also produce an ecosystem-level understanding of how the Arctic Ocean is responding to industrialization and climate change on appropriate time and space scales.

DOCUMENTING CUMULATIVE EFFECTS

As a result of the lack of overall planning for industrial development in the Arctic and the lack of a comprehensive monitoring program the cumulative effects of oil and gas development in Alaska's Arctic cannot be accurately assessed (Spies, 2011).

Distinguishing the effects of oil and gas activities from those of climate change is a challenge that industry might welcome, given the likely much larger and more pervasive effects of climate change. A particular difficulty is to understand what likely would be the relatively local effects of development on Arctic marine ecology, as opposed to anthropogenically driven regional effects of climate change, which most scientists believe will overwhelm local effects.

Some of the longer-term data-collection efforts in the Arctic, such as the aerial surveys of

marine mammals that BOEM is sponsoring, are producing data that can be used to assess cumulative effects. However, without embedding these data-collection efforts in the context of a comprehensive, ecosystem-based, long-term monitoring program, little can be inferred with regard to the causes of changes in populations.

A standard methodology is needed to analyze the cumulative effects of oil and gas development.

Finding a rigorous and standardized approach to cumulative effects analysis has been an unresolved challenge in the Arctic. A number of analysts have grappled with finding the proper methodology, but little progress has been made in developing a worthwhile, standardized methodology to define and predict cumulative impacts. Certainly the lack of a long-term comprehensive monitoring program is a major reason for lack of progress on this issue. Moreover, there is a sense that at present cumulative effects are analyzed because NEPA and OCSLA require it, and there has been little in the way of focused thought and creativity on how best to analyze cumulative effects and the benefit of doing so from a decision-support standpoint. It is recommended that BOEM support the necessary conceptual work and modeling to develop an appropriate approach and standardized methodology for the analysis of cumulative effects and to implement the monitoring and other studies needed to document cumulative effects of development in the Arctic.

BUILDING POTENTIAL DEVELOPMENT SCENARIOS

It would be very helpful to have clear and plausible scenarios that describe the potential range of industrial infrastructures and operational activities related to OCS energy development. The ecological footprints of various developments are needed in order to design an efficient and effective monitoring plan that would capture changes occurring with development, rather than trying to understand such changes retrospectively. These same development scenarios provide a support tool for planning at a landscape level, the analysis of permitting decisions related to siting of facilities, for pre-deployment of response equipment and capacity, and for the analysis of cumulative effects.

A clear and plausible set of development scenarios would be very helpful.

The BOEM should develop a series of potential development scenarios that would address the footprint

and full range of production and transportation-related activity, including pipeline corridors, storage facilities, airstrips, flight corridors and frequencies, vessel traffic, service roads, housing, and waste management, to name a few. Interactions with related developments, such as oil and gas activity in state waters, and commercial shipping and other vessel traffic through the Bering Strait, should also be considered.

USING SCIENCE IN DECISION-MAKING

Science can and should be applied to all aspects of decision-making concerning offshore oil and gas activity in the Arctic. How scientific results are used and how they influence decisions are not always clear and should be made more transparent. For example, identifying where and when drilling should be allowed must take into account the ecological and cultural importance of the place(s) and season(s) under consideration, and should include an assessment of the risks and uncertainties associated with the proposed activity. Similarly, areas with heightened ecological and cultural significance should be identified on the basis of current understanding from science and from traditional knowledge. Offshore oil and gas activity should not be allowed in these areas to avoid disproportionate harm to the ecosystem and to Inupiaq culture. While much remains to be learned about the Arctic offshore environment, a great deal of scientific work has been done that provides an adequate basis for sound conservation measures that also incorporate a margin of error to account for uncertainty. Moving forward, the use of science should include a strong monitoring program to allow for impacts of oil and gas activities to be evaluated, to determine areas that should be protected, and to mitigate and minimize impacts while allowing petroleum resources to be developed.

Science should be applied to all aspects of decision-making concerning oil and gas activity.

SPECIFIC ISSUES

WALRUS

In the Chukchi Sea, the habitat for female walrus and their pups during the late spring, summer, and fall, is undergoing rapid change, most noticeably by diminished sea ice cover. At the same time, exploration and planning for extensive oil and gas extraction are taking place. It is not clear (nor are there currently the means to determine) what this means for the

population of Pacific walrus, but there are already signs that the walrus population is stressed.

Before 2007, most walrus in the Chukchi Sea were on ice flows over the continental shelf where they could feed optimally in depths up to 100 meters (USFWS, 2011) on benthic invertebrates. Since 2007, however, in concert with early ice-free conditions in the eastern Chukchi Sea, large numbers of walrus have been hauled out on land much farther from their preferred foraging habitats (C. Jay, USGS, pers. comm.). They are then faced with the choice of feeding close to the haul-out areas in suboptimal benthic habitats in the nearshore eastern Chukchi Sea or traveling tens of kilometers to the richer offshore benthic habitats, e.g., near Hanna Shoals, an area of intensive interest to the oil and gas industry. Observations in Russia suggest an inverse relationship between the presence of offshore sea ice, on the one hand, and mortality of young walrus and walrus body condition, on the other hand (Nikiforov et al., 2007; Ovsyanikov et al., 2007; Kochnev, 2008; WWF, 2010).

No one knows how the walrus population is responding to rapid changes in habitat, feeding, and migration patterns.

It is not known whether the walrus population is growing, staying the same, or shrinking (USFWS, 2011). There were a minimum of about 130,000 (Speckman et al., 2010) and perhaps as many as 290,000 Pacific walrus in the population in 2006 (USFWS, 2011), but no one knows how the population size is responding to the rapid changes in their habitat, feeding, and migration patterns since then.

An unknown number of walrus are taken by fishing every year and about 5,000 are taken by subsistence, a number that has decreased over the last decade (USFWS 2011). Walrus cannot replace lost members of the population very fast as they have an inherently slow reproductive rate. Female walrus do not reproduce every year, nurturing their pups for two years or more (Fay, 1982) before they reproduce again. No one knows how the added activity by oil companies will affect the walrus population in the coming years.

Walrus are sensitive to disturbance and they are vulnerable on land. There will be an increase in vessel traffic, aircraft, and other activities on land, as well as around Hanna Shoal, where industry lease tracts are going to be explored over the next several years. Therefore the potential for harm exists from offshore drilling activity directly, as well as the potential for industrial activity to exacerbate the negative effects of climate change on walrus.

The unknowns in walrus biology and the rapid changes in their habitat are concerns for management of this species. Because of their size (the largest of the Arctic pinnipeds), the difficulty in capturing and tagging individuals, and other aspects of their behavior, there are significant challenges to obtaining enough information to predict the impacts on walrus of climate change and industrial development in the Bering and Chukchi seas.

Knowledge Gaps

To have enough information to confidently manage this species, the USGS (2011) recommended addressing the following topics (numbers in parentheses refer to the recommendation numbers in the report):

1. The size of the Pacific walrus population, to include a complete census of the Bering and Chukchi seas (4.01) and any walrus in the Beaufort Sea (recommendation from this report).
2. The trajectory of the population of this long-lived species. Is it increasing, staying about the same, or decreasing? This would include analyses of juvenile survival, age of first reproduction, mortality rates and age structure of the population (recommendation from this report and not from the USGS).
3. The reactions of walrus to visual and auditory stimuli, thresholds of disturbance, and reactions relative to the context of the disturbance (6.07, 6.18).
4. Changing levels of ambient noise in the Chukchi Sea, and how changes thereto are likely to affect walrus (6.18).
5. The ways in which climate change and anthropogenic noise may alter energy consumption and expenditures, and the likelihood that habitat changes will result in tipping the balance of energy acquisition and expenditure toward population loss (6.19).

BOEM Studies

BOEM has several studies that address walrus primarily or as part of studies of other marine mammals in the Chukchi and Beaufort seas. In the FY 2012 BOEM Arctic Program, the following studies are included:

1. **Pacific Walrus Foraging Habitat and Prey Identification from Seasonal Haul-Outs Along the Chukchi Sea Coastline.** The justification for this study is as follows: "The Chukchi Sea Lease Sale 193 area overlaps with important walrus foraging habitat.

Identifying key foraging and resting areas, and predicting how these may change over time increases our ability to mitigate potential impacts to walrus from the oil and gas industry by situating offshore and onshore facilities and pipelines in areas of less importance to walrus where possible."

2. **Pinniped Movements and Foraging: Walrus Habitat Use in the Potential Drilling Area.** The justification for this study is as follows: "Large numbers of pinnipeds migrate through and potentially occupy areas of high oil and gas potential in the Chukchi Sea, including habitat near the Burger Prospect. Pinnipeds may be affected in a variety of ways during all stages of oil and gas exploration, development, and production." The components of this joint project with Alaska Department of Fish and Game are not fully developed. The plan will involve synthesis, gathering traditional knowledge on walrus, working with native hunters to deploy satellite transmitters, and conducting shore-based monitoring of haul-outs. Data from satellite-tagged walrus will help illuminate the use of various possible haul-outs, foraging areas, and migration routes in relation to proposed industrial activity.
3. **Distribution and Relative Abundance of Marine Mammals in the Chukchi Sea and the Fall Migration of Bowhead Whales in the Beaufort Sea.** The rationale for this study is as follows: "Abundance, and habitat use of marine mammals in the Chukchi Sea is fundamentally important to evaluating the potential environmental impacts associated with oil and gas exploration and development and other anthropogenic activities." This study will document the distribution and relative density of marine mammals in the Chukchi Sea. It will also identify areas within the Chukchi Sea that are favored by marine mammals. This project will be focused on whales, bowhead whales in particular, but incidental sightings of other marine mammals, including walrus, will be recorded.
4. **Synthesis of Arctic Research (SOAR) Physics to Marine Mammals in the Pacific Arctic.** The justification of this study in relation to marine mammal populations is as follows: "Given recent high investment in interdisciplinary biological and oceanographic research by the Governments in the region, a synthesis of results of completed and ongoing studies would be useful to inform management decision-makers and may be useful in determining needs of future research activities." This is a large synthesis that includes understanding biophysical changes in the Chukchi and Beaufort Seas, motivated by increasing indications of basic changes in these ecosystems and how key

species of marine mammals are changing their distribution, migrations, and foraging areas. This work appears to focus a great deal on whales but does mention as a motivating observation that in 2007 and 2009, when ice cover in the Chukchi was at historic lows, large numbers of walrus were hauled out along the Chukchi sea coast, e.g., around Point Lay.

5. **COMIDA (Chukchi Offshore Monitoring in Drilling Area): Impact Monitoring for Offshore Subsistence Hunting.** The rationale for this study is as follows: "The BOEM needs to establish an early baseline in the area and to monitor on an annual basis any significant changes in subsistence activities over time. In particular, monitoring efforts should be directed toward the hunt for marine mammals, including bowhead and beluga whales, walrus, polar bears, and seals." Since the take of walrus by subsistence hunters is an important source of subsistence and direct anthropogenic mortality, it is important to monitor this harvest under changing conditions for Pacific walrus in the Chukchi Sea. Although tracking various sources of mortality is not an objective of this project, rather this task falls to the USFWS, BOEM could be supporting this important task.

Unaddressed Priority Research Needs for Walrus

While BOEM is to be commended for the research that is being undertaken, and while biologists clearly understand the difficulty in obtaining new information on walrus, there are basic science needs that are not being met in the Arctic with regard to walrus biology and their susceptibility to increasing anthropogenic influence. There are several areas where more work is needed in order to better support decisions about further oil development. The following recommendations include some of the USGS (2011) recommendations, as well as the opinions of the author of this report:

There are basic science needs that are not being met for walrus biology.

1. A renewed effort is needed to estimate the size of the entire Pacific walrus population, or at least to find some proxy, such as age at first ovulation, that is likely tied to the trajectory of the population and that will give managers some indication of the combined effects of climate change, harvest, and oil and gas activities on Pacific walrus. There is nothing in the BOEM plan that addresses directly the cumulative effects of all the stressors acting on the walrus population size.

2. More needs to be done to understand levels of disturbance, whether visual, auditory, or olfactory, that cause stress—and in some cases, cause deadly stampedes—in walrus. Monitoring of ambient noise is also needed, whether a continuation of industry-sponsored work in the Chukchi Sea or new work by BOEM, to gauge the level of threat from industrial development in the Chukchi. There is nothing in the BOEM plan directly addressing this aspect of walrus biology.
3. BOEM should contribute funds towards efforts to obtain samples that reflect body condition, stress levels, or reproductive effort from walrus harvested by Alaska Native hunters. Thyroid hormone levels in blood in relation to stress, uteri for obtaining more information about reproductive history, and blubber as a measure of condition are three types of samples worth investigating for their potential contributions.
4. Much more tagging of walrus with satellite transmitters needs to be done, as well as tracking more walrus over longer periods of time in order to understand the full implications of altered habitats (ice vs. land haul-outs; foraging areas in relation to haul-outs). More effort needs to be put into finding longer lasting satellite tags, extending tag life well beyond the current 1.5 months of use.

EFFECTS OF NOISE ON BOWHEAD WHALES

The effects of increased oil and gas activity on bowhead whales are of long-standing concern. Bowhead whales, specifically the Bering-Chukchi-Beaufort (BCB) stock, are listed under the federal Endangered Species Act as a threatened species. The BCB bowhead whales make an annual migration from the Bering Sea to their summer feeding grounds in the Beaufort Sea. During the returning fall migration there are hunts by Alaska Natives, mainly near Barrow and Wainwright, before the stock returns south through the Chukchi Sea to the relatively less ice-bound portions of the Bering Sea for the winter.

Whales that travel to the eastern Beaufort potentially transit the oil and gas lease tracts in the Beaufort and Chukchi seas twice a year. Whales that feed more extensively in the western Beaufort may transit oil and gas leases more often; less often for those that take a more northerly route in the Beaufort away from the North Slope oil and gas development area and those that take a more easterly route in the Chukchi Sea. Some bowhead whales also transit areas in Canadian waters that have oil and gas activity.

The crux of the noise problem associated with offshore industry is that bowhead whales communicate with low frequency sounds (tens of Hz to 1-2 kHz) and are therefore sensitive

to sounds in this frequency range. This is also the range where much of the increased noise energy is expected with industrial development in the Beaufort and Chukchi seas. In addition, the loss of ice cover in months of previously solid ice in the Chukchi and Beaufort seas is likely already affecting BCB bowhead whales and will continue to influence migratory patterns as the Arctic Ocean warms further.

There is solid evidence from studies in the 1980s and 1990s that bowhead whales will alter their behavior in response to noise from seismic surveys, approaching ships, and aircraft (Richardson and Würsig, 1997). Industrial development in the Arctic will increase ambient noise levels for marine mammals. The concern for bowhead whales therefore revolves around two main questions:

There is solid evidence that bowhead whales will alter their behavior in response to noise from seismic surveys, ships, and aircraft.

1. Will increases in ship and aircraft activity, seismic surveys, and drilling have a negative long-term impact on the BCB bowhead whale stock? Such changes could result from disruption or alteration of feeding, reproductive, resting, or migratory activity.
2. Will increases in industrial activity and the associated noise adversely impact the bowhead whale harvest by Alaska Natives? For example, by causing the whales to take fall migration routes further offshore and thereby increasing the difficulty of the hunt or decrease the take and hunter safety?

Some of the challenges that face biologists trying to understand the effects of sound on bowhead whales are:

1. It appears that their sensitivity to sound is variable depending on the circumstances and history of sound exposure. That is, the context of the sound pollution and history of exposure are important for understanding their potential effects. Bowhead whales will apparently react differently depending on the habitat they are in (e.g., whether there is opportunity to escape), and whether they are resting, feeding, mating, or migrating (Richardson and Würsig, 1997). There is clearly opportunity for habituation to noise so it is possible that continued exposure may de-sensitize whales.
2. It has not been possible so far to determine whether increasing noise will result in changes in the BCB bowhead whale population. In other words, the following remains a challenging question: "Will the cumulative effect of increased industrial activity result in an adverse impact on the population of bowhead whales?"

3. The effects of sound and climate change on bowhead whales will likely interact in ways that are entangled and difficult to separate.

Knowledge Gaps

The steps that could be taken to improve our understanding regarding noise and bowhead whales include the following. The numbers in parentheses correspond to paraphrased recommendations in the USGS report (2011), although additional recommendations are from this present evaluation:

1. Establish an inventory of Arctic seismic surveys (6.02). This will help track this source of disturbance in order to compare any long-term changes in bowhead whale behavior.
2. Establish an inventory and synthesis of vessel noise for vessels used in the Arctic, in order to understand how more ship traffic will contribute to ambient noise levels (6.03). Most industry work in the Arctic measures ambient noise levels prior to exploratory work.
3. Develop a standardized inventory database for icebreakers in the Arctic Ocean (6.04).
4. Quantify aircraft noise as a function of type and approach geometry (6.05).
5. Establish a time series database of ambient ocean noise in the Arctic Ocean in order to have a benchmark for measuring changes due to climate and anthropogenic influences (6.06).
6. Continued and new attention is needed towards understanding the population-level impacts of noise on bowhead whales, especially in regard to: transitory versus cumulative effects (e.g., long-term displacement from favored habitats); use of individual observations to deduce longer-term effects; understanding the context of sound for making predictions about its effects on whale behavior; separating the effects of natural and man-made effects; and quantifying the potential secondary effects of sound (e.g., on the distribution of prey) (6.07). In addition, it seems apparent that an ecosystem-based approach to identify likely areas for congregation of bowhead whale prey, based on prevalent oceanographic features, could aid in predicting congregation areas for bowhead whales and possibly lead to management measures to mitigate long-term effects of noise, and vessel collisions.
7. Develop a synthesis of existing databases on bowhead whale population abundance and structure along with sources and levels of anthropogenic sound (6.08). Tagging data being provided by Alaska Department of Fish and Game will greatly inform this effort.

8. Enhance efforts to integrate industry and agency acoustic monitoring data (6.10). This would include whale vocalizations, satellite telemetry data, local and traditional knowledge, and application of new statistical approaches. This would provide a framework for predicting when whales may respond to noise.

BOEM Studies

There currently are two main BOEM-sponsored studies on bowhead whales in the Arctic:

1. **Bowhead Whale Feeding Variability in the Western Alaska Beaufort Sea 2005-2012.** The objectives of this study are to track movement in the study area, document feeding areas, and establish the timing and rate of feeding.
2. **Distribution and Relative Abundance of Marine Mammals in the Chukchi Sea and the Fall Migration of Bowhead Whales in the Beaufort Sea.** This is the continuation of a survey that has been ongoing since 1979 and for this reason is valuable for understanding long-term changes in whale use of the Arctic Ocean. The objectives of this study include:
    a. "Document the distributions and relative densities of marine mammals in the Chukchi Sea Planning Area.
    b. "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 molting, calving/pupping, and feeding.
    c. "Define the annual fall migration of bowhead whales, significant inter-annual differences, and long-term trends in the distances from shore and water depths at which whales migrate.
    d. "Monitor temporal and spatial trends in the distribution, relative abundance, habitat, and behaviors (especially feeding) of endangered whales in Arctic waters.
    e. "Provide real-time data to BOEM and NMFS [the National Marine Fisheries Service] on the general progress of the fall migration of bowhead whales across the Alaskan Beaufort Sea for use in protection of this endangered species, if needed.
    f. "Provide an objective wide-area context for management understanding of the overall fall migration of bowhead whales and site-specific study results.
    g. "Record and map Beluga whale distribution and incidental sightings of other marine mammals.

h. "Determine seasonal distribution of endangered whales in other planning areas of interest to BOEM."

In addition, there is an ongoing study, COMIDA—Factors Affecting the Distribution and Relative Abundance of Endangered Whales: Biophysical Moorings and Climate Modeling—which should provide valuable information on annual and interannual biophysical changes in the Chukchi Sea that will affect bowhead whale distribution, abundance and foraging.

Unaddressed Priority Research Needs for Bowhead Whales

There are a number of specific recommendations in the 2011 USGS report with regard to establishing inventories and databases and performing syntheses of various noise sources in the Arctic that appear to be unaddressed in the current BOEM plan. These include those mentioned above for seismic sources, icebreakers, other vessels, and aircraft (6.03-6.05). In addition, there is no mention of a time-series database of ambient ocean noise in the BOEM annual studies plan (6.06).

Of particular importance is the need to aggregate existing data on whale distribution and movement.

Also of particular importance is the need to aggregate existing data on whale distribution and movement with records of sound sources of all kinds (6.08). Addressing this last need seems to be particularly crucial in helping to determine potential long-term population effects of industrial activity. Questions about such effects are apparently not answerable with the information in hand and are the crux of concern about the effects oil and gas development on whales in the Arctic Ocean.

ARCTIC COD AND OTHER FORAGE SPECIES

Arctic cod are the most prominent fish in biological trawl samples from the Beaufort and Chukchi seas (e.g., Parker-Stetter et al., 2011). The populations of Arctic cod and other small fishes that contribute to the energetic support of marine birds and mammals are perhaps not as important in the Chukchi Sea as they are in the Bering Sea and Gulf of Alaska ecosystems, as benthic invertebrates appear to play a proportionally larger role as secondary consumers, at least in the Chukchi Sea.

Arctic cod are nevertheless important, and their importance could increase as the Arctic marine ecosystem shifts in response to ice loss, rising temperatures, a longer open-water season, etc. (Grebmeier, 2012). In addition, a 2008 survey unexpectedly found pollock,

crab of commercial size, and Pacific cod in the Beaufort Sea, likely harbingers of a radical shift in the ichthyofauna as Bering Sea fishes move northward. A species such as the Arctic cod could well serve as an indicator in a shifting ecosystem and a possible representative species for contaminant bioaccumulation and toxicological studies. Arctic cod also would be an appropriate species for studying the physiological adaptations or lack thereof in key Arctic species.

Arctic cod could serve as an indicator species in an ecosystem shifting due to ice loss and warmer temperatures.

Knowledge Gaps

What are the knowledge gaps for small fishes? All of the following are taken from the findings and recommendation 3.07 in the USGS report (2011), direct quotes are so indicated:

1. The nearshore and shelf icthyofauna of the Beaufort and Chukchi seas are not well-sampled, and so it is appropriate that BOEM substantially expand its knowledge base of small fish distribution, abundance, life history, physiology, habitat requirements, and likely changing roles in an ecosystem under stress from anthropogenic-induced change. Inshore-offshore life history stage distributions are not well-known. Nor is much known about these fishes for nine months of the year when they are under ice. Clarifying the role of small fishes in the Arctic Ocean, both in open water and under ice, may well play a pivotal role in an evolving understanding of changing spatial and temporal patterns of primary productivity and secondary consumption leading to marine mammals and birds.
2. "Greater reliance on modern scientific technologies and their applications, such as remote sensing, telemetry, genetics, and molecular biology, and quantitative ecology (for example, predictive models) is needed to establish species environmental relationships, address existing gaps about relative importance of habitats, understand natural variation in fluctuating stocks, and to more accurately assess effects of proposed offshore oil and gas activities."
3. "Effects of ocean variability on production cycles and the distributional behavior, movement, and abundance of marine and anadromous fishes should be emphasized in future research and monitoring on select resources in strategic location undertaken to understand natural trajectories of change and effects of human interactions."
4. "Effects of environmental parameters on physiological processes [feeding, digestion,

assimilation, growth, responses to stimuli (i.e., orientation and swimming speed), and reproduction] are poorly known for most Arctic fish species. These processes are dependent on key water properties, including temperature, salinity, light penetration, and oxygen concentration. Animal health also is affected by the presence of toxic substances, infectious pathogens, and parasites."

5. "Seismic and noise effects on fishery resources have not been studied and is a research need. Much information could be borrowed from marine mammal research in Alaska and elsewhere regarding natural ambient sound and anthropogenic sound levels to guide experimentation."
6. "Effects of invasive species associated with increased tankering, vessel support, and offshore construction activities on important biological habitats and ecosystems are unknown."

BOEM Studies

There has been increased interest in Arctic cod and other small fishes recently, and this interest is reflected in the following continuing and proposed studies by BOEM:

1. **Arctic Cod Pilot Genetics and Toxicity Study.** This study of Arctic cod genetics may help determine their likelihood of adapting to retreating ice through differential expression of existing genes.
2. **Beaufort Sea Marine Fish Monitoring Survey in the Central Beaufort Sea (2010-2013).** The available distribution and abundance data on marine fish are outdated. This study includes under-ice sampling as a pilot program. The objectives are to:
    a. "Identify the fish species that occupy the central outer continental shelf (OCS) Beaufort Sea lease area.
    b. "Develop and recommend a methodology adapted to arctic conditions and specific BOEM information needs in the Beaufort Sea for use in future surveys.
    c. "Identify the fish species that occupy the central lease area during the ice-covered season.
    d. "Correlate observation of seabirds and marine mammals to fish and zooplankton for increased understanding of this arctic ecological system."
3. **Distribution of Fish, Crab and Lower Trophic Communities in the Chukchi Sea Lease Area.** The objective of this study is to "develop a broader understanding of abundance and distribution of demersal and pelagic fish, crab, and lower trophic communities

needed to evaluate and mitigate the effects of offshore oil and gas development."

4. **U.S.-Canada Transboundary Fish and Lower Trophic Communities.** This study extends recent marine fish and lower trophic surveys in the Beaufort Sea to assess potential effects of offshore development on lower trophic food webs and essential fish habitat (EFH). A 2008 study sponsored by MMS [the Mineral Management Service, BOEM's predecessor] found commercial cod, pollock and crab. The objectives of this study are to:
    a. "Document baseline fish and invertebrate species presence, abundance, distribution, and biomass.
    b. "Analyze dietary habits, age, and growth patterns of the most abundant species to support Canadian development of a Beaufort shelf fish and marine mammal food web model.
    c. "Test under-ice methods and provide baseline information for the ice-covered season.
    d. "Estimate seasonal variability of fish and habitats.
    e. "Document the hydrographic structure of the eastern Beaufort shelf.
    f. "Enhance understanding of how habitat variables (such as temperature and salinity) affect distributions under different climate conditions."
5. **Distribution and Habitat Use of Fish in the Nearshore Ecosystem of the Beaufort and Chukchi Seas.** The objectives of this study are to:
    a. "Inventory the distribution and diversity of nearshore fish, their habitat and prey along high priority sites in the Beaufort and Chukchi seas.
    b. "Assess age and diet of fish important as prey species.
    c. "Describe oceanographic features of areas with nearshore fish.
    d. "Understand how habitat variables like temperature and salinity affect fish species distributions."
6. **Current and Historic Distribution and Ecology of Demersal Fishes in the Chukchi Sea Lease Area.** The objectives of this study are to:
    a. "Collect fishes and document species presence, abundance, distribution, geographic range, species diversity, species assemblages, and habitat parameters.

b. "Assess physical and oceanographic feature (water mass) characteristics that define demersal fish habitat.

c. "Assess physical characteristics that define juvenile and adult fish communities and compare among collection periods and with historic collections.

d. "Correct the identification of historical archived fish specimens for accurate comparison with the proposed collections in the Chukchi Sea Planning Area.

e. "Synthesize historic distribution patterns of fish species in and near the Chukchi Sea Planning Area, and compare with 2007-2008 collections.

f. "Incorporate both historic and current scientific fish collection data from the northeast Chukchi Sea into electronic format suitable for incorporation into the BOEM database.

g. "Provide a basis for post-sale monitoring of fishes in the Chukchi Sea."

7. **Synthesis of Arctic Research (SOAR).** The objectives of this project are to:

   a. "Increase scientific understanding of the inter- and intra-relationships of oceanographic conditions, lower trophic prey species such as small fish and krill, and marine mammal distribution and behavior in the Chukchi Sea lease area and adjacent waters.

   a. "Enhance capability to predict future changes in oceanographic features such as currents, upwellings, and ice leads and associated changes in the behavior of marine mammals and their prey."

8. **Trophic Links: Forage Fish, Their Prey, and Ice Seals in the Northeast Chukchi Sea.** The main objectives of this study are to:

   a. "Assess the diet composition of forage fishes.

   b. "Establish trophic level of forage fish species and of their prey.

   c. "Analyze interannual differences in diet of fishes and in the trophic level of fishes and their prey.

   d. "Document the trophic level of ice seals.

   e. "Document ice seal trophic history.

   f. "Develop isotopic mixing models.

   g. "Compare trophic levels of forage fishes to those of ice seals."

9. **Joint Funding Opportunities in Existing Marine Fish Studies.** This project will involve cooperative work with established programs and ships of opportunity in the Arctic. The objectives of this work will be to:
    a. "Estimate the spatial distribution, species composition, and feeding ecology for fish species in designated and potential planning areas.
    b. "Process the data (GIS-based maps and attribute tables) for entry into the BOEM fish database for future accessibility and to facilitate new information for Oil-Spill-Risk Analysis and Essential Fish Habitat designations.
    c. "Preserve specimens for further study and for Alaska Museum voucher specimens.
    d. "Identify high priority locations for mitigation or deferral areas under consideration in environmental assessments."

Unaddressed Priority Research Needs for Arctic Fishes

There is little in the ongoing and proposed BOEM studies to address the identified need for information on the distribution and abundance of early life history stages, which is necessary to provide a more complete picture of the life cycle of Arctic cod and other potential forage fishes. This would also be important from the standpoint of assessing oil spill impacts.

Significant questions about basic biology of the Arctic cod include: What is the age of sexual maturity? Where and when do these fish spawn? What are the habitats for the developing larvae and juveniles? How long do they live? What are their prey? How are changing patterns of productivity in the Arctic Ocean likely to affect foraging of these fish and their predators?

A more complete picture is needed of the life cycle of Arctic cod and other forage fishes.

Individual-based models on growth of the early life stages and mortality of Arctic cod (Thanassekos and Fortier, 2012; Thanassekos, Robert and Fortier, 2012), have been developed based on studies in Canadian and Greenland waters. These models would provide a potential starting point for determining growth and mortality of Alaskan stocks from field sampling of various life history stages. Also there are dietary studies of larval and juvenile Arctic cod in the Canadian Beaufort (Walkusz et al., 2011), the results of which would provide a potential comparison with studies in the western Beaufort and Chukchi seas. In this latter study the Mackenzie River plume was an important feature in the feeding ecology of young cod and suggests that

Alaskan river plumes would be features worthy of similar study.

While early-life-stage survival of Arctic cod and other small arctic fishes appears to be unaddressed by the suite of proposed BOEM studies, a lack of detailed information, both on the contents of ongoing studies and the study plans of proposed projects, makes it difficult to determine exactly what information may be gathered in regard to these data needs. That being said, the BOEM study plans for Arctic cod and other small fishes appear in general to be a robust start to closing priority knowledge gaps in these key species.

SEABIRDS

Various marine and aquatic bird species are important members of the marine ecosystems of the Chukchi and Beaufort seas. A now outdated summary of the bird life in the Beaufort Sea is available (Johnson and Herter, 1989), but there is no similar compendium on birds of the Chukchi Sea. Data on the seabirds of the Chukchi are decades old and badly need to be updated through publication of any agency data that have been gathered more recently. Moreover, knowledge of seabirds, waterbirds and other groups is sparse for the Chukchi Sea and needs to be supplemented, especially given the susceptibility of seabirds to oil spills.

Data on seabirds of the Chukchi Sea are decades old and in need of updating.

Knowledge Gaps

The USGS recommendations regarding data needs for seabirds are listed below. These are all from recommendations 3.05, 3.06 and 3.07 of the USGS report (USGS, 2011).

1. "Biological hotspots for long-term research and monitoring of coastal, marine, and human impacts need to be identified. Potential sites include: Bering Strait (marine ecosystem processes); Kasegaluk, Simpson, and Beaufort Lagoons (nearshore fish assemblages); Barrow Canyon/Hanna Shoal (benthic productivity); Capes Lisburne and Thompson (seabird colony and fishery oceanography dynamics); Point Barrow (transitional biogeographic zone); Boulder Patch (kelp bottom ecosystem); Stefansson Sound/Camden Bay (Arctic cod ecology); Mackenzie, Colville, and Canning River Deltas (physical and biological onshore-offshore linkages); ice edge and polynyas (biological significance to fish, birds, and marine mammals)."
2. "Recent at-sea information on marine birds for most of the study area is lacking or unpublished. Similarly, with the exception of information from Cooper Island and Cape

Lisburne, much of the seabird colony information is out-of-date. Filling these data gaps would enhance our ability to measure the effects of climate change and assess the impacts of development and transportation."

3. "The Chukchi Sea is a dynamic area for marine birds during the summer. Studies to examine seasonal dynamics of seabirds in the Chukchi Sea related to oceanography, climate, sea-ice dynamics, primary and secondary productivity and movements of birds from breeding colonies (for example, Cape Lisburne) are necessary. Studies in the Chukchi Sea Lease Sale Area have been underway by Shell to address this but are not yet published. Similar studies, but focused on sea ducks and their benthic habitats, also would be helpful to evaluate climate impacts and to assess impacts of oil and gas development."
4. "Data from studies of birds at colonies, for example at Cooper Island and Cape Lisburne, need to be published and continued. Onshore studies of seabirds to measure abundance, productivity, and food habitats provide a unique window and understanding into offshore marine processes."
5. "Modeling the impact of oil pollution on birds using oil-spill trajectory models, population models, satellite telemetry data, and new information on seabird distribution and abundance would be informative for some species."
6. "A better understanding of the timing of migration and habitat use of at-risk species of waterbirds in the Chukchi and Beaufort Seas [is needed]. New information based on satellite telemetry is available for common, king, and spectacled eiders, and red-throated and yellow-billed loons. Existing data need to be analyzed and published, and additional telemetry studies are necessary to assess timing and pathways of migration and use of coastal areas for foraging and molting for other species including Pacific brant, long-tailed ducks, and Pacific and Arctic (G. arctica) loons."
7. "Coastal lagoons of the Chukchi and Beaufort Seas are important stopovers for migrating birds, particularly Pacific brant. Data on distribution, numbers, and periods when birds occur in coastal lagoons are needed to identify sensitive areas and times when disturbance should be minimized."
8. "Further analyses and studies are needed to increase the understanding of seasonal and inter-annual variation in shorebird use (numbers of birds, timing of their use, change in site quality) of key post-breeding areas, especially coastal areas where oil development is likely to occur (for example, the deltas of the Meade, Ikpikpuk, Colville,

Sagavanirktok, and Canning Rivers, and coastal sites on NPR-A)."

9. "Sea-level rise, increased frequency and severity of storms, and more frequent and severe episodes of coastal erosion and flooding are occurring or are predicted to occur in the study area and could have large impacts on migratory birds. Many northern shorebird and waterfowl species are dependent on these littoral habitats during some phase of their annual cycle. Understanding change in coastal geomorphology—from both physical and trophic standpoints and whether driven by climate change or other factors—is an important data gap."
10. "If an oil spill were to occur in broken sea-ice habitats, or if lead systems were to become contaminated with oil, understanding and being able to predict what wildlife would be affected in these ice habitats and the effectiveness or consequences of hazing arctic marine animals, including birds, will be important."
11. "Local residents are often the first to notice changes in fish and wildlife populations. Mechanisms should be developed to better solicit and integrate local and traditional knowledge as a basic source of information."

BOEM Studies

Following are the ongoing or proposed BOEM studies concerning seabirds:

1. **Shorebirds and Infaunal Abundance and Distribution on Delta Mudflats along the Beaufort Sea.** The objectives of this study are to:
    a. "Quantify the spatial and temporal distribution of macrofauna assemblages at coastal lagoons and river deltas along the Beaufort Sea coast within the USFWS Arctic Refuge at 3 sites associated with the coastal lagoons at the Jago, Hulahula/Okpilak, and Canning Rivers.
    b. Assess whether patterns of invertebrate abundance and distribution correspond to foraging shorebird abundance and distribution.
    c. Develop a model describing the connection between wind patterns and water levels on the mudflat and sediment dispersion that can be used to assess available foraging habitat for shorebirds.
    d. Assess whether shorebirds respond physiologically to a greater abundance in food resources through body condition measurements and increased triglyceride levels.

   e. Assess whether available invertebrate resources in the coastal lagoons and river deltas along the Beaufort Sea are sufficient for pre-migratory fattening of shorebirds or provide information for bioremediation."

2. **Monitoring Marine Birds of Concern in the Eastern Chukchi Nearshore Area (Loons).** The objectives of this study are to: "Document spatial distribution, species composition, timing of use, and residence times by foraging, molting, and staging Spectacled Eider, Yellow-billed and Red-throated Loons, and Pacific Black Brant in the vicinity of Peard Bay, Ledyard Bay, and Kasegaluk Lagoon in the eastern Chukchi nearshore environment."
3. **Beaufort Sea Marine Fish Monitoring Survey in the Central Beaufort Sea.** One of the objectives of this fish study is to: "Correlate observation of seabirds and marine mammals to fish and zooplankton for increased understanding of this arctic ecological system."
4. **Seabird Distribution and Abundance in the Offshore Environment.** The objectives of this study are to:
   a. "Estimate the spatial distribution, species composition and seasonal changes in species and abundance for marine birds in designated and potential planning areas.
   b. "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."
5. Improving Estimates of Abundance and Distribution of Avian Species during Peak Spring and Fall Migration Pathways through Near Shore Areas of the Eastern Chukchi Sea. The objectives of this study are to:
   a. "Document Pacific Brant spatial distribution, abundance, and timing of use in Kasegaluk Lagoon, landward of the Chukchi Sea Planning Area.
   b. Document Spectacled Eiders, Yellow-billed Loons, and Steller's Eiders spatial distribution, abundance, and timing of use within the offshore areas between Cape Lisburne and Barrow."

Unaddressed Priority Research Needs for Arctic Seabirds

The ongoing and planned BOEM studies do a reasonably good job of addressing the research needs identified in the USGS report. The major gaps that remain are to bring

the seabird colony information from the Chukchi Sea up to date and into the open, peer-reviewed scientific literature, and to continue to monitor important colonies, such as those at Cape Lisburne, Cape Lewis and Cape Thompson. Colony studies at Cape Lisburne should be expanded to include more on foraging distributions during the summer and patterns of dispersal by adults and juveniles upon leaving the colonies. Also, diet studies should be resumed to understand current trophic dependencies and to compare to the wealth of information obtained from the 1970s to the 1990s. Much has changed in the physical environment since then and these changes may have affected food web structure and patterns of energy flow. Cape Lisburne is, after all, the largest seabird colony in the Chukchi and Beaufort seas, and one of the largest in Alaska and the western Arctic.

No BOEM studies are addressing wintering seabirds. For example, black guillemots from Alaska, Canada, and Russia spend the winter in ice-covered regions likely to be affected by spilled oil. How many and where exactly are they? Perhaps some of this information may be obtained through use of satellite telemetry.

Gaps remain in science around food web structure, wintering species, important colonies, and impact areas.

If there is a major oil spill in the Chukchi Sea, the colonial seabirds that feed at areas of high productivity, such as the area around Hanna Shoal, will be the most likely victims of spilled oil on the ocean surface. Looking only at seabird abundance and distribution in the lease sale area is insufficient. Studies must be made within the entire area likely to be impacted by a spill from a drilling platform (taking into account winds and currents) or from transportation corridors between the platforms and receiving facilities. For example, spilled oil could end up in Ledyard Bay, a foraging area of critical importance to seabirds from Cape Lisburne and to transient and molting birds from the Bering and Beaufort seas, not to mention marine mammals.

SUBSISTENCE

Subsistence encompasses the traditional practices that provide food, clothing, and other materials from the land and sea and that are of paramount importance to the people, communities, and cultures of northern Alaska. The Iñupiat Eskimos have developed knowledge, skills, and tools to harvest and process marine mammals, land mammals, fish, birds, invertebrates, and plants efficiently and as safely as possible for the hunters, fishers,

and gatherers. Their success is evident from the simple fact that they have thrived in the Arctic for countless generations.

Subsistence is susceptible to disruption in various ways. Societal changes, such as regulatory systems or the demands of wage labor, can reduce opportunities to hunt or the number of animals that can be taken. Disturbance to the environment can alter the distribution of animals and thus their availability to hunters, either reducing harvests or increasing the risks associated with hunting.

Understanding coastal subsistence practices is vital to undertanding the full impacts of oil and gas activities.

For coastal residents of Arctic Alaska, marine mammals are a vital resource, at times accounting for more than half of the total subsistence harvest for the year. Hunting marine mammals, either from shore-fast ice in winter and spring, or in pack ice or open water in summer and fall, entails considerable risk. Understanding how this form of hunting may be affected by offshore oil and gas activity is essential to understanding the full environmental and cultural impacts of petroleum development and related activities.

Knowledge Gaps

The USGS report (2011) contained several findings and two recommendations concerning subsistence, all in Section 3.08, as follows:

1. "Subsistence harvests are seasonally and regionally variable. Although general usage patterns are known, village surveys have been conducted intermittently. In some cases, the data are old enough and may no longer be representative of actual harvests."
2. "Future work is needed to fully understand the environmental, ecological, and cultural context of Beaufort Sea and Chukchi Sea subsistence harvests. To predict or model with any degree of accuracy the future of Arctic subsistence, with or without the impact of hydrocarbon exploration and extraction, a greater understanding of the past and present will be necessary."
3. "Because local patterns of resource exploitation are closely tailored to local environments and ecologies, they are potentially vulnerable to the effects of climate change and oil and gas development. The impact of climate change need not necessarily be harmful to human subsistence. A growing body of anecdotal evidence suggests that previously rare salmon species are appearing with greater frequency on the North Slope. New runs and greater numbers of salmon in the future could well

provide the basis of new subsistence traditions. However, the unpredictable effects of climatic instability on fish and wildlife populations are not likely to be a net benefit to Arctic subsistence users in the near future."

4. "Oil and gas exploration and development pose a potential hazard to native subsistence livelihoods. Anadromous fish, marine mammals, and marine birds are crucial to human subsistence across the study area and are potentially vulnerable to disturbance and (or) pollutants associated with exploration, drilling, and transportation. Many fish species (including those not directly sought after for human use) comprise a major portion of the diets of sea mammals and birds that in turn sustain human populations."
5. "Subsistence users may be among the first to notice changes in abundance and distribution of fish and wildlife species as it relates to climate change, development, and other stressors. Local traditional knowledge should be more formally incorporated and integrated into resource assessments."

BOEM Studies

The BOEM Study Plan lists five ongoing and one planned study related to subsistence in the Arctic. Their titles and justifications are:

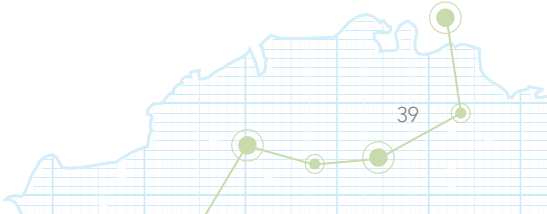
1. **Study of Sharing Networks to Assess the Vulnerabilities of Local Communities to Oil and Gas Development Impacts in Arctic Alaska (AK-05-04a).** "This information will be used for NEPA analysis and documentation for Beaufort Sea and Chukchi Sea Lease Sales and DPPs [Development and Production Plans]. This study addresses aspects of USGS Recommendations 3.06, 3.08, and 6.10."
2. **Continuation of Impact Assessment for Cross Island Whaling Activities (AK-08-01).** "Long-term study efforts to monitor potential effects of such development activities (Northstar and Liberty) have occurred through the ANIMIDA [Arctic Nearshore Impact Monitoring in Development Area] and cANIMIDA [continuation of ANIMIDA] projects, 1999-2007. There remains a continuing, ongoing need to monitor Cross Island whaling activities for potential impacts over the next five years. The information will be used for NEPA analysis and documentation for Beaufort Sea Lease Sales and DPPs. This study addresses aspects of the USGS recommendations 3.06, 3.07, 3.08, and 6.10."
3. **COMIDA: Impact Monitoring for Offshore Subsistence Hunting (AK-08-04).** "This study will constitute a key component of Chukchi Sea environmental studies pertinent

to Chukchi Sea Lease Sale 193 scheduled for 2007. Industry has expressed strong interest in leasing in this area, likely followed by exploration and possibly development. The COMIDA workshop conducted November 1-3, 2006 recommended the monitoring of offshore subsistence hunting. The BOEM needs to establish an early baseline in the area and to monitor on an annual basis any significant changes in subsistence activities over time. In particular monitoring efforts should be directed toward the hunt for marine mammals, including bowhead and beluga whales, walrus, polar bears, and seals. The BOEM analysts and decision makers will use the information in NEPA analysis and documentation for Lease Sales, EPs and DPPs and in post-sale and post-exploration decision making in the Chukchi Sea. This study addresses aspects of USGS recommendations 3.06, 3.07, 3.08, and 6.10."

4. **Social Indicators in Coastal Alaska: Arctic Communities (AK-11-09).** "This study will update key socio-cultural and economic baseline data for analysis of potential local and regional impacts from offshore exploration and development activities that may occur in federal waters off the North Slope of Alaska. Information from this study will be used for OCSLA and NEPA analyses, for documentation, and may serve as the basis for long-term monitoring for Chukchi and Beaufort oil and gas exploration in the region."
5. **Subsistence Use and Knowledge of Beaufort Salmon Populations (08-12-04).** "This study will … be used to meet EFH [essential fish habitats] and NEPA requirements for Beaufort Sea lease sales. This research will inform local communities, local and State resource managers, and BOEM of ecosystem health, which is so important to subsistence lifestyle. This study addresses aspects of USGS recommendation 3.06."
6. Baseline Nutritional Survey: Inventory and Content Analysis of Subsistence and Market Foods as Consumed by North Slope Communities (proposed for 2013). "This study will facilitate scientific understanding and analysis of potential health impacts that could derive from oil and gas industrial activities. It will also address longstanding concerns about potential cumulative effects of oil and gas activities on the North Slope."

Unaddressed Priority Research Needs for Subsistence

The USGS recommendations (2011) about subsistence are broad and general. The first simply calls for more research on subsistence harvests in their wider context. The six BOEM studies listed above address this recommendation in part, but there is no assessment either of the degree to which the full range of subsistence activities is addressed, or of criteria for establishing which aspects of subsistence are most in need of further study. MMS/BOEM has



studied aspects of subsistence in the Arctic for nearly 30 years. A synthesis and appraisal of what has been learned, what has changed, what remains accurate, and what needs further study should be carried out promptly to help determine the extent to which past, present, and proposed research addresses the spirit of the USGS recommendation.

The second USGS recommendation concerning subsistence is about traditional knowledge and its use in resource assessments. Such knowledge derives in large part from participation in subsistence activities, but the documentation and application of traditional knowledge should be seen as contributions to many areas of OCS research, not just to subsistence. The BOEM study on "Subsistence use and knowledge of Beaufort salmon populations" is one that addresses this recommendation, but only in very small part. Other studies, such as COMIDA, have the potential to incorporate aspects of traditional knowledge and contemporary observations in their monitoring and analyses, but it is not clear that they are doing so.

The inclusion of traditional knowledge should be done rigorously and as a substantial component of any study to which it contributes.

The inclusion of traditional knowledge should be done rigorously and as a substantial component of any study to which it contributes, not simply as a token effort. BOEM should work with experts including practitioners and indigenous organizations and communities to identify a standardized process for using traditional knowledge. Currently, BOEM leaves the inclusion of traditional knowledge up to the individual researcher that was awarded the request for proposal for each study area.

The justifications given in the BOEM study plan refer in several cases to USGS recommendations. The connections between some of the studies and the recommendations cited are unclear. For example, recommendations 3.06 and 3.07 are about marine birds and marine fishes, respectively. Both make passing reference to traditional knowledge but do not address subsistence in any substantive way. It is thus not clear, for example, how the "Continuation of impact assessment for Cross Island whaling activities" is going to generate relevant information concerning birds or fishes.

CONCLUSIONS

Much environmental research is being carried out within the U.S. portion of the Arctic Ocean, but the effort could be much more efficient and fruitful with better planning, coordination, and synthesis of existing and newly obtained information. To conclude, the findings of this report on the current BOEM Science Plan are summarized as follows:

1. The BOEM has clearly supported much valuable research on Arctic marine ecosystems, but is only one of many institutions carrying out research on these changing ecosystems. The Arctic research effort cries out for a dedicated, spatially comprehensive, long-term monitoring program to characterize alterations occurring now due to a changing climate and other local anthropogenic effects.
2. While there is a great deal of research activity in the Arctic, the overall effort would benefit from a greater level of coordination and integration. This would entail initially completing a comprehensive inventory of ongoing and finished studies, bringing all of the relevant data into a common computing environment, and constructing a conceptual model of Arctic marine ecosystems and how they are affected by climate and anthropogenic disturbance, to guide allocation of research effort. While BOEM is making a greater effort to cooperate with other agencies, and this is commendable, there is much left to be done. Completion of the BOEM-sponsored SOAR synthesis is an important concrete step and will make possible greater integration of the Arctic research effort.
3. The lack of a comprehensive, long-term monitoring program, as noted above, makes it extremely difficult, if not impossible, to document the cumulative effects of industrialization on Alaska's Arctic, specifically in the Beaufort and Chukchi seas and the Bering Strait. There is little or nothing in the BOEM plan to address directly the cumulative effects of development, which does not bode well for adaptive management of further impacts on Alaska's Arctic or of potential impacts of contemplated energy development on the Bering, Chukchi and Beaufort seas.
4. Related to the need to monitor cumulative impacts of industrial development through institution of a long-term monitoring program, there needs to be a major effort to construct potential development scenarios that would specify the full range of production and transportation-related activity. Such scenarios would help in a variety of

ways, including plans for accurately monitoring resultant impacts, which thereby would allow adaptive management to mitigate or reverse adverse impacts.

5. Statutes such as OCSLA, OPA, and NEPA require federal agencies to collect or use scientific and other information to inform their planning and management decisions. Although these laws impose diverse requirements—some broad and some specific—they make clear that agencies like BOEM cannot simply collect information for information's sake. Instead, federal agencies and policymakers must incorporate information into their decision-making processes to improve planning and management outcomes. It is vital that the process of incorporating study findings into the decision-making process be made as transparent as possible.

The following comments refer to selected resources and topics in the BOEM science plan.

6. Walrus. While the challenges of studying walrus in the Chukchi Sea are recognized, still not enough is currently known to be fully protective of these mammals in the face of further exploration and development. In particular, the size and trajectory of the Pacific walrus population is not known. Nor do we have a clear idea of the impacts of development, especially noise, on walrus behavior and other aspects of their biology.
7. The effects of noise on bowhead whales is a long-standing concern. BOEM is addressing many of these questions in one way or another, but the agency needs to establish inventories and databases and perform syntheses of information on sound sources and ambient sound levels.
8. In general, the ongoing and proposed studies on Arctic cod and other small fishes go a long way toward addressing the identified information needs on Arctic fishes. However, more attention to the distribution of early life history stages and supporting habitats is needed, as are studies and models of growth and mortality.
9. Investigating the status of seabird colonies on the US coast of the Chukchi Sea is a high priority, as is publication of this and other agency-held data in the peer-reviewed literature.
10. Research on subsistence practices has yielded much valuable information, but a great deal of that work is now decades old. Of particular importance is the adaptation of subsistence practices in the face of change, both environmental and societal, building on the baseline of data acquired since the 1980s on the North Slope.

11. Incorporation of traditional knowledge in research and decision-making in northern Alaska is important, but action to date has largely been limited to a few studies documenting traditional knowledge about selected species or phenomena. An assessment of the degree to which traditional knowledge has been used in decision-making would help identify ways to improve the involvement of such knowledge and those who hold it.

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