

ECOSYSTEM SCIENCES AND MANAGEMENT WORKING GROUP

Review of the High Arctic Program in NOAA

A report to the NOAA Science Advisory Board

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Executive Summary

In 2014, the NOAA Science Advisory Board (SAB) requested input from the Ecosystem Sciences Management Working Group (ESMWG) to review NOAA's Arctic ecosystem research portfolio, with the task to provide input on two high level activities that form the basis of our committee activities:

- Evaluate the quality and direction of the NOAA Arctic Ecosystem research portfolio and identify any gaps in activities that need to be filled, and
- Evaluate NOAA's overall organization for undertaking Arctic Ecosystem research.

The ESMWG Arctic Subcommittee developed Terms of Reference (TORs) in August 2014. The Arctic Subcommittee decision was made to focus on the High Arctic, Bering Strait and north, including the Chukchi and Beaufort Seas. For this effort, the High Arctic ecosystem is defined as encompassing biological, physical, and chemical as well as sea ice and atmospheric aspects. Although there was not a focus on local community input during our study, the Arctic Subcommittee discussed social science issues through interagency partner discussions and we expect further details in the ongoing ESMWG Indigenous Local Ecological Knowledge (ILEK) Subcommittee that began in 2015.

The NOAA request reflected the agency's recognition that the Arctic region is undergoing rapid sea ice retreat, sea level rise, and ocean warming that are known to have global implications that impact the United States and world. The atmospheric changes we are observing in the Arctic are connected to the subarctic regions. Atmospheric processes occurring in the Arctic are major drivers in our global weather patterns as well as directly influencing ocean circulation, although we have limited understanding of the processes involved. We know Arctic conditions impact the Atlantic overturning circulation that drives thermohaline circulation and global atmospheric and oceanographic connections. Ecosystem indicators including warming seawater, changing sea ice phenology and declining multi-year ice are stressors influencing biological systems and carbon cycling. These changing conditions in the Arctic are influencing northward migration of fish, marine mammals and seabirds and altering their prey populations.

The ESMWG Subcommittee's investigation benefited from many recent science planning efforts to identify key themes to advance our understanding of the Arctic ecosystem and to track the status and trends of stressors influencing the Arctic environment, such as identified in the National Research Council report "The Arctic in the Anthropocene: Emerging Research Questions" (NRC 2014), the Pacific Marine Arctic Regional Synthesis (PacMARS, Grebmeier et al. 2015), other national and international Arctic science planning efforts, as well as ongoing activities associated with the first Arctic Science Ministerial under the US chairmanship of the Arctic Council that will occur in Washington, DC on September 28, 2016.

In addition, the White House, under President Obama, released the US National Strategy for the Arctic (NSAR) in May 2013 (White House Executive Office, 2013a), followed by the NSAR Implementation Plan in 2014 (White House Executive Office, 2014). The NSAR sets forth the United States Government's strategic priorities for the Arctic region. The three core "pillars" of the NSAR are:

- (1) Advance United States Security Interests,
- (2) Pursue Responsible Arctic Region Stewardship, and
- (3) Strengthen International Cooperation.

NOAA is identified in the NSAR as having a leadership role as a US government agency in overall Arctic activities both for scientific understanding and operational aspects. Within NOAA there are Line Offices (LO) that either have direct scientific and management programs in the Arctic and/or are funded by other US agencies to undertake science activities that feed into NOAA's management authority. Over the last few years there has been a ramping up of NOAA LO coordination for research and management efforts in the Arctic, such as collaboration between the National Marine Fisheries Services (NMFS) and the Office of Ocean and Atmospheric Research (OAR). OAR supports other mission-oriented NOAA Line Offices such as the National Ocean Service (NOS). NOAA is heavily involved in the US Global Change Research Program and provides scientific input to the World Meteorological Organization and United Nations Intergovernmental Panel on Climate Change (IPCC) assessments as well as coastal community connections (e.g., climate change impacts on scallops, ocean acidification).

During the course of its study, the ESMWG Arctic Subcommittee had productive interactions with the NOAA Line Offices that assisted us with our questions and discussions. Notably, we found the utility of the effort to be as much in the process as in the set of recommendations as many of the points raised during our study have been addressed by NOAA internally over the past year. For example, during our review, we identified that there was no central node for a NOAA Arctic program. NOAA management also recognized the need to develop cross-Line Office (LO) activities focused on the Arctic through coordinated activities and, in 2014, developed a NOAA Arctic Executive Committee (AEC). We found this to be a positive action and believe that our ongoing ESMWG and LO Arctic discussions were facilitating AEC efforts. We also recognized a common need for annual evaluation of the Arctic activities and budget issues through our study. We applaud the introduction of a NOAA project database over the length of our two-year committee process that indicates how the Line Offices work well with each other.

While recognizing the progress noted above, additional actions are warranted to further enhance the development of a cohesive, science-based NOAA Arctic strategy. Even with the improved communication and transparency in the NOAA Arctic portfolio, the ESMWG Arctic Subcommittee found that enhanced coordination among NOAA Line Offices with respect to Arctic activities would strengthen the collective science-based efforts of its Arctic program.

The ESMWG Arctic Subcommittee process included a Fall 2014 ESMWG meeting including presentations from each LO of its Arctic activities, along with those of other government

agencies (e.g., Bureau of Ocean Energy Management, BOEM). At the Spring 2015 ESMWG meeting in Silver Spring, MD, we received input on the AEC office activities, the US Interagency Arctic Research and Policy Committee (IARPC) efforts, and the US Department of State for planned Arctic Council activities. The Arctic Subcommittee then developed a survey and budget questionnaire on NOAA High Arctic activities and requested input by each NOAA LO, including estimated budget expenditures.

Key points from the NOAA LO and other agency reports are the successful cases of LO activities in the High Arctic, with strong contributions from atmospheric and sea ice monitoring, through coastal bathymetric surveys, ecological surveys, and cross-LO partnerships for field measurements and ship use. These positive actions are important steps toward a strengthened NOAA Arctic research program. The ESMWG Arctic Subcommittee recognizes these positive activities and, to enhance further the effectiveness of NOAA's Arctic research, finds that further improvements in science-based coordination and enhanced platforms (e.g., fleet replenishments) are advised to fulfill its mission and provide international leadership. The Committee believes that NOAA should take a leadership role in a coordinated, five-year Arctic-focused "flag ship" interagency field and modeling program. This will facilitate an enhanced understanding of the ecosystem of an internationally accessible Arctic Ocean that is poorly known, yet pivotal to world climate and economic expansion. The reduction in sea ice in the Arctic is opening up extensive areas for trans-arctic shipping, exploration and biodiversity changes. Bathymetric charting is essential for developing the Arctic as an open access ocean, yet has only been undertaken to a limited extent. It is time for NOAA to take a more explicit leadership role in Arctic science and observing.

1. Recommendations

The ESMWG Arctic Subcommittee developed 15 recommendations through the course of its High Arctic study. Based on NOAA's request to identify a limited number of high priority activities from this list, we have separated our findings into: A. Near-term priority recommendations for immediate action (0-3 yrs.), B. Intermediate term recommendations to enhance NOAA's Arctic portfolio, and C. Longer-term recommendations to continue to support and strengthening NOAAs ongoing, internal science management activities. An overall goal of the combined recommendations is to enhance NOAA's High Arctic profile of activities to multiple stakeholders, both nationally and internationally.

A. Near-Term High Priority Recommendations (Prioritized)

Recommendation #1: NOAA should develop and coordinate, across multiple line offices, a comprehensive, five-year High Arctic Research Program, including both field and modeling efforts. Recent studies indicate that the US needs to enhance its understanding of the High Arctic ecosystem, especially in relation to northward movement of natural resources, including in the Arctic Basin. As such, NOAA needs to enhance its platforms to fulfill its leadership role for understanding the changing Arctic system. There is an opportunity with new international

research programs to augment research currently funded by NOAA if there is some flexibility for coordination. Developing issues (e.g., fisheries and ecosystem management in the Central Arctic Ocean, biodiversity topics, climate change impacts regionally and globally) are important topics. In addition, cross-platform asset use in the Arctic should be encouraged.

Recommendation #2: *Increased and focused investments are needed in order for NOAA to fulfill its identified responsibilities within national and international observing programs that are the front line of detecting change in the Arctic ecosystem.* NOAA considers observing systems to be “The heart of NOAA’s Environmental Intelligence” (SAB Synthesis Session, April 16-17, 2015). Therefore, long-term support for multi-disciplinary and multi-national observing and modeling activities to evaluate the status and change to Arctic physical stressors and trophic ecosystem response are needed.

Recommendation #3: *NOAA should continue to strengthen its international efforts and science-based leadership through the working groups of the Arctic Council, e.g., Circumpolar Biodiversity Monitoring Program (CBMP) and Emergency Prevention, Preparedness & Response Subcommittee (EPPR).* NOAA should focus and expand its international collaborative observing programs, such as the Distributed Biological Observatory (DBO) and the International Arctic Systems for Observing the Atmosphere (IASAO). NOAA should also work toward reinitiating the Russian American Long-term Census of the Arctic (RUSALCA) program.

Recommendation #4: *NOAA should systematically estimate the impact of science partnerships (both in kind efforts and monetary support) through cross Line-Office, US interagency and international partnerships supporting its High Arctic Program.* Findings from such a survey would explicitly show the strengths and vulnerabilities of internal and external decisions that could influence its High Arctic activities portfolio.

Recommendation #5: *NOAA should develop a clearer vision and statement of its strategic role and scientific research activities in the Arctic, both nationally and internationally.* Focused outreach documents should be developed to highlight NOAA projects in the Arctic, the connection within and among LOs and connections with other US government agencies and international groups. There is value in a central Arctic office in NOAA, with staff to facilitate the new Arctic Executive Committee in order to coordinate NOAA’s Arctic portfolio and address strategic national needs.

B. Intermediate Term Recommendations (not prioritized)

Recommendation: *Local and indigenous knowledge systems should be used to contribute to NOAA’s understanding of the Arctic ecosystems and to share results of NOAA scientific endeavors with coastal communities.* It is essential that NOAA and its partners assess the needs and importance of social sciences in the Arctic and to increase support for the human component as part of “ecosystem science”.

Recommendation: NOAA should develop an explicit budgetary survey to capture the flow of funds for Arctic science activities within each Line Office, with a specific definition as to what “activities” for Arctic information is needed. Both within and cross-LO budget levels for Arctic research should be identified, with an explicit definition of activities as being research and observing activities, as well as operational costs associated with these activities. Such a composite, cross-LO evaluation will form the basis for evaluating LO High Arctic activities within the Congressional funding base across all Line Offices. The budgetary detail would relate to both internally and externally supported activities, as well as associated full-time effort (FTE) support for the NOAA High Arctic research (including ecosystem) portfolio. NOAA needs to better capture the “metrics of success” from its Arctic research activities.

Recommendation: NOAA should strengthen its US interagency science coordination efforts through the Interagency Arctic Research and Policy Committee (IARPC), including continued leadership on observing activities (e.g., Observing Collaborative Team and Distributed Biological Observatory Collaborative Team), and their inclusion in the revised format for the next five-year IARPC plan (2017-2021).

C. Longer-Term Recommendations (not prioritized)

Recommendation: NOAA should continue to coordinate and facilitate an open and transparent data archiving protocol that is usable by all components of NOAA-supported science activities in the Arctic. In terms of academic relationships, NOAA could make incentives for collective contributions from both NOAA scientists and academia, along with improved methods for making data available while maintaining QA/QC and publication opportunities.

Recommendation: Continued and expanded science-based coordination efforts with other federal agencies undertaking High Arctic research should be encouraged. NOAA relies greatly on the US Department of the Interior’s Bureau of Ocean Energy Management (BOEM) for funding of NOAA High Arctic research activities. Therefore, some form of evaluation should be considered to make sure that NOAA provides core funding as an agency priority for the nation, along with collaborative support via other US agencies.

Recommendation: NOAA should regularly evaluate its academic partnerships supporting NOAA Arctic scientific research activities that occur both through direct competitive calls and Cooperative Institutes (CIs), specifically looking at trends in the level of support, productivity and transparency of effort. Specific to the CIs, NOAA should determine if the academic partnerships are being used for direct capacity for NOAA activities or if NOAA is supporting efforts that could be filled by academic entities directly.

Recommendation: Linkages between researchers and mid-level management within and among LOs and the NOAA Arctic Executive Committee leadership should be strengthened. There should be a formal link of task force activities to agency planning, programming,

execution, and evaluation, along with budget allocations for a common Arctic portfolio goal via cross agency initiatives.

Recommendation: NOAA should continue to expand its capabilities provided through its newly developed bibliographic effort to capture all research products (peer-reviewed and gray literature as well as data sets) from all its funded Arctic projects across Line Offices (both internally by NOAA employees and through its externally funded projects) through a standard reporting of output results.

Recommendation: The NOAA domestic fleet for research is deteriorating and inadequate for undertaking High Arctic marine research. NOAA should take leadership in working through IARPC and other channels to obtain ship support for Arctic research activities.

Recommendation: Both NOAA employees and external non-NOAA entities supported through NOAA-funded High Arctic projects (e.g., academics, collaborative institute funded projects, NPRB, AOOS) should be included in a design process in order to develop “metrics of success” from its Arctic research projects for future science planning and budgetary decisions.

REVIEW OF THE HIGH ARCTIC PROGRAM WITHIN NOAA

1. Background and Purpose

In 2014, the NOAA Science Advisory Board (SAB) requested input from the Ecosystem Sciences Management Working Group (ESMWG) to review NOAA's Arctic ecosystem research portfolio, with the task to provide input on two high level activities that form the basis of our committee activities:

- Evaluate the quality and direction of the NOAA Arctic Ecosystem research portfolio and identify any gaps in activities that need to be filled, and
- Evaluate NOAA's overall organization for undertaking Arctic Ecosystem research.

The NOAA request reflected the agency's recognition that the Arctic region is undergoing rapid sea ice retreat, sea level rise, ocean warming and increasing freshwater input that are known to have global implications that impact the United States and world. The atmospheric changes we are observing in the Arctic are connected to the subarctic regions. Atmospheric processes occurring in the Arctic are major drivers in our global weather patterns as well as directly influencing ocean circulation, although we have limited understanding of the processes involved. We know Arctic conditions impact the Atlantic overturning circulation that drives thermohaline circulation and global atmospheric and oceanographic connections. Ecosystem indicators including warming seawater, changing sea ice phenology and declining multi-year ice, and ocean acidification, are stressors influencing biological systems and carbon cycling. These changing conditions in the Arctic are influencing northward migration of fish, marine mammals and seabirds and altering their prey populations.

The Arctic is also a region of expanding interest in commercial and resource exploitation as well as continuing importance to local coastal community use. NOAA and other US agencies have responsibilities for ecosystem management in the Bering Strait and northward including the Chukchi and western Beaufort seas in the Pacific Arctic region. The international interest in the Pacific Arctic has expanded to encompass significant involvement by Korea, China, Japan, and others, in addition to focused United States, Canadian and Russian activities. NOAA is also active in national and international atmospheric and oceanographic studies related to climate and observing activities.

Rapidly expanding opportunities for development and commerce are occurring in the Arctic. Arctic sea ice extent was the lowest on record in 2012, with 2016 sea ice levels in July tracking close to these low levels. Development of petroleum resources and shipping are on the rise, and issues of protected species within the region of US oversight are critical topics for the Arctic. NOAA has already established a closure on development of commercial fisheries north of

Bering Strait. Changing environmental conditions are allowing increased access to the entire Arctic. In response, there has been a large increase in US Arctic initiatives since 2010, including development of the 2010 National Ocean Policy (White House Executive Office, 2010), 2011 NOAA Arctic Vision and Strategy Report (NOAA, 2011), the 2011 Interagency Working Group on Coordination of Domestic Energy Development and Permitting in Alaska (White House Executive Office, 2011), the 2013 National Strategy for the Arctic Region (NSAR; White House Executive Office, 2013a), the 2013 Interagency Arctic Research and Policy Committee (IARPC) 5 year plan (White House Executive Office, 2013b; a new 2017-2021 plan is under development), the 2013 Integrated Arctic Management (IAM) Action Report to the President (Heyes et al. 2013), the 2014 NSAR Implementation Plan (White House Executive Office, 2014), 2014 NOAA Arctic Action Plan (NOAA, 2014), the 2015 NSAR Implementation Progress Report (AESC, 2016a), and the 2016 NSAR Implementation Framework (AESC, 2016b).

Specifically, the White House, under President Obama, released the US National Strategy for the Arctic (NSAR) in May 2013 (White House Executive Office, 2013a), followed by the NSAR Implementation Plan in 2014 (White House Executive Office, 2014). The NSAR sets forth the United States Government's strategic priorities for the Arctic region. The three core "pillars" of the NSAR are:

- (1) Advance United States Security Interests,
- (2) Pursue Responsible Arctic Region Stewardship, and
- (3) Strengthen International Cooperation.

NOAA is identified in the NSAR as having a leadership role as a US government agency identified in the NSAR in overall Arctic activities both for scientific understanding and operational aspects. Within NOAA there are Line Offices (LO) that either have direct scientific and management programs in the Arctic and/or are funded by other US agencies to undertake science activities that feed into NOAA's management authority. Over the last few years there has been a ramping up of NOAA LO coordination for research and management efforts in the Arctic, such as collaboration between the National Marine Fisheries Services (NMFS) and the Office of Ocean and Atmospheric Research (OAR). OAR supports other mission-oriented NOAA Line Offices such as the National Ocean Service (NOS). NOAA is heavily involved in the US Global Change Research Program and provides scientific input to the World Meteorological Organization and United Nation's Intergovernmental Panel on Climate Change (IPCC) assessments as well as coastal community connections (e.g., climate change impacts on scallops, ocean acidification).

NOAA has mandates under the Marine Mammal Protection Act, the Endangered Species Act, and the Magnuson-Stevens Fishery and Conservation and Management Act (MSA) that are linked to the Arctic. Commercial fishing is closed north of Bering Strait at this time and for all realistic purposes, areas for commercial fishing are closed in the Bering Sea north of the Pribilof Islands as well. Work continues to map the seabed in the Arctic for navigation and to prepare US claims for seabed delineation.

With respect to NOAA’s strategic efforts to address the National Strategy for the Arctic, the following activities were highlighted in NOAA’s Vision and Strategy Report summarized in **Table 1**. NOAA’s key goals are to forecast sea ice, improve weather forecasts and warnings, strengthen foundational science to understand and detect Arctic climate change and ecosystem changes, improve stewardship and management of ocean and coastal resources in the Arctic, advance resilience and healthy Arctic communities and economies, and enhance international and national partnerships.

Table 1. Relationship of NOAA’s strategic goals in relation to the US themes within the National Strategy for the Arctic Region (NOAA, 2014).

National Strategy for the Arctic Region — lines of effort —	NOAA’s Arctic Vision and Strategy — strategic goals —
<ul style="list-style-type: none"> • Advance U.S. security interests 	<ul style="list-style-type: none"> • Forecast sea ice • Improve weather and water forecasts and warnings
<ul style="list-style-type: none"> • Pursue responsible Arctic region stewardship 	<ul style="list-style-type: none"> • Strengthen foundational science to understand and detect Arctic climate and ecosystem changes • Improve stewardship and management of ocean and coastal resources in the Arctic • Advance resilient and healthy Arctic communities and economies
<ul style="list-style-type: none"> • Strengthen international cooperation 	<ul style="list-style-type: none"> • Enhance international and national partnerships

1.1 NOAA’s Responsibilities in the Arctic

NOAA’s Arctic responsibilities are challenging because of rapid environmental change, the ensuing human activity this allows, and limited resources available to support work in the Arctic. Understanding the changing Arctic seascape challenges NOAA to make the best use of its limited funds. The NOAA 2013 Arctic funding for the Bering Sea and the High Arctic indicates that NOAA Stewardship and Management makes up 61% of the agency Arctic budget, while efforts in Communities and Economies account for 14%, Weather and Sea Ice Forecasts account for 14%, Foundational Science account for 4%, Sea Ice Research account for 3%, and Partnerships account for 2.8% in the NOAA Arctic budget (NOAA, 2014).

Within the 6 NOAA Line Offices undertaking Arctic research (including the Bering Sea), the following funding expenditures in 2013 were identified in the NOAA Arctic Action Plan (NOAA, 2014):

- NOAA National Environmental Satellite, Data and Information Service – NESDIS (2.4%)
- NOAA National Marine Fisheries Service – NMFS (59.2%)
- NOAA National Ocean Service – NOS (9.1%)
- NOAA National Weather Service - NWS (14.0%)
- NOAA Ocean and Atmospheric Research – OAR (7.4%)
- NOAA Office of Marine and Aviation Services – OMA (7.8%)

It should be noted that NMFS primarily undertakes research in the Bering Sea, which is considered part of the Arctic region for US national funding (as well as conforming to the Arctic Council's definition). Most Arctic science funding for activities undertaken by NOAA NMFS scientists north of Bering Strait is provided via the US Bureau of Ocean Energy Management (BOEM) as an interagency agreement. Because the ESMWG Arctic Subcommittee decided to only focus on the regions from Bering Strait northward, our results section will provide findings for that region for comparison to the values indicated in the NOAA 2014 Action Plan.

As examples of activities in support of NOAA's strategic goals (**Table 1**), NOAA has a leadership role in coordinated, international efforts for atmospheric, climate and ecosystem observing, including the International Arctic Systems for Observing the Atmosphere (IASAO) atmospheric observatory and the Distributed Biological Observatory (DBO), a change detection array in the Pacific Arctic developed to track ecosystem response to sea ice retreat and seawater warming. Whereas NOAA directly supports IASAO through core funding, current DBO support by NOAA is primarily as a subunit within core funded programs, such as the Russian American Long-term Census of the Arctic (RUSALCA) and the Arctic Marine Biodiversity Observing Network (AMBON), the latter co-funded by BOEM and Shell Oil Exploration and Production, Inc. With Shell's decision to pull out of Arctic exploration in the Chukchi and Beaufort Seas (September 2015) there is uncertainty in terms of continued support for some of these research efforts as well as support to local Alaska communities that were preparing for exploration activities. For example, there has been a reduction of science activities such as the AMBON program that is co-funded by NOAA NOS and BOEM. Similarly, the decision to suspend the RUSALCA program by the NOAA OAR ARP in June 2016 resulted from a lack of available Russian ship support and Russian inability for clearance issues to be resolved in a timely fashion. These issues were compounded by the continued embargoes on Russia by the US government.

The ESMWG Subcommittee's investigation benefited from many recent science planning efforts to identify key themes to advance our understanding of the Arctic ecosystem and to track the status and trends of stressors influencing the Arctic environment, such as identified in the National Research Council report "The Arctic in the Anthropocene: Emerging Research Questions" (NRC, 2014), the Pacific Marine Arctic Regional Synthesis (PacMARS, Grebmeier et al. 2015), other national and international Arctic science planning efforts, as well as ongoing activities associated with the first Arctic Science Ministerial under the US chairmanship of the Arctic Council that will occur in Washington, DC on September 28, 2016.

1.2 Goals of the Report

NOAA's Arctic responsibilities are challenged because of rapid environmental change in the region of US interests, the ensuing human activities that are increasing in the region, and limited budgetary resources within NOAA to support focused work in the Arctic. It is in this context that the NOAA Science Advisory Board (SAB) requested input from the Ecosystem Sciences Management Working Group (ESMWG) on Arctic-relevant issues from an ecosystem

science perspective. The ESMWG Subcommittee was tasked to evaluate the themes within the new NOAA Arctic Action Plan in relation to current NOAA Line Office activities and the relevancy of the NOAA Arctic Action Plan to the 2014 National Strategy for Arctic Research (NSAR) Implementation Plan.

The NOAA Science Advisory Board requested input from the ESMWG Arctic Subcommittee on two high level activities that form the basis of our committee activities:

- Evaluate the quality and direction of the NOAA Arctic Ecosystem research portfolio and identify any gaps in activities that need to be filled, and
- Evaluate NOAA's overall organization for undertaking Arctic Ecosystem research.

Based on the SAB request, the ESMWG formed an Arctic Subcommittee to evaluate NOAA's activities and management structure for Arctic Research. The ESMWG Arctic Subcommittee developed Terms of Reference (TORs) in August 2014 (Appendix 10.1). The committee decided that we would focus our evaluation of NOAA activities in the High Arctic from the Bering Strait north in the US Exclusive Economic Zone, including the Chukchi and Beaufort Seas (EEZ; **Fig. 1**), thus excluding the Eastern Bering Sea fisheries that are currently listed as accounting for just over half of the NOAA Arctic budget (NOAA, 2014). For the purposes of this report the Arctic ecosystem was defined as atmosphere and ocean, including physical, chemical and biological components. We did not evaluate the social science aspects of the NOAA Arctic portfolio, but express the need for this type of evaluation. Although the ESMWG Subcommittee discussed social science issues through interagency partner discussions, we expect specific details and recommendations to come forward through the ongoing ESMWG Indigenous Local Ecological Knowledge (ILEK) Subcommittee efforts that began in 2015.

The Arctic ESMWG goals for this report include to:

- (1) identify synergistic efforts in the Arctic that can be undertaken among pertinent NOAA Line Offices;
- (2) suggest programs that could enhance strategic benefits and increased efficiencies for NOAA activities in the Arctic;
- (3) identify gaps in NOAA's ecosystem research portfolio related to the Arctic; and
- (4) encourage partnerships that will build capacity between US agencies for activities in the Arctic.

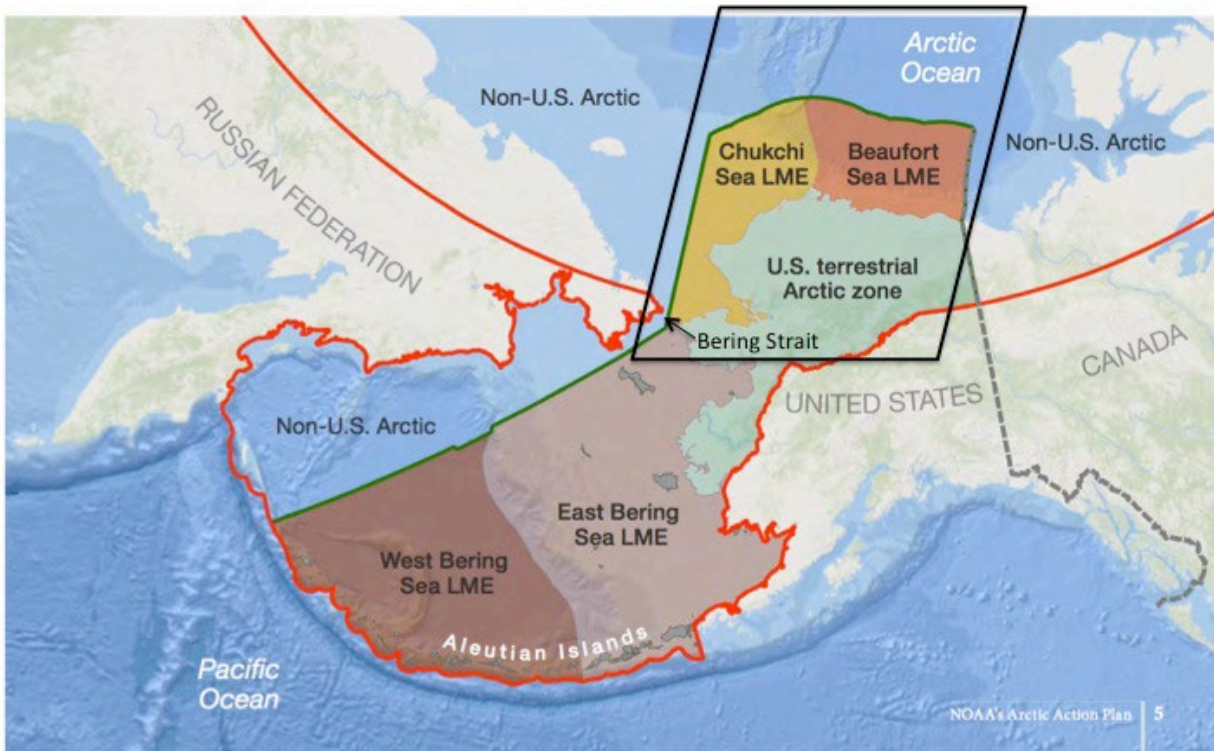


Figure 1. Region focus of the ESMWG Arctic review of NOAA activities in the “High Arctic” from Bering Strait northward, including the Chukchi and Beaufort Sea Large Marine Ecosystems (LME’s) as outlined in the black box (modified from NOAA, 2014).

By doing this, the Arctic foci will align and integrate NOAA’s science assets, partnerships, and capabilities for research that support NOAA’s Arctic region mission requirements for the sustainable use, protection, and restoration of coastal and marine ecosystems, as well as the ecosystem services they provide. NOAA is also working to increase partnerships and capabilities for research with other nations and entities working in the Arctic, especially in support of the US National Arctic Strategy as the US continues the Chairmanship of the Arctic Council through March 2017.

The January 2015 Presidential Executive Order (White House Executive Order, 2015) created a high-level, governmental Arctic Executive Steering Committee (AESC) that includes senior leadership from all federal agencies with Arctic activities. NOAA serves on this committee, which is developing an Executive document that is looking at overlap and gaps in the federal enterprise in the Arctic towards a goal of more collaboration and efficiency. Overall, NOAA’s organization for the Arctic includes Dr. Kathy Sullivan as the NOAA Administrator on the AESC, David Kennedy as the Arctic Special Assistant to the NOAA Administrator, the NOAA Arctic Executive Team that includes senior officials from each NOAA Line Office, and input from the scientists within the pertinent LOs.

2. Review Format and Evaluation

The ESMWG Arctic Subcommittee has evaluated the status, trends and gaps of NOAA Line Office High Arctic activities, effort, and products across the NOAA ecosystem research portfolio. The Arctic Subcommittee evaluated and identified key activities and gaps within the NOAA portfolio, specifically using NOAA and US government Arctic planning documents, two Arctic sessions at meetings of the ESMWG (Fall 2014 and Spring 2015), and a questionnaire for each of the Line Offices. The two core sessions included one meeting in Fall 2014 in Anchorage, AK that focused on NOAA LO presentations on Arctic activities, as well as invited presentations by other US agencies supporting NOAA science in the region, specifically the Bureau of Ocean Energy Management. The second Arctic core session occurred in Spring 2015 at NOAA Headquarters in Silver Spring, MD, with presentations focused on NOAA's Arctic Executive Committee, interagency activities through the Interagency Arctic Research and Policy Committee (IARPC), and international aspects as presented by the US Department of State on NOAA's involvement in Arctic Council activities. The Arctic Subcommittee then developed a survey and budget questionnaire on NOAA High Arctic activities and requested input by each NOAA LO, including estimated budget expenditures.

In October 2014 the ESMWG Arctic Subcommittee invited representatives of the pertinent NOAA Line Offices working in the Arctic to make presentations at a meeting in Anchorage, Alaska, requesting responses to four questions listed below. The key questions for both the workshop participants in Anchorage and the subsequent questionnaire to the NOAA Line Offices were designed to allow the responders to relate their activities to the themes within the 2014 US NSAR Plan, 2015 NSAR Implementation Plan, and NOAA 2014 Arctic Action Plan:

1. What are the specific short-term and long-term activities being undertaken in each NOAA Line Office that are beneficial for NOAA's capabilities to respond to national needs as recommended in the US National Arctic Strategy and Implementation plans?
2. What are the gaps in current/planned Arctic activities that limit NOAA's capabilities to respond within its national and international programs to support the US Arctic National Strategy and what would be a minimum portfolio of NOAA activities that could realistically fill those gaps?
3. How do activities of NOAA, both nationally (including through the US Interagency Arctic Research and Policy Committee, IARPC) and internationally (including participating in the Arctic Council as the US takes over the Chair from 2015-2017), influence decision-making within NOAA in relation to the US National Arctic Strategy Implementation Plan?
4. What improvements can be recommended to build capacity for coordination within and across Line Offices of NOAA for its management and decision-making activities in the Arctic?

3. Report Results: NOAA Line Office Input and Committee Recommendations

NOAA plays a large role in Alaskan and Arctic research supporting NOAA's 2014 Arctic Action Plan at its posts in Alaska, including formal and informal activities with Alaskan Natives. Formal examples include eight agreements between NMFS and Native entities, and an annual Arctic Open Water Meeting that is currently being revamped to be more proactive in connecting research and local community needs. Informally, there are many focus groups, meetings, workshops, and joint projects between NOAA scientists, managers and local community members that go unrecognized as products of NOAA activities. For example, NOAA has an Alaska Forum on the Environment, NOS conducts hydrosurvey meetings with local communities, NWS has coastal storm hazard communication focus groups, and there are programs such as the Arctic Shield, North Slope Science Initiative, and the Sea Ice for Walrus Outlook.

The Arctic Subcommittee posed the four questions listed previously to an array of presenters related to NOAA's activities in the Arctic. Each of the NOAA Line Offices provided both oral and written summaries of their activities, as well as input via the questionnaire stage of our committee activities. Summarized below are responses by each Line Office, including our committee recommendations:

3.1 What are the specific short-term and long-term activities being undertaken in each NOAA Line Office that are beneficial for NOAA's capabilities to respond to national needs as recommended in the US National Arctic Strategy and Implementation plans?

Overall, NOAA's internal efforts include the Arctic Vision and Strategy (NOAA, 2011), the NOAA Arctic Action Plan (NOAA, 2014), the NOAA Arctic Testbed (NWS, NESDIS, OAR, NSF, ONR, Canada, NASA, World Weather Research Program Polar Prediction Project), and the NOAA Sea Ice "team" (Alaska NWS, National Ice Center, OAR Earth System Research Laboratory, OAR Pacific Marine Environmental Laboratory (PMEL) project, and NOAA's National Centers for Environmental Prediction). NOAA works with State and Local governments and industries in Alaska through memoranda of understanding, steering committees, joint projects, Yukon River Salmon run timing coordination, and the North Pacific Fishery Management Council (NPFMC). For example, there is the Coastal Storms Pilot and an Alaska Regional Response Team. In terms of industry relationships, up to summer 2015 there was a NOAA-Shell/Conoco-Phillips/Statoil data sharing agreement. However, the previous Shell-Borough Science agreement was terminated in late summer 2015 as Shell pulled out of Alaska science activities. The NWS provides information to the Alaska State Emergency Operations Center on Fall storms and Fall and Spring floods, as well as sea ice forecasts. NWS continues to provide information to the oil and gas industry along the North Slope of Alaska, with partners including the oil industry, the Coast Guard, Search and Rescue, HAZMAT, BOEM, and subsistence hunters, although with Shell's termination of activities in the Pacific Arctic region, this partnership is being revamped.

NOAA also works with other federal agencies through National Strategies, National and Regional Working Groups, and International partnerships. For example, there have been multiple national documents on the Arctic since 2013, including the National Strategy for the Arctic Region, the Arctic Deep Draft Port Study, the U.S. Arctic Marine Transportation System: Overview and Priorities for Action, Managing for the Future in a Rapidly Changing Arctic, and the Interagency Arctic Research Policy Committee Arctic Research Plan: FY2013 – 2017 (White House Executive Office, 2013b) that is currently in revision for the 2017-2021 period. NOAA participates in the Interagency Working Group on Domestic Energy Permitting in Alaska, as well as on Arctic Council Working Groups, and the Distributed Biological Observatory (DBO). Partners include the National Science Foundation (NSF), the Office of Naval Research (ONR), the Fish and Wildlife Service (FWS), BOEM, National Aeronautic and Space Administration (NASA), and US Geological Survey (USGS). NOAA has a particularly close working relationship with BOEM in Alaska and the Arctic as much of NOAA's NMFS Arctic research is funded by BOEM.

Listed below are specific summaries by the five NOAA Line Offices as to their ongoing Arctic activities. More detailed information on current and planned activities is provided in individual documents available on the ESMWG Arctic Subcommittee website.

National Marine Fisheries Service (NMFS) conducts living marine resource surveys and assessments, some that have been completed and others that are continuing in support of the Arctic National Strategy Line of Effort 2: Pursue Responsible Arctic Region Stewardship (**Table 1**). Some examples of programs that have recently concluded are: the ARctic Whale Ecological Study (ARCWEST) – eastern Chukchi Sea bowhead and gray whales, fin and humpback whales (NMFS Alaska Fisheries Science Center, PMEL, BOEM, North Slope Borough, Woods Hole Oceanographic Institute), the Ecology of ice-associated seals (NMFS, Alaska Native hunters from Kotzebue, Wainwright, and Barrow), the Chukchi Acoustic Oceanographic and Zooplankton Study (CHAOZ) (OAR, NMFS), Climate Regimes and Ecosystem Productivity (2 decades of biophysical observations in the Bering Sea) (NMFS, OAR), Bering-Aleutian Salmon International Survey (BASIS), and Arctic Ecosystem Integrated Survey (linked to BASIS).

National Ocean Service (NOS) has two main focus areas in the Arctic: charting the Arctic and hazard assessment and response. The NOS Office of Response and Restoration has an Environmental Response Management Application for the Arctic (ERMA-Arctic). Efforts to chart the Arctic that are associated with IARPC and the NSAR include: updating nautical charts, environmental sensitivity index maps, and other Arctic feature maps with data acquired through annual field seasons; building hydrodynamic models, vertical datum transformation tools, and digital elevation models for U.S. Arctic coasts; collecting airborne gravity data over the State of Alaska (including the Aleutian Islands) and refining the experimental Alaska geoid model to help correct errors in Arctic regions; developing prototype Arctic-capable water level gauges to fill gaps in NOAA water level observations for tidal determinations and to support charting and mapping efforts; continuing efforts to develop force-multiplying survey technologies (e.g., autonomous platforms and technologies, LIDAR, Interferometric Synthetic Aperture Radar (INSAR), satellite sensors) capable of collecting high quality Arctic survey data;

developing a plan for an integrated maritime heritage mapping project to find the lost whaling fleets of the western Arctic and implement when feasible; and providing at-sea vessel capability to support charting and research operations in the Arctic (in coordination with OMAO).

NOS also has efforts associated with IARPC and NSAR related to hazard assessment and response including: continuing compiling and refining the data sets provided by the online data portal Arctic Environmental Response Management Application (ERMA); participating in interagency research and data integration to improve Arctic natural resource maps that feed scenario development and risk assessment; strengthening models for oil spill trajectory as well as the weathering and fate of oil; improving oil spill prevention, containment, and response infrastructure, plans, and technology for use in ice-covered Arctic seas, using all available sources, such as federal agencies, industry, academia, and international partners; and finalizing and testing contingency plans to ensure adequacy of response equipment, trained personnel, and nearshore protection strategies using existing response preparedness efforts, such as the Aleutian Island Risk Assessment.

National Weather Service (NWS) provides forecasts, warnings, and information for surface, marine, and aviation weather interests in the Arctic with emphasis, when possible, on high-impact events including major storms and polar lows, storm surge, and other coastal hazards, even volcanic ash and space weather. Services are delivered through a number of media from Internet to high-frequency radio broadcasts. NWS has partners and stakeholders in Alaska and the Arctic area that depend on it to consistently provide the environmental intelligence critical to the protection of life and property and for decision-making activities. Specific services include: National Centers for Environmental Prediction (NCEP) guidance/models/forecasts: Climate Prediction Center (CPC) issues extended range temperature and precipitation outlooks, monthly mean Arctic Basin sea ice coverage as forecast by NOAA's operational dynamic climate model, the Climate Forecast System. The Environmental Modeling Center (EMC) maintains global and regional numerical forecast systems for the atmosphere, hydrosphere, and cryosphere, Ocean Prediction Center (OPC) provides high seas warning and forecast bulletins transmitted via the Global Maritime Distress and Safety System (GMDSS) for the North Pacific and Arctic Weather Prediction Center (WPC) provides guidance via gridded forecast fields for the medium range for Day 4 through 8 for Alaska. In Alaska, there are three Weather Forecast Offices (WFOs) in Anchorage, Fairbanks, and Juneau that provide public forecasts 365 days a year, 24-hour-a-day.

Ocean and Atmospheric Research (OAR) has four overall mission objectives for the Arctic: 1) strengthen science to understand and detect climate and ecosystem changes, 2) improve stewardship and management of ocean and coastal resources, 3) advance resilient and healthy Arctic communities and economies, and 4) enhance international and national partnerships. OAR observational data and model forecasts show that the Arctic Basin will be sea ice free during summer as early as 2020 and as late as 2080, depending on large-scale climate drivers that are not well understood. Arctic temperatures over the last decade have increased at least three times the rate of mid-latitudes relative to temperatures at the end of the 20th century. Multiple interacting feedbacks are a hypothesized cause for this Arctic Amplification and much

of the current uncertainty. Many of these feedbacks, such as ocean circulation, cloud processes rising greenhouse gas levels and atmospheric dynamics act on a regional basis and their non-linear interactions are not well captured in climate models. Accordingly, there is wide scatter in sea ice forecasts on multiple time scales leading to gaps in understanding of ocean warming and biogeochemical impacts, such as ocean acidification. This has created gaps in NOAA's ability to provide services supporting shipping, energy exploration, and environmental stewardship. There is a critical need for improved estimates for the "faster than expected" changes in the Arctic and their wider hemispheric impacts, based on expanded observations and analysis.

National Environmental Satellite, Data and Information Service (NESDIS) provides timely access to global environmental data and information services from satellites and other sources to promote, protect, and enhance the nation's economy, security, environment, and quality of life; along with NESDIS Strategic Objectives of: 1) enhancing operational satellite sensing systems and 2) promoting critical environmental data and information services, and provide and ensure in turn a unique research and operational observing capability for the Arctic Region. NOAA's National Geophysical and National Oceanographic Data Centers focus on ensuring the quality and accessibility of coastal, oceanographic, geophysical and marine ecosystem observational data that further support regional science and augment their value by transforming data into useful comprehensive products and services. This meets the dual goals of supporting science-based management requirements essential to NOAA and the Nation's Arctic mission while meeting NOAA's data mandates under the Open Data Initiative and Public Access to Research Results. Through OSPO and Satellite Applications and Research (STAR), NESDIS provides NOAA's contribution to the U.S. National Ice Center (NIC). The NIC is a tri-agency partnership of NOAA, the United States Navy (USN), and the United States Coast Guard (USCG) charged with providing global ice and snow analysis and short term forecasting services (USN mission requirement) for the maximum benefit of the United States government. Although the NIC produces global sea ice and snow cover products, the emphasis is on monitoring due to crosscutting missions of the 3 partner agencies in the region.

In addition, NOAA has many national partnerships, such as the Interagency Arctic Research Policy Committee (IARPC) Implementation Teams, BOEM Environmental studies projects, Landscape Conservation Cooperatives, the Alaska Center for Climate Assessment and Policy, the Cooperative Environmental Studies Unit, the Alaska Climate Change Executive Roundtable (ACCER), the North Slope Science Initiative (NSSI), the North Pacific Research Board (NPRB), Land Conservation Cooperatives (LCCs), the Alaskan Ocean Observing System (AOOS), and Interagency Working Groups (IAWGs), to name a few.

NOAA works with academia through interdisciplinary programs, joint proposals, partnership programs, many through Cooperative Institutes (CI), such as the Cooperative Institute for Alaska Research (CIFAR) and the Cooperative Institute for North Atlantic Research (CINAR). For example, the previous Bering Sea Ecosystem Study and Bering Sea Integrated Ecosystem Research Program (BEST-BSIERP), funded by NSF and NPRB, was a successful partnership program, and NOAA was successful in its application for the new NPRB Arctic research effort

starting in 2016. NOAA also works on the annual Arctic Report Card that includes academic and NOAA personnel. Note that sometimes the CIs are used as a mode for “pass through funding” that allows NOAA to hire scientists who actually work for NOAA, but are not NOAA personnel. Some concerns were expressed during the committee deliberations about the interactions with academic partnerships via this arrangement.

Through the course of our review we identified that there was no central node for a NOAA Arctic program. NOAA management has recognized the need to develop cross-Line Office activities focused on the Arctic through coordinated activities, thus in 2014 it developed a NOAA Arctic Executive Committee. We recognize a common base need for annual evaluation of the questions we developed during our study, some of which have been addressed by NOAA during our committee activities. As an example, the introduction of a NOAA project database over the two year committee deliberations will facilitate the within and cross-link LO activities for future evaluation. [The ESMWG subcommittee notes that through the process of the Arctic Subcommittee workings, its value and utility are more in the process than the actual recommendations because many of the recommendations we outline in this report have been or are in the process of being implemented by NOAA itself.]

Recommendation: NOAA should develop a clearer vision and statement of its strategic role and scientific research activities in the Arctic, both nationally and internationally. Focused outreach documents should be developed to highlight NOAA projects in the Arctic, the connection within and among LOs and connections with other US government agencies and international groups. There is value in a central Arctic office in NOAA, with staff to facilitate the new Arctic Executive Committee in order to coordinate NOAA’s Arctic portfolio and address strategic national needs.

Recommendation: NOAA should regularly evaluate its academic partnerships supporting NOAA Arctic scientific research activities that occur both through direct competitive calls and Cooperative Institutes (CIs), specifically looking at trends in the level of support, productivity and transparency of effort. Specific to the CIs, NOAA should determine if the academic partnerships are being used for direct capacity for NOAA activities or if NOAA is supporting efforts that could be filled by academic entities directly

One of the strong international programs funded through NOAA, until recently, was the Russian-American Long-term Census of the Arctic (RUSALCA, OAR), which provided an observational platform, including moorings in western Bering Strait and time series transect lines in the Pacific Arctic. Unfortunately, due to uncertainties related to ship access and clearance, the RUSALCA program was suspended in late June 2016. Results from the first decade of the RUSALCA program (2004-2014) were recently published in a special issue of the Oceanography Magazine (Crane and Ostrovskiy, 2015), including topics such as monitored fluxes of fresh and salt water, nutrients, and heat through the Bering Strait, monitored ecosystem indicators through all core trophic levels that are susceptible to climate change in the Chukchi Sea and Pacific Arctic region, linked ice cover to ecosystem structure with multidisciplinary observations, and ocean CO₂ uptake patterns that indicated differences

between the western Russian side and eastern US side of the Chukchi Sea. The planned next steps for the RUSALCA program were to maintain a mooring in the western Bering Strait, to continue physical, chemical and biological measurements at the time series sites in the southern Chukchi Sea coincident with the DBO program, and to extend the time series studies on DBO4 in the northeastern Chukchi Sea westward to Wrangel Island. In addition, the planned next stage of the RUSALCA program would allow NOAA to continue collaborating internationally with members of the Pacific Arctic Group (PAG) to design and implement the Pacific Arctic Climate-Ecosystem Observatory (PACEO) of repeat transects in the northern slope to basin areas where continued sea ice retreat and seawater warming is observed.

Other NOAA collaborative programs that include academic and other partnerships include: the Distributed Biological Observatory (DBO) that focuses on the biological response of the Pacific Arctic continental shelf system to change environmental conditions, acting as a “change detection array” to track status and trend in coordination with national (e.g., NOAA/OAR and NMFS, NSF, BOEM, NASA) and international partners through the Pacific Arctic Group (PAG). The DBO has been in place since 2010 (<http://www.arctic.noaa.gov/dbo/index.html>) and is centered on biological “hotspots” along a latitudinal gradient in the northern Bering and Chukchi Seas.

The Arctic Marine Biodiversity Observing Network (AMBON) focuses on the Chukchi Shelf and links pan-Arctic observation networks (funding by NOAA/NOS, BOEM, and previously Shell). The partnership is through the National Oceanographic Partnership Program, which started in 2015. However, due to Shell’s termination of Alaska activities, AMBON’s future biodiversity activities after the 2017 field season are uncertain. AMBON includes two DBO lines in the Chukchi Sea.

NOAA will continue to serve as the lead for the Arctic Council’s Arctic Biodiversity data service for the Circumpolar Biodiversity Monitoring Program (CBMP; caff.is/marine) of the Arctic Council’s Conservation of Arctic Flora and Fauna (CAFF) working group. CBMP is an international network of scientists, government agencies, indigenous organizations and conservation groups working together to harmonize and integrate efforts to monitor the Arctic’s living resources. Results from the DBO, AMBON, and hopefully again through RUSALCA efforts, help provide NOAA’s contribution to international biodiversity studies.

The Synthesis of Arctic Research (SOAR) connects results across a spectrum of science projects and observations. SOAR Phase I goals were presented in a 2015 special issue of *Progress in Oceanography* (Moore and Stabeno, 2015), with a 2nd special issue in progress as a special issue of *Deep Sea Research II* (funding by BOEM and NOAA).

3.2. What are the gaps in current/planned Arctic activities that limit NOAA's capabilities to respond within its national and international programs to support the US Arctic National Strategy and what would be a minimum portfolio of NOAA activities that could realistically fill those gaps?

3.2.1 NOAA and Arctic Ecosystem Sciences

There are specific ecosystem measurements needed for the NOAA Arctic portfolio. Our definition of ecosystems is a composite of science from physics, chemistry and biology. A major concern is the continued need for observations. For example, the NWS lacks observations to tie down their model predictions (otherwise they are just guesses). This need includes better satellite guidance from the National Ice Center and a whole suite of other observations (surface, upper air observations, ocean buoys, and water level gauges). Forecast skill is greatly inhibited without these observations.

Observing systems (both physical and biological) need to be maintained and expanded across international boundaries. There is a need for variable sampling platforms (ship time and capacity, remote vehicles, and year-round observing moorings), data integration (visualization and archiving), coordination of funding, and new observing tools and data for seasonal forecasting for both ice melt/freezing for operations and disaster response, and to better determine ecosystem response to climate change.

Improved Arctic climate models are needed to couple the Arctic with mid-latitudes. In addition, ecosystem modeling, with appropriate regional subroutines for various Arctic regions relevant to US interests, is needed. We also have very little understanding of the fate and behavior of oil modeling, toxicity rates on trophic components, and a lack of peer-reviewed cold water and ice/oil behavior studies.

There is also a poor baseline understanding of Arctic coastal processes. Vast portions of the Arctic are not adequately surveyed. Currently NOAA is leading the NSAR Chart the Arctic Region effort (with USGS and State of Alaska). However, challenges include precise positioning, harsh environments, telecommunications, and a complex seafloor. There is also lack of water level gauging and shoreline mapping. Bathymetric charting is also essential for developing the Arctic as an open ocean and it is time for NOAA to take the leadership. There is also a need for winter sampling, emphasizing the need for unmanned sensors. Atmospheric changes are a black box, driving our weather and overturning circulation. Teleconnections are a key role for NOAA, but it is suffering from lack of coordination, such as between ongoing atmospheric activities supported by OAR and NWS.

Recommendation: Increased and focused investments are needed in order for NOAA to fulfill its identified responsibilities within national and international observing programs that are the front line of detecting change in the Arctic ecosystem. NOAA considers observing systems

to be “The heart of NOAA’s Environmental Intelligence” (SAB Synthesis Session, April 16-17, 2015). Therefore, long-term support for multi-disciplinary and multi-national observing and modeling activities to evaluate the status and change to Arctic physical stressors and trophic ecosystem response are needed.

3.2.2 NOAA and People as Part of the Arctic Ecosystem

The scope of what may be included in “Ecosystem Science and Management” in NOAA still does not have a uniform interpretation within NOAA or between NOAA and all its partners. This commonly does not impede progress on ecosystem science and management, even if it complicates discussions during reviews of past and present “ecosystem science” in NOAA, or in planning for “future ecosystem science”. However, these complications sometimes do cause misunderstandings that result in certain potentially important science activities not being undertaken efficiently, and sometimes not at all.

Those complications and misunderstandings can arise anywhere, but the Arctic is an area where they are likely to occur. One such issue of scope is the inclusion of people as part of “ecosystems”. It is now nearly universal to acknowledge that people are part of the ecosystems in which they live. Acknowledging that relationship is a step forward, but from that acknowledgment it follows that the social sciences are part of “ecosystem science”. This is particularly important in the Arctic, because the daily life of inhabitants in the Arctic are closely tied to the ecosystem in which they live. So, the study of the human dimension of Arctic ecosystems is particularly important to understanding how the Arctic ecosystems influence human well-being in the Arctic, and how human activities affect and are affected by the status and trends of the components of Arctic Ecosystems.

There are good examples where NOAA has been involved with traditional ecological knowledge, such as working with local communities on the bowhead whale harvest of that Endangered Species. It was the Barrow residents that told NOAA that there were high abundances of bowheads offshore (>50+ miles out) and only after many studies were these findings supported and used to allocate subsistence harvest on a known population level. NOAA needs to continue to work with local communities in the Arctic, including social science as a mode to evaluate community resilience to environmental status and change.

The second and related issue is that even though the linkages between human lifestyles and well-being in the Arctic and the state of Arctic ecosystems are particularly tightly coupled, the scientific data and research results in a “western science” sense are often shorter and/or more incomplete from Arctic Ecosystems than from ecosystems in more temperate latitudes. However, the coupling of human lifestyles and well-being with Arctic ecosystems over generations in the Arctic, particularly but not exclusively among Indigenous Peoples living in the Arctic has meant that knowledge systems of Indigenous and Ecological Knowledge (ILEK) may be particularly rich. This provides a natural opportunity for supporting the use of those

alternative knowledge systems to complement and enrich the knowledge available from “western science in the Arctic”.

Thus, there are clear gaps in NOAA’s Arctic research range from minimal social science and local community engagement to missing observations at the appropriate scales and the need for better mechanisms for pooling federal resources for Alaskan and Arctic research. There is an overall need to engage more with Alaskan Native communities across the Line Offices. Comparatively, NMFS engages fairly well, whereas NOS and OAR could bolster their outreach activities. There is a need to keep Alaskan and other Native communities in the conversation. Native communities want to be engaged in the science through participation and education, and further, there should be a closing of the loop with communication, i.e. reporting back to the communities’ research products or findings. This takes advance planning and coordination to prevent meeting overload, but ensure the right balance of communication. Overall, there could be an increase in the visibility of what coordination does successfully occur in Alaska and the Arctic.

Recommendation: *Local and indigenous knowledge systems should be used to contribute to NOAA’s understanding of the Arctic ecosystems and to share results of NOAA scientific endeavors with coastal communities.* It is essential that NOAA and its partners assess the needs and importance of social sciences in the Arctic and to increase support for the human component as part of “ecosystem science”.

3.3. How do activities of NOAA, both nationally (including through the US Interagency Arctic Research and Policy Committee (IARPC)) and internationally (including participating in the Arctic Council as the US holds the Chair from 2015-2017) influence decision-making within NOAA in relation to the US National Arctic Strategy Implementation Plan?

3.3.1 NOAA’s Arctic Efforts Nationally

NOAA’s Arctic Vision and Strategy strategic goals (NOAA, 2011) are aligned with the three lines of effort in the US National Strategy for the Arctic Region (White House Executive Office, 2013a; see **Table 1**). NOAA provides the backbone of basic research, including providing a better understanding of climate issues to bathymetric charting, necessary to address many aspects of the NSAR. NOAA is active in IARPC collaboration teams (CT), having worked on the current 5-year plan (White House Executive Office, 2013b) to coordinate interagency efforts, and is currently working on the next IARPC 5-yr plan (2017-2021). Currently there are 12 teams and 16 agencies involved in IARPC, with NOAA chairing the Observing Collaborative Team (CT; Jeremy Mathis, OAR) and the DBO CT (Sue Moore, NMFS Office of Science & Technology).

NOAA contributes with management and regulatory decisions, such as managing fisheries (MSA), co-managing marine mammal subsistence harvests in Alaska, conserving protected

species through the National Environmental Policy Act (NEPA), the Marine Mammal Protection Act (MMPA), and the Endangered Species Act (ESA), and implementing integrated arctic management (NOAA, 2013b).

Recommendation: NOAA should strengthen its US interagency science coordination efforts through the Interagency Arctic Research and Policy Committee (IARPC), including continued leadership on observing activities (e.g., Observing Collaborative Team and Distributed Biological Observatory Collaborative Team), and their inclusion in the revised format for the next five-year IARPC plan (2017-2021).

3.3.2 NOAAs Arctic Efforts Internationally

NOAA has variable roles in all components in the pillars of the US Chairmanship for the Arctic Council, and has involvement in both national and international committees. As part of the Department of Commerce (DOC) NOAA has many leadership positions in the Arctic Council and plays an important role as the US currently is chairing the Arctic Council from 2015-2017. NOAA is now the Co-chair of the Emergency Prevention, Preparedness & Response Subcommittee (EPPR) with the National Nuclear Security Administration. NOAA also co-chairs the Task Force on Arctic Marine Cooperation with the Department of State. NOAA participates in the Arctic Council Conservation of Arctic Flora and Fauna (CAFF) working group, chairing the Circumpolar Biodiversity Monitoring Plan (CBMP; <http://www.caff.is/monitoring>), and is also involved in other working groups, including PAME (Protection of the Arctic Marine Environment) and AMAP (Arctic Marine Assessment Program). NOAA is active in Traditional Ecological Knowledge (TEK) at a basic level, along with activities by multi-disciplinary science within the NOAA Arctic Research Program (ARP/OAR) and CBMP. Developing issues, such as fisheries and ecosystem management in the Central Arctic Ocean (CAO), biodiversity topics, and climate change impacts globally, are important topics requiring international leadership. In addition, international cross-platform asset use in the Arctic should be encouraged.

Within the Arctic Council the US has developed “Balanced thematic pillars” for its chairmanship of the Arctic Council, which are: Improving Economic and Living Conditions, Arctic Ocean Safety, Security, and Stewardship, and Addressing Impacts of Climate Change. NOAA has an important role in many of the topics within the three pillars:

1. Arctic Communities topics include: Renewable Energy, Community Sanitation and Public Health, Arctic Water Resources Vulnerability Index, Arctic Freshwater Security, Telecommunications Infrastructure, and Mental Health and Suicide Prevention.
2. Arctic Ocean topics include: Search & Rescue Exercises; Marine Environmental Protection, Marine Protected Areas Network (DOC/NOAA), Arctic Ocean Cooperation (DOS, DOC/NOAA), and Arctic Ocean Acidification (DOC/NOAA, DOS).

3. Arctic Climate topics include: Short-lived Climate Pollutants; Arctic Climate Adaptation and Resilience; Pan-Arctic Digital Elevation Map; and Climate Change Indicator System.

There are also priority, on-going topics of the Arctic Council that are relevant to NOAA's mission, specifically:

- *Adaptation Actions for a Changing Arctic (AACA)*: This U.S.-Norway-led major scientific assessment will be a lasting legacy of the U.S. chairmanship in that its goal is to make science directly relevant to policy-making on climate adaptation (University of Alaska is lead for the Chukchi Sea).
- *Task Force on Science Cooperation*: This U.S.-Russia led task force will finalize a legally-binding agreement among the Arctic States to facilitate scientific research such as lowering barriers in moving people, equipment, samples and ships across international borders. (NSF lead).
- *Invasive Species*: The CAFF working group will prioritize work on invasive species in the Arctic terrestrial and marine environments as a follow-up to the Arctic Biodiversity Assessment (NOAA lead for CBMP).

Recommendation: *NOAA should continue to strengthen its international efforts and science-based leadership through the working groups of the Arctic Council, e.g., Circumpolar Biodiversity Monitoring Program (CBMP) and Emergency Prevention, Preparedness & Response Subcommittee (EPPR).* NOAA should focus and expand its international collaborative observing programs, such as the Distributed Biological Observatory (DBO) and the International Arctic Systems for Observing the Atmosphere (IASAO). NOAA should also work toward reinitiating the Russian American Long-term Census of the Arctic (RUSALCA) program.

3.4. What improvements can be recommended to build capacity for coordination within and across Line Offices of NOAA for its management and decision-making activities in the Arctic?

Overall, the earlier NOAA Arctic Task force and current Arctic Executive Committee have a positive strategy for organizing NOAA's Arctic research and capabilities. For example, the Arctic Test Bed is important for better alignment between OAR/NWS. However, some specific improvements were recommended during the LO presentations in the context of ongoing changes in the institutional structure.

The revision of the NOAA Arctic Task Force structure to a NOAA Arctic Executive Committee (AEC) with LO membership of managers with budgetary authority should enhance the linkages to decision-makers, although there is still a need to facilitate communication across and among Line Offices for Arctic activities. Specifically, there is need for a revised structure that enhances linkages between researchers, mid-management, and NOAA/Whitehouse leadership (note that

this revision process is apparently underway by the AEC). There is a need to formally link task force activities to agency planning, programming, execution, and evaluation, along with budget allocations for a common Arctic portfolio goal via cross agency initiatives.

Recommendation: *Linkages between researchers and mid-level management within and among LOs and the NOAA Arctic Executive Committee leadership should be strengthened.* There should be a formal link of task force activities to agency planning, programming, execution, and evaluation, along with budget allocations for a common Arctic portfolio goal via cross agency initiatives.

There is a need for synergistic coordination for interagency data exchanges for Arctic data collections. There is also a need to develop a central data portal for marine observatory data and products, perhaps through the AOOS/Axiom workspace. Enhancing long-term data archiving through the National Ocean Data Center (NODC), the National Center for Atmospheric Research (NCAR) and the University Corporation for Atmospheric Research (UCAR) are also needed. For example, the DBO has a distributed data archive, with a central metafile archive for all national agency and international partners to submit four types of data collections (transect data, satellite, mooring, and upper trophic level surveys) to the UCAR/Earth Observing Laboratory. The actual location of the data, linked by description within the standard DBO metafile, stays with the required funded archive (e.g., NODC, NSF, AOOS/Axiom workspace, and internationally at the KOPRI-Korea, JAMSTEC-Japan, and PRIC-China national archives).

Recommendation: *NOAA should continue to coordinate and facilitate an open and transparent data archiving protocol that is usable by all components of NOAA-supported science activities in the Arctic.* In terms of academic relationships, NOAA could make incentives for collective contributions from both NOAA scientists and academia, along with improved methods for making data available while maintaining QA/QC and publication opportunities.

4. High Arctic Activities and Budgetary Inventory for NOAA Line Offices (LOs)

The ESMWG Arctic Subcommittee asked each LO to identify High Arctic projects that it was involved in relation to the three pillars of the NSAR: (1) Advance U.S. security interests, (2) Pursue responsible Arctic region stewardship, and (3) Strengthen International cooperation. For the summary of Arctic relevant projects, the composite finding was 35 projects, but these did not include the long term monitoring sites at the Barrow Atmospheric Baseline Observatory. **Fig. 2** shows the 35 projects evaluated in our effort in relation to the NSAR three Pillars, with 63% of the projects addressing U.S. security interests (Pillar 1), 100% of the projects addressing (responsible stewardship (Pillar 2), and 34% addressing international cooperation (Pillar 3). It should be noted that the summary of Projects by Line Offices shows the minimum number of projects because some projects are large, multi-agency, and long-term efforts that cross annual budgets, but were only identified as one project. In addition, an important metric to track is the

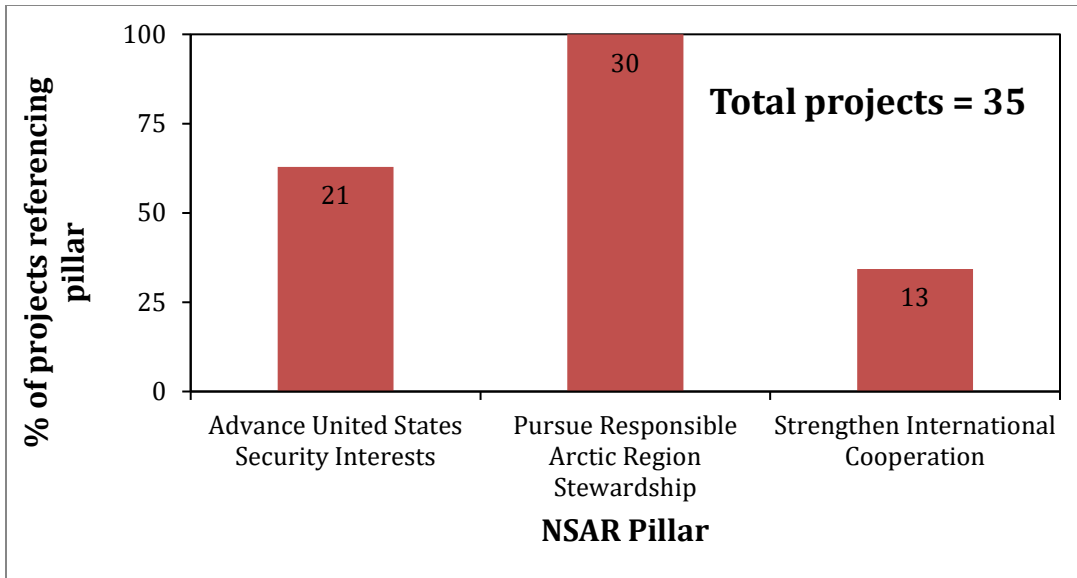


Figure 2. Percent of NOAA projects supporting each of the National Strategy for the Arctic (NSAR) pillars, inclusive of all reported activities by LOs.

identification of cross-Line Office projects as it shows that NOAA is being more efficient in collaborative efforts and reducing “stove-piping” within only one Line Office. There is a positive direction of recent integrative efforts within NOAA that should be continued.

The following questions were posed to each of the NOAA LOs. The responses are summarized below by LO for each question. The request letter to the LOs was for identification of activities and associated budget from Bering Strait northward, defined as the “High Arctic” for the purposes of this report. Note that NWS and OMAO did not report budget values in their response because they do not consider themselves as undertaking any High Arctic research. This interpretation is misleading because the NWS expends funds in the Arctic for weather activities as part of their mandate that produce products that are used by the research community. NOAA needs to explicitly define what “research” means for its portfolio, because any funds expended on Arctic “activities” under NOAA’s mandate should be accountable by all the Line Offices for management decisions, regardless of the interpretation of the term.

4.1. How much of your total Line Office appropriations are allocated to High Arctic research for the periods FY12 through FY16? Please provide both dollar amounts and percentage of the total LO research budget. What is the associated FTE effort for each FY year?

4.1 Budget Response by Line Offices

Fig. 3a summarizes the direct NOAA based funding for High Arctic research for FY12-FY16 as obtained through our survey, with the caveat that NOS did not identify FY12 funding and all FY16 for all LO funding is projected. Excluding FY12, we see about a 20-23 million dollar annual

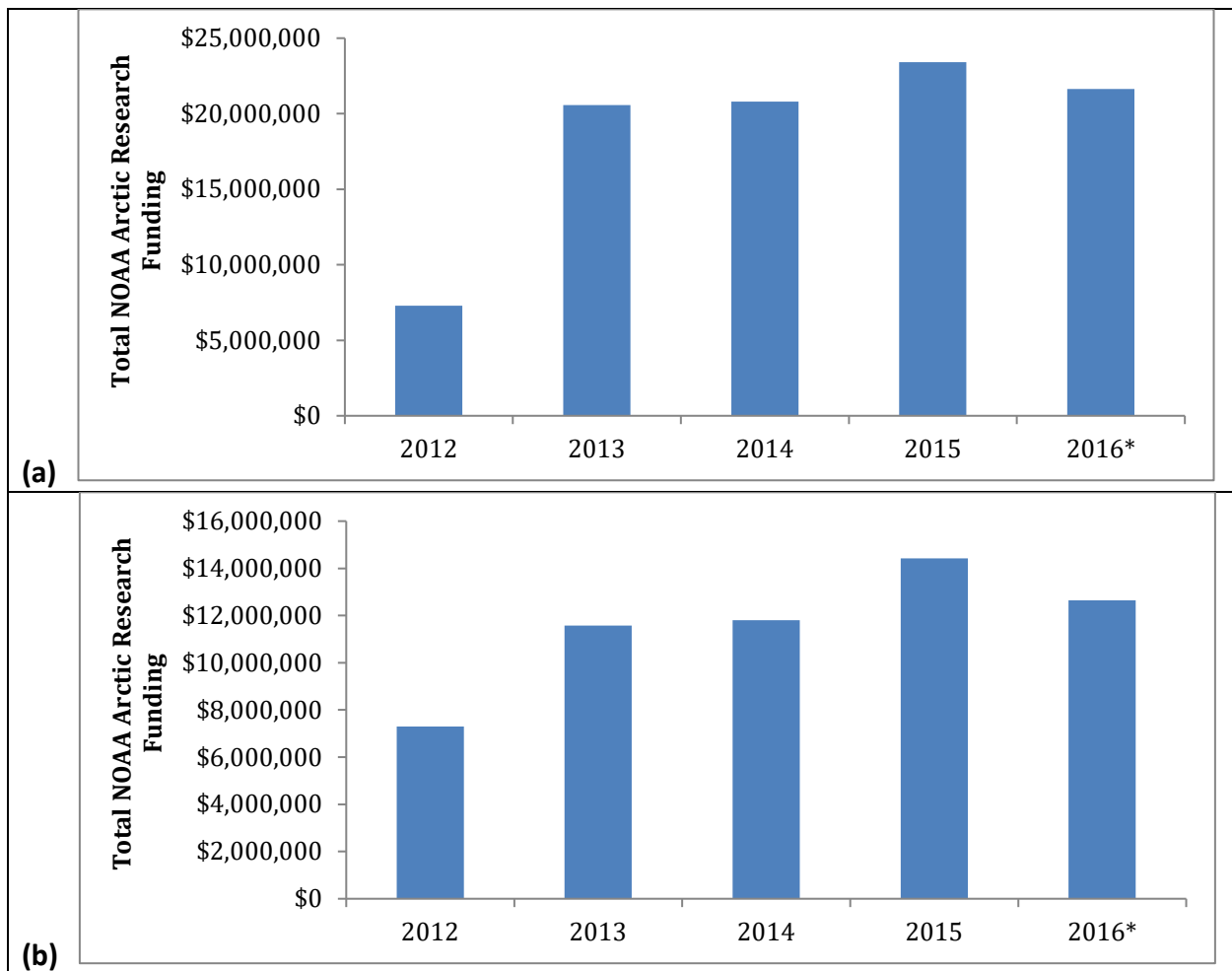


Figure 3. Total NOAA direct funding for High Arctic activities for FY12-FY16 with **(a)** all Line Offices, inclusive of NOS charting project, and **(b)** excluding NOS charting project. *= Estimated project funding amount for FY2016. Note NOS did not report FY12 funding.

budget for NOAA direct funding of High Arctic activities over the last four years. Note that NOS included one very high dollar program in their second response to the survey: hydrosurvey charting of the Arctic region, averaging about \$9 Million annually. If you remove the NOS hydrosurvey charting project, the annual NOAA high Arctic activities budget declines to about \$12-14 million dollars annually (**Fig. 3b**). Also, NOAA should consider the impact of Shell Oil’s pull out from the Arctic when interpreting the FY16 bar for NOAA’s overall High Arctic budget.

Finally, not many of the LOs were able to provide budget numbers for cross-Line Office budgets or full-time effort statistics for each fiscal year. Therefore we are not able to provide that summary. However, we suggest NOAA should determine a method to track this metric of NOAA personnel vs. outsourcing of activities to academic personnel and private industry.

Individual LO budgets for the High Arctic activities from FY12-FY16 are different than the amounts listed in the NOAA 2014 Arctic Action Plan, which included activities in the Bering Sea

(Fig. 4a, b). We also recognize uncertainties in our results based on each LO defining “activities” differently, questioning whether these activities were research vs. observing vs. operational support. In the NOAA 2014 Arctic Action Plan the LO annual budgets included the Bering Sea, specifically the annual Bering Sea fisheries surveys by NMFS. In that report NMFS expended 59% of the total NOAA Arctic funding level, whereas NMFS expenditures were <10% of the annual expenditures for High Arctic science occurring north of Bering Strait in our current study (Fig. 4a). By comparison, NOS Arctic activities, made up 53% of the total NOAA High Arctic support compared to a previous 2.4% in the NOAA 2014 Arctic Action Plan, but the majority of this increased allocation was due to the hydrographic charting project. This difference in reporting budgets between the NOAA 2014 Arctic Action Plan and our study indicate that there are inherent uncertainties in budget allocations that NOAA should evaluate. OAR expenditures were 29% of the total NOAA High Arctic budget allocation between FY12-16 (Fig. 4a) compared to the previous 2014 Arctic Action Plan of 7.4% for that LO. Note that the National Weather Service was listed to have 14% of the NOAA Arctic budget in the 2014 NOAA Arctic Action Plan, but NWS did not report any budgetary expenditure for High Arctic activities in our survey request. Similarly, the Marine and Aviation Services (OMA) was listed to have 7.8% of the NOAA Arctic budget in the 2014 NOAA Arctic Action Plan, but OMA did not report any budgetary expenditures for High Arctic activities in its response to our survey request. Note that LOs said it was not possible to break out “in-kind” budgets for partnership activities. Notably, if the NOS hydrographic charting project is removed from the analysis, the summary percent funding by Line Offices change to OAR having the highest overall NOAA-funded High Arctic support (47%), followed by NOS (23%), and NMFS and NESDIS about equal (15% each; Fig. 4b). There was no budgetary information from NWA and OMA.

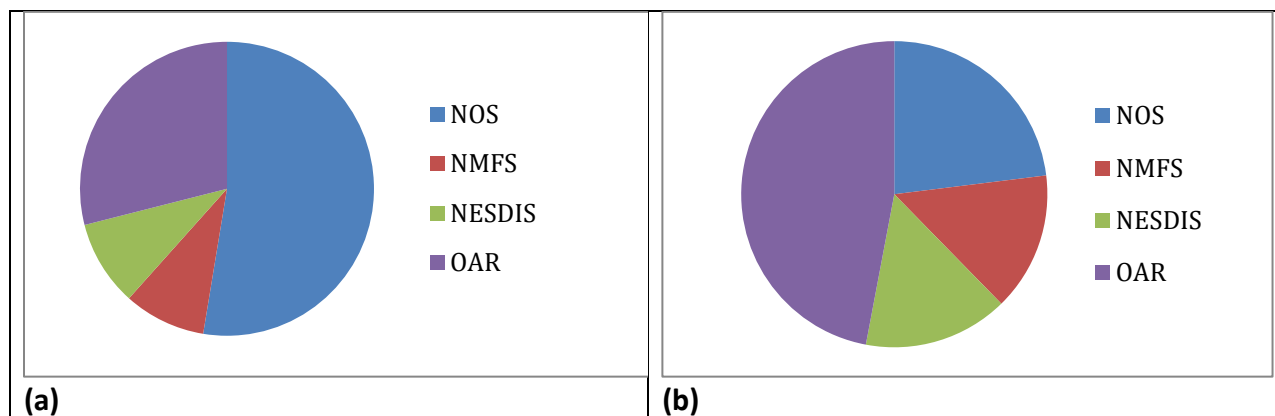


Figure 4. Percentage funding by Line Offices of total NOAA High Arctic funding over the FY12-FY16 period, with FY16 only with projected numbers for: (a) all projects reported and (b) excluding the NOS hydrographic charting project. Note that NOS did not report fiscal year 2012 numbers and neither NWS nor OMAO reported budgets for Arctic research activities.

The ESMWG Arctic Subcommittee also separated the annual LO High Arctic budget expenditures for FY12-FY16, with the higher budgets in NOS due to inclusion of the hydrographic charting activities (Fig. 5a). We also show the annual LO expenditures with the NOS hydrographic charting project removed (Fig. 5b). Overall, the annual budgets are stable for

each of the four LOs that provided budget numbers, with a small ramp up in 2015 in overall funds. The fiscal year 2012 total NOAA High Arctic budget is lower due to NOS not reporting FY12 budgets.

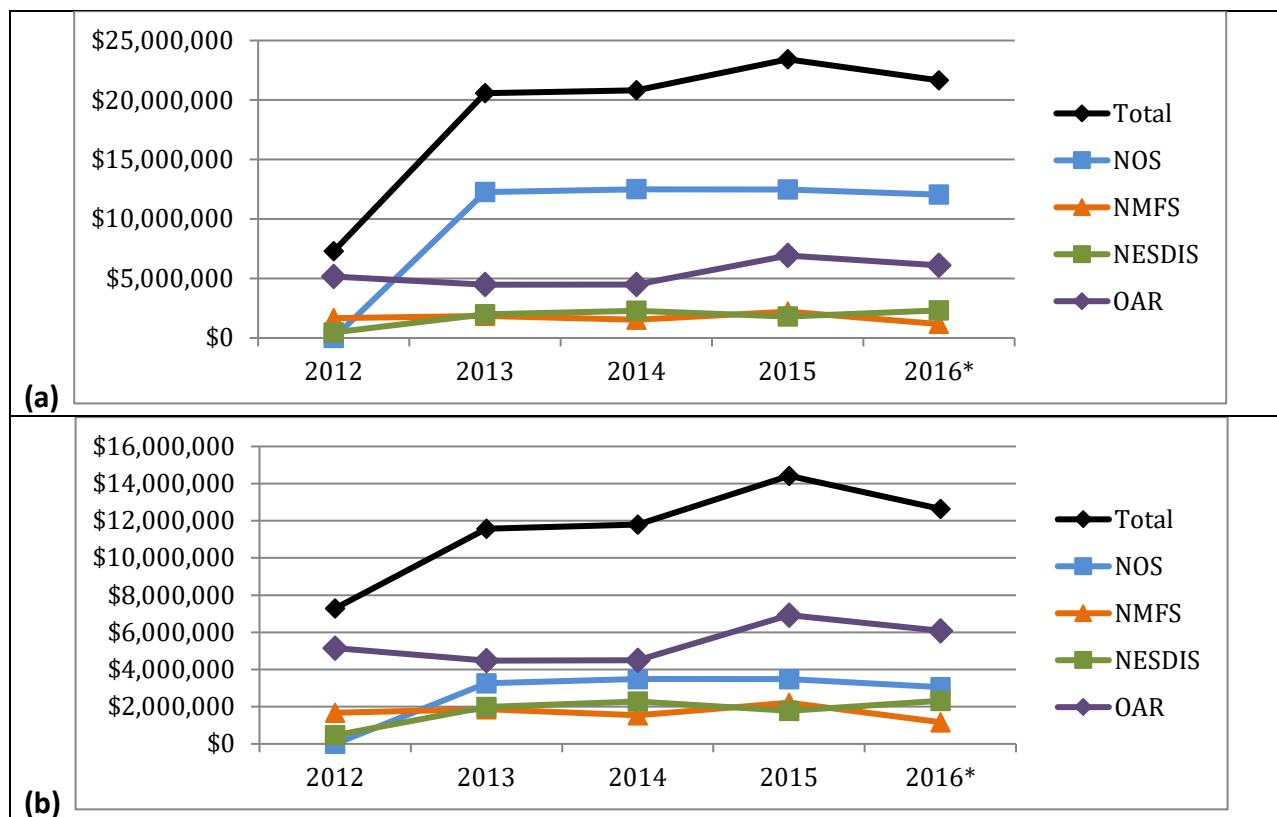


Figure 5. Time series of Line Office NOAA funding of High Arctic activities from 2012-2016: **(a)** with the NOS hydrographic charting project as an Arctic activity and **(b)** with NOS hydrographic charting project excluded. Note that FY2016 is projected and NOS did not report FY12 budget numbers.

Of the 35 projects reported by all LOs, there was mean project funding of \$2.2 million dollars, with a mean length of 4.4 years/project. Total NOAA funding FY12-FY16 was ~\$93.7 million dollars (without NOS FY12 funding reported), with NOS having primarily NOAA core funding in contrast to the high partner funding for NMFS (**Fig. 6**). **Table 2** shows the percent of projects reported by each Line Office, both NOAA funded projects and other partner funding. Note that through the survey text response we know that NOS, OAR and NESDIS do have partner agencies (national and international), yet budgetary amounts for partners were not reported in the survey. Thus, while NMFS listed both budgetary amounts from partners in addition to text responses, most of the other LOs only listed the name of the partners in the summaries below.

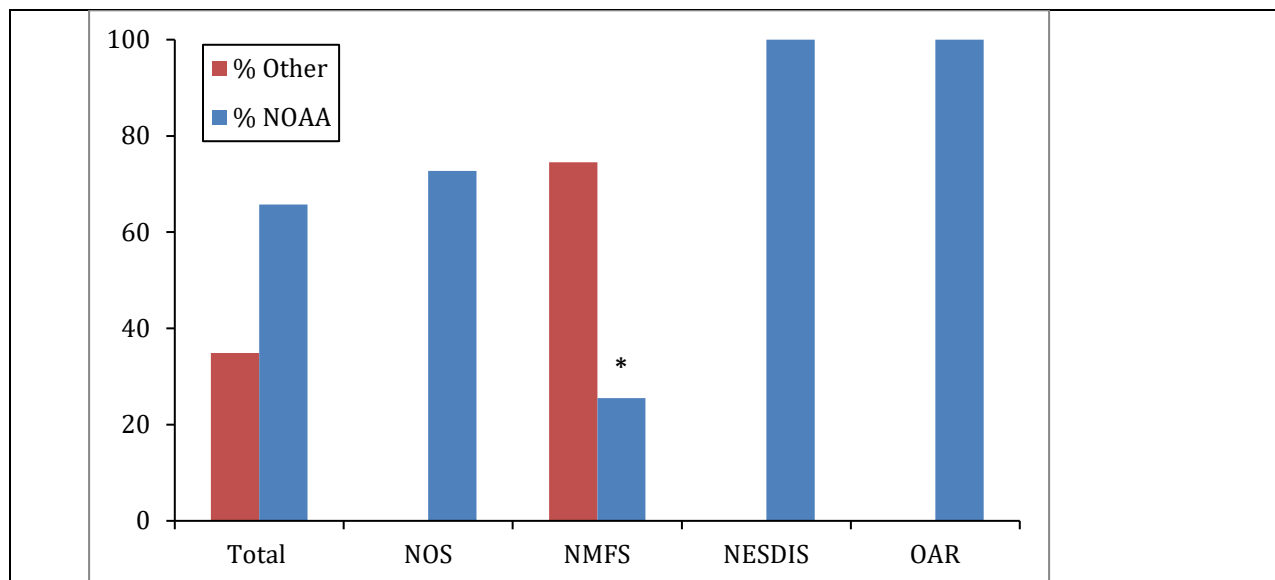


Figure 6. Percent of funding over the FY12-FY16 period for High Arctic NOAA portfolio activities supported through direct NOAA fund compared to support via other partner funding. Note that NOS only reported budget numbers for FY13-FY16. The asterisk (*) indicates NMFS has the lowest core NOAA funding for High Arctic activities. See text for listing of partner in-kind support, by name only, for NESDIS and OAR.

Table 2. Summary of NOAA Arctic research activities as percent of total budget over the FY12-FY16 period. Note NOS did not report for FY12. Key: NR=None reported.

	Percent (%) of total budget				
	All NOAA	NOS	NMFS	NESDIS	OAR
Total Projects=35					
-NOAA lead agency	65.1	72.7	25.5	100	100
-Partner Agency	34.9	NR	74.5	NR	NR

A future survey should request LO response to include both partner names as well as budget information.

4.2. Summary of LO written response to activities, budgets, and partner agencies

NMFS: The Alaska Fisheries Science Center (AFSC) conducts research in the High Arctic as possible, but it has no appropriated funds that are truly allocated to work in this region. Instead, the AFSC and PMEL leverage resources from private and non-governmental organizations and/or other federal, state, and local governments, with current primary science support coming from BOEM and the North Pacific Research Board (NPRB).

OAR: Within the Climate Observations Division, the Arctic Research Program’s budget is approximately \$3.1M (<1% of the total OAR budget which is about \$480M) that is dedicated to High Arctic Research. Within the Climate Program Office (CPO), there is an additional \$75K spent on sea ice modeling and the Climate Variability and Predictability Program will fund an

additional \$1.9M/year for three years on Understanding Arctic Sea Ice Mechanisms and Predictability, which supports 11 new three-year projects during the FY15-18 timeframe. Within Arctic Observatories (www.iasoa.org), 100% of the budget is allocated to High Arctic research.

NOS: The Integrated Ocean Observing System (IOOS) and Office of Coastal Survey (OCS) activities were considered operational support and were therefore not included in the first response by NOS, although the relevant information pertaining to the Office of Response and Restoration (ORR) were provided in the original budgetary spreadsheet. After further requests, NOS provided more details of its observing activities, resulting in NOS having the largest budget for overall High Arctic activities, including hydrographic surveys for the charting project and ecosystem studies. This revision suggests overall NOAA management needs to develop standard requirements and definitions of the type of activities to be reported to evaluate specific LO budget expenditures for High Arctic activities, including research, observing, and support activities (e.g., ships).

NWS: NWS does not report spending any funds for Arctic research, but states that other Line Offices fund its projects. NWS does not have an appropriation in its budget for research allocated specifically for the High Arctic. What research NWS does conduct for this region, primarily at the National Centers for Environmental Prediction (NCEP), is funded by other NOAA LOs, such as OAR/CPO or outside agencies. Note that the NWS is an important and funded component of NOAA's Arctic portfolio, but it is hard to grasp the budgetary equivalent of its efforts within our current evaluation. It is likely the NWS funding is included in the OAR reported budget numbers.

OMAO: No budgetary listing for High Arctic activities was provided. However, the OMAO portfolio includes vessels undertaking research, so they should be able to provide a budgetary number for expenditures for research projects undertaken in each LO for Arctic science efforts. Also, OMAO has a maintenance budget paid for by the other Line Offices. Note that OAR and NMFS are the only LOs that pay directly for ship time. However, there is uncertainty in this accounting. For example, NMFS includes ship time in part of its research budget, such as for charters, but it is uncertain whether internal ship time is explicitly listed within the NMFS research budget category. A similar question could be raised with OAR.

NESDIS: Only NCEI/USCRN and STAR use allocated funds to perform High Arctic research from FY12 to FY16. This includes a total of \$3,933,000 in funding for research with an FTE effort of 6.0 for each year (2 federal/4 non-federal). Note that \$4,900,000 was reported in the results related to monitoring in the High Arctic.

In summary, originally the main Line Offices that considered themselves doing High Arctic research were NMFS, OAR, and NESDIS, while NOS considered their funding as monitoring, and NWS and OMAO considered their funding as operational in the Arctic or as direct research support that comes from other Line Offices. We subsequently requested further input from the NOS to capture activities that NOS undertakes via AMBON and Ocean Exploration research, including direct research and observational data that produced a higher budget allotment. This

request significantly increased NOS's High Arctic budget support as it then included hydrographic charting (hydrographic survey data acquisition) as well as marine ecosystem observations.

Through this survey it became clear that NOAA needs to obtain more detailed knowledge about which budgets are being used by either individual LO or cross-LOs to undertake Arctic research, including ship time and other asset operations. Our survey was interpreted differently by some LOs, thus we recommend that NOAA management develop an explicit and transparent format to capture the accounting of LO and cross-LO budget levels for Arctic activities (inclusive of research, observing, and operational support) so that each LO budgetary needs and use can be evaluated in a standard way. There is a need for explicit budgetary details on the flow of funds for Arctic science within each Line Office using a standardized budgetary survey.

Our findings indicate it is hard to get a handle of NOAAs investments in the High Arctic, due to lack of budget sharing between Line Offices as well as differences in interpretation of what "activities" and "research" mean to each LO. NOAA's Arctic portfolio needs both process-oriented research and monitoring activities, along with logistical support, but these budget items need to be traceable within the NOAA budget and portfolio inventory. We found administrative barriers for cross talk between Line Offices, although there was a general interest by the more research-oriented LOs to undertake such a discussion. We realize large budgets are required for field collections, from satellites to ecosystem surveys. With respect to interpretation, NMFS considers its annual groundfish surveys as monitoring, similar to how the NOS considers much of the activity level as observing, not research. However, both are time-series data that are critical for tracking ecosystem health for ecosystem-based management that is a current direction of NOAA. We focused our subcommittee effort on the Large Marine Ecosystem (LME) designations for the Chukchi Sea and Beaufort Sea, thus from Bering Strait northward, but it is obvious that the inflow parameters (physicals chemical and biological) to these LMEs is directly influenced by ecosystem processes in the Bering Sea LME, especially in the northern Bering Sea based on its Arctic-like characteristics.

Through this exercise we identified the need for NOAA to have the necessary budget information, production of routine data products, and continued science activities to discover the status and trends in the Pacific Arctic region to forecast Arctic ecosystem change. Thus, we identified the need for NOAA LOs to report across all three focused areas of interest in our survey: budgets, projects, and products. To this end, NOAA should develop an annual matrix of the overall agency effort in the High Arctic, both by NOAA FTEs and academic-supported partners. There needs to be a mechanism to understand their composite productivity relative to NOAA investments via monitoring, research and data delivery.

Recommendation: NOAA should develop an explicit budgetary survey to capture the flow of funds for Arctic science activities within each Line Office, with a specific definition as to what "activities" for Arctic information is needed. Both within and cross-LO budget levels for Arctic research should be identified, with an explicit definition of activities as being research and observing activities, as well as operational costs associated with these activities. Such a

composite, cross-LO evaluation will form the basis for evaluating LO High Arctic activities within the Congressional funding base across all Line Offices. The budgetary detail would relate to both internally and externally supported activities, as well as associated full-time effort (FTE) support for the NOAA High Arctic research (including ecosystem) portfolio. NOAA needs to better capture the “metrics of success” from its Arctic research activities.

Recommendation: Both NOAA employees and external non-NOAA entities supported through NOAA-funded High Arctic projects (e.g., academics, collaborative institute funded projects, NPRB, AOOS) should be included in a design process in order to develop “metrics of success” from its Arctic research projects for future science planning and budgetary decisions.

4.2. What logistical challenges does your Line Office face in conducting High Arctic research (e.g., personnel, access to ship time, etc.)?

NMFS: The AFSC leveraged resources are generally provided through NOAA contributing federal labor and research platforms (ship and aircraft time). Note that the NMFS states that it has no appropriated funding for High Arctic (Bering Strait northwards) activities, which is similar to the response from the NWS below. Note that based on our definition of research and the location of the High Arctic, the annual groundfish surveys undertaken by NMFS south of Bering Strait were excluded surveys. Also, access to NOAA ship time is limited, especially as ice-capable ships are expensive to charter, NOAA has limited ship time dedicated to Alaska, and none is slated specifically to the High Arctic. Finally, personnel were considered limiting because NMFS is dependent on non-appropriated funds, instead relying on contractors and grantees to do much of its High Arctic research.

OAR: A key limitation to OAR activities in the High Arctic was the ongoing U.S.-Russia sanctions, with the recent suspension of the RUSALCA program highlighting the casualty to scientific collaboration after a successful decade of NOAA-led scientific research. In 2016 the lack of procurement of Russian ship time for the field program and delayed confirmation for clearance to work in Russian waters for research activities resulted in the suspension of this successful program in late June 2016. Additional issues limiting international science activities are related to the transport of equipment across international borders and expensive sites to be accessed to undertake research. International collaboration requires developing and maintaining bilateral government agreements with environmental agencies of the other Arctic countries. Some of these agreements fall under the NWS as signatories to a Memorandum of Understanding (MOU) between NOAA and Roshydromet, and OAR must piggyback on this MOU. Another MOU falls under the Russian Academy of Sciences and OAR has successfully continued its operations for RUSALCA until the suspension of activities in late June 2016. With respect to Russia, OAR also has International Traffic and Arms Regulations (ITAR) restrictions from the U.S. side, which determine which types of technology may be exported to the Russian Federation, as well as restrictions from both the U.S. Coast Guard and the Russian Border Guards.

NOS: NOS identified funding for High Arctic research as a major limitation for its efforts. In addition, logistical constraints on land access and ship time limited its activities in the High

Arctic. The logistical challenges for working in the High Arctic are weather and infrastructure related. Without much infrastructure in the Arctic (e.g., docks, piers, electricity, high ground areas), and the harsh winters, NOS projects are not able to install water level sensors like they do in the lower 48 states. It is very costly to move materials as well to these locations, and they recognize at least six gaps in water level datum coverage north of the Bering Strait.

NESDIS: NESDIS identified the core logistical challenge to its efforts being the significant coordination that is required for field activities to work on USCG and NASA platforms as well as at the Barrow Observatory. In addition, access to necessary data and personnel at Arctic sites, the short building and maintenance season that occur in the Arctic, limited access to sustained A/C power, harsh conditions during winter that prevent unscheduled maintenance, and the need for sources of alternative power systems (e.g., solar, wind and/or methanol generator during winter) as logistical limitations for their Arctic efforts.

NWS: NWS did not feel it had any logistical challenges in conducting High Arctic research. Instead the research that the NWS does conduct is focused on improvements to NWSs numerical weather, ocean, and ice models, which are used by forecasters in Weather Forecast Offices (WFOs) in Juneau, Anchorage, and Fairbanks, Alaska.

Recommendation: *The NOAA domestic fleet for research is deteriorating and inadequate for undertaking High Arctic marine research. NOAA should take leadership in working through IARPC and other channels to obtain ship support for Arctic research activities.*

4.3. What internal and external partnerships exist or are established within the US or with non-US partners?

NMFS: NMFS has significant internal and external research partnerships, including work with other NOAA LOs. The Pacific Marine Environmental Laboratory (PMEL) partners a lot with OAR, and the U.S. Department of the Interior Bureau of Ocean Energy Management (BOEM). In Alaska, NMFS partners with the Alaska Department of Fish and Game (ADFG) - Alaska Sustainable Salmon Fund, the Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative, the North Slope Borough (NSB), the National Fish and Wildlife Foundation (NFWF), and the North Pacific Research Board (NPRB) that recently awarded funding to NMFS scientists to be part of their new Arctic Program. Up until September 2015, NMFS partnered with the Shell Exploration and Production Company via in-kind resources only. An important point to highlight is that two thirds of research funding for NMFS funding for the High Arctic is coming from outside funding, something that is visible in **Fig. 5**. This result highlights the fragility of support for the NOAA NMFS research enterprise.

OAR: The IASAO and RUSALCA programs are built from both internal and external partners in and outside the U.S. For IASAO, for example, U.S. agencies involved include NOAA, DOC, NSF, ONR, DOI and the U.S. Department of State. Numerous universities contribute scientists to the programs. International partners include all Arctic Council Countries, (Finland, Sweden, Norway, Iceland, Denmark-Greenland, Russia, Canada and the USA), and Observer Country Nations such

as Korea, China and Japan, and Germany. Agencies in Russia, which participate in collaborative sustained observations in the Arctic, include the Russian Academy of Sciences, Roshydromet, the Ministry of Natural Resources, the Ministry of Defense, the Ministry of Science and Education and the Ministry of Foreign Affairs. Continuation of US-Russian scientific collaborations should be pursued by NOAA for the High Arctic. Other partners include the Finnish Meteorological Institute, Environment Canada, Canadian Universities, and NSF.

NOS: The NOS has partnerships with BOEM, and previously Shell via the National Ocean Partnership Program (NOPP)-supported AMBON project. The pullout of Shell support from the AMBON project after the 2nd year of a 5-year project leaves behind a \$2 million dollar gap in funding as Shell was a core funder for the AMBON project, and there is uncertainty whether BOEM and NOAA can fill this gap. NOAA and BOEM have a tight relationship across multiple LO's and this finding is a critical issue that NOAA needs to better track and to help facilitate coordination of interagency efforts. NOS also partners with the US Coast Guard and Canada. The Center for Operational Oceanographic Products and Services (CO-OPS) maintains relationships with local Native Corporations and Villages. Additionally, NOS partners with the Alaska Ocean Observing System, the National Weather Service, National Park Service, Alaska Division of Geological and Geophysical Sciences. Partners for the NOS National Geodetic Surveys include the USGS and data acquisition contractors.

NWS: The NWS partners internally with all other NOAA LOs. External domestic partnerships include the Navy, Department of Interior/USGS/BOEM, Department of Energy, U.S. Coast Guard, Department of Homeland Security/FEMA, industry stakeholders that use NWS products, and the academic community, such as the University of Alaska Fairbanks. External international partnerships include the World Meteorological Organization (WMO), a UN entity.

The ESMWG Arctic Subcommittee finds that the definition of “partners” needs to be explicit for adequate reporting by each of the LOs. Some responded to our survey with both national and international partners, while others did not. Any redesigned survey needs to be developed to obtain the same type of data from each LO. The difference in response from the written information above and the budget survey is based on the fact that extensive partnering does occur, while not all of it necessarily includes funding. NOAA has programs where it is the funder and provides money to others, or where it provides in-kind support for projects with other agencies. In terms of NWS and OMAO, “research” may mean enabling or supporting research conducted by other agencies or Line Offices. The two LOs are heavily involved in High Arctic research, but in more of a support capacity. This disparity of survey results makes it difficult to obtain a quantitative estimate of partner impacts on NOAA's High Arctic activities and associated agency funding allocations.

Recommendation: NOAA should systematically estimate the impact of science partnerships (both in kind efforts and monetary support) through cross Line-Office, US interagency and international partnerships supporting its High Arctic Program. Findings from such a survey would explicitly show the strengths and vulnerabilities of internal and external decisions that could influence its High Arctic activities portfolio.

4.3 Beyond FY16, does your Line Office have plans for High Arctic research, and if so, please provide a brief summary of those planned activities, depending on funding.

NMFS: The AFSC plans to continue High Arctic work past FY16, including periodic surveys for cetaceans and pinnipeds, and research to collect baseline information on abundance and distribution of living marine resources and their habitat, particularly those which could be affected by oil and gas development.

OAR: OAR through the Arctic Research Program (ARP) will continue its support of the International Arctic System for Observing the Atmosphere (IASAO) program, the International Buoy Program (IBP), and the Ice Mass Balance Program (IMBP) that facilitate sea ice forecasting. The dramatically changing conditions in the Pacific Arctic are connected to widespread Northern Hemisphere extreme weather events. Continued observations are needed to supply data for assimilation to build more robust models, which can help to develop better forecasting of upcoming weather events. Up to the end of June 2016, ARP was the lead for the RUSALCA program that had plans to facilitate expansion of the DBO program in Russian waters in the northern Chukchi Sea. However, with the suspension of RUSALCA, ARP plans to pivot towards more direct field support of the DBO effort until opportunities arise to also reinstate sampling in Russian waters. Plans for enhancing long-term sustained observations via the new Pacific Arctic Climate-Ecosystem Observatory (PACEO), a joint effort from the Pacific Arctic Group countries to gather synoptic observations in the area where ice loss has been a maximum, are ongoing through international collaborative efforts. Further details can be found at: www.iasoa.org, <http://www.esrl.noaa.gov/psd/forecasts/seaice/>; <http://www.noaa.dbo/>, <http://www.arctic.noaa.gov/rusalca/>, <http://www.arctic.noaa.gov/reportcard/>, and <http://pag.arcticportal.org/>.

NOS: NOS provides foundational services that are needed to chart Arctic waters. Essential for mariners' safety and security, these data also serve many other purposes, such as coastal ocean science, maritime heritage protections, management of living marine resources, habitat characterizations, emergency response, climate adaptation strategies, and coastal zone management. As the lead on the Integrated Ocean Observing System (IOOS), NOS is supporting the implementation of the Arctic Marine Biodiversity Observation Network (AMBON). The annual NOAA contribution (from NOS/IOOS and OER) is approximately \$100K, leveraging an initial \$2M investment from Shell Oil and an annual \$500K investment from BOEM. Shell's subsequent withdrawal from Arctic activities has created a significant funding gap resulting in cancellation of the 2016 AMBON cruise - NOAA and BOEM have negotiated additional support to ensure a 2017 cruise but status of any future activities remains uncertain. NOS supports the Alaska Ocean Observing System (AOOS), which is working to build out an Arctic Coastal Ocean Observing System as a network of critical ocean and coastal observations, data, and information products. There are four focus areas for AOOS: safe marine operations, coastal hazard mitigation, tracking ecosystem and climate trends, and monitoring water quality. As the

lead on Integrated Ocean and Coastal Mapping, NOS is working with partners to augment its capacities to provide a stronger geospatial foundation and the data needed for safe navigation, science, and more-informed coastal decision-making.

NESDIS: STAR is planning the application of improved sea ice forecasting models in collaboration with the Naval Research Laboratory and others, exploration of new spaceborne sensors and enhancement of buoy deployments during the Year of Polar Prediction (YOPP) mid-2017 to mid-2019. OSPO's National Ice Center (NIC) will be working with research partners in the future to assess if applications of their research would benefit NESDIS operations. NIC does not conduct High Arctic research but spent \$900,000 on High Arctic monitoring during FY15 and projects to spend \$1.4 million in FY16. Of the eventual network of 29 US Climate Reference Network (USCRN) stations, 8 of these would be considered High Arctic. There are three remaining that still must be installed. This along with maintenance and sustainment of all eight stations represents the future of USCRN's plans for High Arctic research.

NWS: The NWS is in the process of developing an Arctic Test Bed (ATB), which will help facilitate the R2O (research to operations) process for the Arctic region. The initial charter has been submitted and, once approved, the ATB will become an official NOAA Test Bed. One of the first projects is to set up a sea-ice model verification/evaluation system.

Recommendation: *Continued and expanded science-based coordination efforts with other federal agencies undertaking High Arctic research should be encouraged.* NOAA relies greatly on the US Department of the Interior's Bureau of Ocean Energy Management (BOEM) for funding of NOAA High Arctic research activities. Therefore, some form of evaluation should be considered to make sure that NOAA provides core funding as an agency priority for the nation, along with collaborative support via other US agencies.

5. NOAA Arctic Publications as Metric of Arctic Productivity within the Agency

The Arctic Subcommittee reviewed the new effort to identify NOAA related publications for the research activities undertaken in the Arctic initiated through OAR. The bibliographic results allow for development of a metric for products developed from the Arctic activities supported by NOAA and NOAA-supported projects as obtained from the Web of Science related to the NSAR ecosystem topics (**Fig. 7**). We were also able to identify the level of LO publications related to Arctic topics (**Fig. 8**) with OAR having the highest number of publications with Arctic in the title or abstract (50%), followed by NMFS (25%), NESDIS (15%), NWS (7%), and NOS (3%).

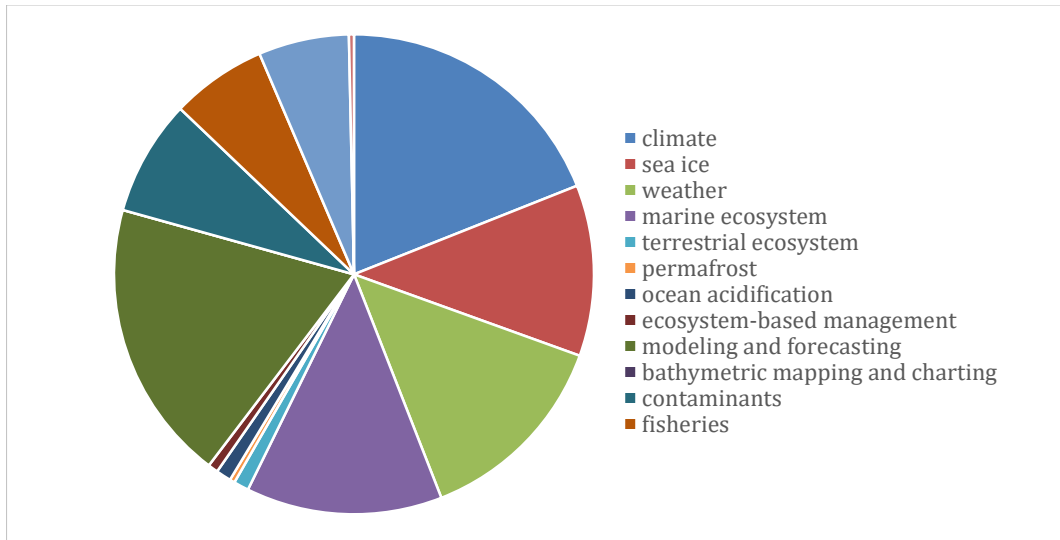


Figure 7. Summary of the NOAA High Arctic publications across all Line Offices of relevant Arctic activities identified in the NSAR over the period 2012-2016.

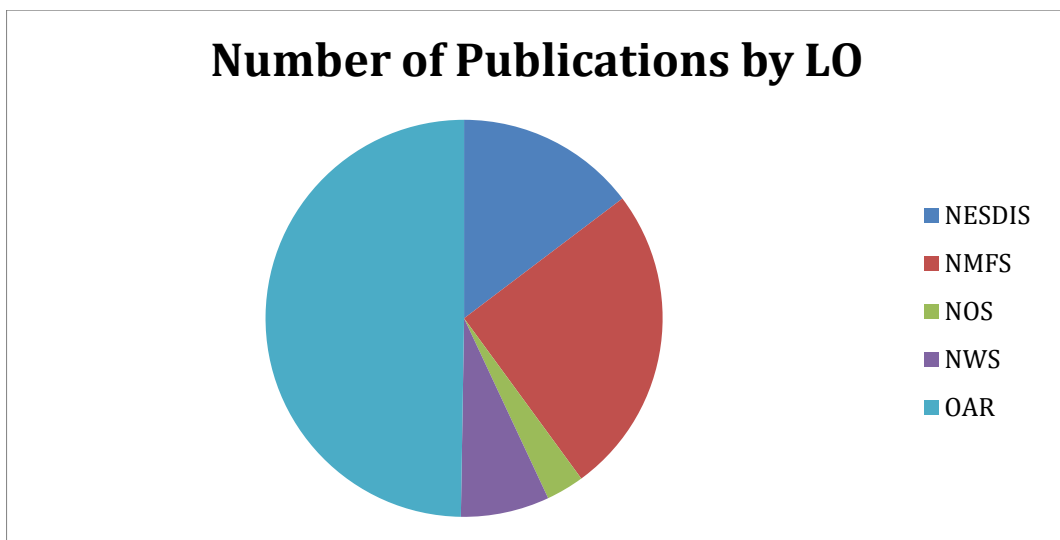


Figure 8. Number of publications that mentioned the High Arctic in the NOAA bibliographic file.

The limitation of the OAR system is that only NOAA full time effort (FTE) activities are reported, with no publications traceable from NOAA-supported academic or non-NOAA collaborator products. The new OAR system is also not able to capture gray literature as the system only evaluates peer-reviewed literature using the Web of Science format. Gary Matlock (OAR) stated that the unofficial estimate was that 40% of external funded projects by NOAA are not captured in metrics of success for NOAA. Use of this service would be valuable to NOAA management to determine products for NOAA support research, although the results would be limited to only NOAA employees and not including reports. NOAA will be adding in the funded programs after the beginning of 2016 for all NOAA Technical Reports. In addition, starting in January 2016 all projects will include a Digital ID attached to all publications and reports within all databases.

Although this new format for tracking NOAA activity products is a very good effort, the need for leveraging limited funding requires the agency capture the output from funded and collaborative projects that NOAA supports in its Arctic portfolio. The messages here are inconsistent – 1/3 of NOAA’s budget is reliant on outside funding, but then NOAA only reports publications by NOAA PIs. NOAA should also be tracking datasets, at least those that are assigned DOI numbers. Notably, NOAA datasets are being transferred into a format available for the public. This is an ongoing project as part of the Administrations Public Access to Research Results (PARR), and was projected to be completed sometime in Spring 2016.

Recommendation: NOAA should continue to expand its capabilities provided through its newly developed bibliographic effort to capture all research products (peer-reviewed and gray literature as well as data sets) from all its funded Arctic projects across Line Offices (both internally by NOAA employees and through its externally funded projects) through a standard reporting of output results.

6. Developing NOAA High Arctic Efforts in the Future

Arctic fisheries and ecosystem studies in the Central Arctic Ocean (CAO) is an emerging issue and NOAA is a key lead agency working towards a binding “5+5” agreement for developing an integrated ecosystem assessment (IEA) for the High Arctic specifically related to fisheries and ecosystem structure. The 5 Arctic countries (Canada, Norway, Russia, United States, Denmark) and 5 others (China, Japan, Korea, Iceland, and the European Union) are developing a research plan for science in the CAO using ecosystem-based management. Ship time for scientific studies for this poorly known region will be a key driver for developing best management practices with the opening of the Arctic to increased transportation and resource extraction. There is a need for a flagship project for NOAA to take leadership for High Arctic and CAO activities in relation to addressing NSAR goals of the United States. A joint science project, using NOAA and NSF ship time, would be a strong example of agency collaboration. Good examples of these joint science projects in the past include the Bering Sea Ecosystem program where NSF and NOAA collaboration on ships that are managed by both agencies facilitated excellent science to understand the Bering Sea Ecosystem (Van Pelt, 2015). Four Deep-Sea Research journal special issues highlighted the results of this effort, with multiple public outreach activities (see <http://nprb.beringseaproject/> for further details). The newly initiated Arctic program of the North Pacific Research Board is supporting both NOAA and academic scientists in a program utilizing the new NSF research vessel *Sikuliaq* as well and NOAA science vessels to better understand the northern Bering and Chukchi Sea seasonally as sea ice retreats (see NPRB Arctic Program website for further details: <http://www.nprb.org/arctic-program>).

Recommendation: NOAA should develop and coordinate, across multiple line offices, a comprehensive, five-year High Arctic Research Program, including both field and modeling efforts. Recent studies indicate that the US needs to enhance its understanding of the High Arctic ecosystem, especially in relation to northward movement of natural resources, including in the Arctic Basin. As such, NOAA needs to enhance its platforms to fulfill its leadership role for

understanding the changing Arctic system. There is an opportunity with new international research programs to augment research currently funded by NOAA if there is some flexibility for coordination. Developing issues (e.g., fisheries and ecosystem management in the Central Arctic Ocean, biodiversity topics, climate change impacts regionally and globally) are important topics. In addition, cross-platform asset use in the Arctic should be encouraged.

7. Conclusion

The Arctic region is undergoing rapid sea ice retreat and warming as well as other changes that are known to have global implications and that impact the United States directly. Within NOAA there are Line Offices that either have direct scientific and management programs in the High Arctic or are funded by other US agencies to undertake science activities that feed into NOAA's management jurisdiction. Through the course of our study it was hard to get a handle on NOAA investments in the High Arctic, with a lack of systematic budget sharing and differences in interpretation of what are the relevant activities with each LO's Arctic portfolio. Both process and monitoring data collections are core collections of NOAA and all the LOs should identify these activities for cross-LO evaluation by upper management. There also appear to be administrative barriers for cross-talk between LOs. The ESMWG Arctic Subcommittee was concerned about the extent of big budget hits for data collections compared to applied monitoring-type activities. For example, NMFS considers surveys part of its research activities, whereas the NWS does not consider its monitoring efforts to be categorized as research activities in the Arctic. Part of the issue is to separate regional budget allocations for large programs such as seafloor mapping and assigning weather products as part of High Arctic activities. There is a need for standard budgetary approach to evaluation, an accounting system for production of routine data products, and continued activities that support science for discovery as well as to applied products for management decisions. The ESMWG Arctic Subcommittee was unable to obtain a consistent response of the full-time effort (FTE) for all High Arctic activities for each LO. NOAA needs a mechanism to understand its overall productivity relative to its investments associated with monitoring, research, and data collection.

Our overarching finding is that NOAA's Arctic efforts need coordinated improvement, including fleet replenishments, as NOAA needs to enhance its platforms to fill its leadership role. We recommend a 5-year program of focused interagency field and modeling effort as the Arctic is a national priority, with NOAA taking a key leadership role. The US needs to enhance our understanding of the ecosystem that is poised to open up an internationally accessible ocean that is basically unknown, yet pivotal to world climate and containing extensive areas for trans-Arctic shipping, exploration and biodiversity changes. Bathymetric charting is essential for developing the Arctic as an open ocean, yet has only been undertaken to a limited extent. NOAA needs to play a more explicit and active leadership role in Arctic activities, both for scientific understanding and operational aspects.

The report identified 15 recommendations: 5 prioritized, near-term activities, with three intermediate and seven longer, ongoing directions for future NOAA activities, summarized in Table 3 and in the Executive Summary of this report.

Table 3. Report recommendations related to High Arctic science and management.

A. Near-Term High Priority	Prioritization
High Arctic, cross-Line Office 5-yr field program	1
Observing systems and modeling	2
International leadership and coordination	3
Science partnerships within NOAA Line Offices, nationally and internationally	4
Clearer Arctic vision statement and outreach activities	5
B. Intermediate	No Prioritization
Use of local and indigenous knowledge	
Explicit budgetary survey within and between NOAA Line Offices	
Strengthen US interagency science coordination via IARPC	
Longer-Term	No Prioritization
Open and transparent data archiving protocols	
Expand science-based coordination efforts with US federal partners	
Regularly evaluate mechanisms for academic partnerships	
Improve linkages between Line Office researchers and management	
Expand bibliographic effort to capture research products	
Fleet improvement for high Arctic science activities	
Improve connectivity between NOAA and external non-NOAA scientists in planning activities	

8. Acknowledgements

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10. Appendix

10.1. NOAA ESMWG Arctic Subcommittee Terms of Reference FINAL-August 21, 2014

Arctic Subcommittee

Chair of Subcommittee: Jacqueline Grebmeier; Members: Michael Castellini, David Fluharty, Jake Rice, and James Yoder; NOAA advisor: Richard Merrick/NOAA; NOAA Staff: Candace Nachman, NOAA Arctic Liaison; Laura Ferguson (current Knauss Fellow), Robert Ellis (past Knauss Fellow), and Mary Anne Whitcomb (NOAA Contractor)

Background and Purpose

The Arctic is experiencing rapid sea ice retreat, seawater warming, regions of ocean acidification, and increased freshwater inputs that drive ecosystem changes. It is also a region of expanding commercial and resource exploitation interest as well as continuing importance to local coastal community use. NOAA and other US agencies have responsibilities for ecosystem management in the northern Bering, Chukchi and Beaufort seas in the Pacific Arctic region. The international interest in the Pacific Arctic has expanded to encompass Asian country involvement by Korea, China, Japan, and India, in addition to focused US, Russian and Canadian activities. NOAA is also active in national and international atmospheric and oceanographic studies related to climate and observing activities.

Rapidly expanding opportunities for development and commerce are occurring in the Arctic. Arctic sea ice retreat was the highest on record in 2012, development of petroleum resources and shipping are on the rise, and issues of protected species within the region of US oversight are critical topics for the Arctic within NOAA which has already established a ban on development of commercial fisheries in the area. Changing environmental conditions are allowing increased access to the US Arctic. In response, there has been an exponential increase in US Arctic initiatives since 2010, including development of the 2010 National Ocean Policy, 2011 NOAA Arctic Vision and Strategy report, the 2011 Interagency Working Group on Coordination of Domestic Energy Development, the 2013 National Strategy for the Arctic Region, the 2013 Interagency Arctic Research and Policy Committee (IARPC) 5 year plan, the 2013 Integrated Arctic Management (IAM) Action Report to the President (2013), the 2014 National Arctic Implementation Plan and the 2014 NOAA Arctic Action Plan. NOAA has mandates under the Marine Mammal Protection Act, the Endangered Species Act, and the Magnuson-Stevens Fishery and Conservation Management Act, although commercial fishing is currently closed north of Bering Strait at this time and for all realistic purposes, areas for commercial fishing are closed in the Bering Sea north of the Pribilof Islands as well. Work continues to map the seabed in the Arctic for navigation and to prepare US claims for seabed delineation.

NOAA's Arctic responsibilities are challenged because of rapid environmental change in the region of US interests, the ensuing human activities that are increasing in the region, and

limited budgetary resources within NOAA to support focused work in the Arctic. It is in this context that the NOAA Science Advisory Board (SAB) has requested input from the Ecosystem Sciences Management Working Group (ESMWG) on Arctic-relevant issues from an ecosystem science perspective. The ESMWG Subcommittee is tasked to evaluate the themes within the new NOAA Arctic Action Plan in relation to current NOAA Line Office activities and the relevancy of the NOAA Arctic Action Plan to the 2014 National Arctic Implementation Plan. The Arctic ESMWG subcommittee anticipates both recommendations on synergistic activities to increase efficiency between Line Offices related to Arctic activities as well as new activities in order reach the goals of NOAA and the Nation in the Arctic.

The Arctic ESMWG effort will provide a strategic focus and a plan to: (1) evaluate and develop constructive synergistic efforts in the Arctic between the pertinent NOAA Line Offices; (2) suggest programs that could enhance strategic benefits and increased efficiencies for NOAA activities in the Arctic; (3) identify and fill gaps in NOAA's ecosystem research portfolio related to the Arctic, and (4) encourage partnerships that will build capacity between US agencies for activities in the Arctic. By doing this, the Arctic foci will align and integrate NOAA's science assets, partnerships, and capabilities for research that support NOAA's Arctic region mission requirements for the sustainable use, protection, and restoration of coastal and marine ecosystems, as well as the ecosystem services they provide. NOAA is also working to increase partnerships and capabilities for research with other nations and entities working in the Arctic, especially in support of the US National Arctic Strategy as the US takes on the US Chairmanship of the Arctic Council from 2015-2107.

NOAA's Arctic responsibilities are challenging because of rapid environmental change, the ensuing human activity this allows, and limited resources to work in the Arctic. Understanding the changing Arctic seascape challenges NOAA to make the best use of its limited funds. Within the NOAA 2013 Arctic funding, there is a summary by NOAA agency goals coincident with US National Strategy needs that indicates that the NOAA Stewardship and Management makes up 61% of the agency budget (NOAA Arctic Action Plan April 2014-Figure 2). Following that are Communities and Economies (14%), Weather and Sea Ice Forecasts (14%), Foundational Science (4%), Sea Ice Research (3%), and Partnerships (2.8%).

Within the 6 NOAA Line Offices undertaking Arctic research, the following expenditures in 2013 were identified in the NOAA Arctic Action Plan (2014):

- NOAA National Environmental Satellite, Data and Information Service – NESDIS (2.4%)
- NOAA National Marine Fisheries Service – NMFS (59.2%)
- NOAA National Ocean Service – NOS (9.1%)
- NOAA National Weather Service - NWS (14.0%)
- NOAA Ocean and Atmospheric Research – OAR (7.4%)
- NOAA Office of Marine and Aviation Services – OMA (7.8%)

It should be noted that NMFS primarily undertakes research in the Bering Sea that is considered part of the Arctic region for US national funding (as well as conforming to the Arctic Council's

definition), with most Arctic science support undertaken by NOAA north of Bering Strait provided via the US Bureau of Ocean Energy Management (BOEM) as an interagency agreement.

Objectives

Based on the SAB request, an Arctic subcommittee has been designated to develop a work plan through the lens of Arctic decisions to be made, and information required, for NOAA activities and management. After discussions at the spring 2014 ESMWG meeting, it was decided that the Arctic subcommittee will focus its evaluation of NOAA activities in the High Arctic north of Bering Strait, thus excluding the Eastern Bering Sea fisheries that are currently just over half of the NOAA Arctic budget (NOAA Arctic Action Plan, 2014). Thus, the Large Marine Ecosystems (LMEs) for evaluation in this effort will include the Chukchi Sea LME (currently receiving 11.1% of the NOAA 2013 Arctic funding) and the Beaufort Sea LME (currently receiving 8.2% of the NOAA 2013 Arctic budget). The committee will, where appropriate, evaluate NOAA's responsibilities on factors that influence inputs through Bering Strait and downstream impacts on both the Arctic Basin and eastern Beaufort Sea as is relevant to the charge to understand NOAA's role in monitoring and developing impact plans in an Arctic system level perspective.

The ESMWG Arctic Subcommittee has two high level activities being requested from NOAA Science Advisory Board that form the basis of our committee activities:

1. Evaluate the quality and direction of the NOAA Arctic Ecosystem research portfolio and identify any gaps in activities that need to be filled, and
2. Evaluate NOAA's overall organization for undertaking Arctic Ecosystem research.

The initial activities of the Arctic subcommittee will be to evaluate and identify key activities and gaps within the NOAA portfolio, specifically within the following documents:

1. NOAA Arctic Action Plan April 2014
2. NOAA Arctic Vision and Strategy Plan 2011
3. U.S. National Strategy for the Arctic Region Implementation Plan January 2014
4. U.S. National Strategy for the Arctic Region Science Plan May 2013
5. Arctic Marine Biodiversity Monitoring Plan: USA 2013 Implementation

The ESMWG Arctic Subcommittee is developing a list of invitees from the different NOAA Line Offices working in the Arctic to request presentations at the October 2014 meeting in Anchorage, Alaska and also at the spring 2015 meeting in Washington, DC. A series of questions will be posed to each speaker to address during their presentations. These key questions will be put forward to each of NOAA Line Office representations related to their activities relevant to the themes within the NOAA Arctic Action Plan 2014 and US Arctic policy that influence decision-making by NOAA to support the US National Strategy for the Arctic Region Implementation Plan.

We are focusing on the following questions:

- 1) What are the specific short-term and long-term activities being undertaken in each NOAA line office that are beneficial for NOAA's capabilities to respond to national needs as recommended in the US National Arctic Strategy and Implementation plans?
- 2) What are the gaps in current/planned Arctic activities that limit NOAA's capabilities to respond within its national and international programs to support the US Arctic National Strategy and what would be a minimum portfolio of NOAA activities that could realistically fill those gaps?
- 3) How do activities of NOAA, both nationally (including through the US Interagency Arctic Research and Policy Committee (IARPC)) and internationally (including participating in the Arctic Council as the US takes over the Chair from 2015-2017), influence decision-making within NOAA in relation to the US National Arctic Strategy Implementation Plan?
- 4) What improvements can be recommended to build capacity for coordination within and across Line Offices of NOAA for its management and decision-making activities in the Arctic?

Updated Timeline for Arctic ESMWG Subcommittee Study (2016)

Summer 2014 - ESMWG agreed to undertake Arctic Review and develops a Terms of Reference (TOR)

Fall 2014 - Approved TOR and list of Arctic-relevant speakers. Speaker information, guidance and invitation letters for October meeting sent to speakers. ESMWG Arctic Subcommittee evaluated key NOAA and US Arctic planning documents at Fall ESMWG and subsequent Arctic Subcommittee meeting. We developed the plan for Subcommittee activities.

Winter 2015-Continued collating and reviewing pertinent Arctic documents related to Subcommittee activities.

Spring 2015 – ESMWG meeting Washington, DC to address NOAA efforts to support US Arctic Council Chairmanship, IARPC activities, and overall NOAA Arctic coordination and activities.

Fall 2015 - Drafting report for ESMWG and first brief-out

Spring 2016 - Draft Final report for ESMWG meeting WHOI

Summer 2016 - Final draft evaluated by Arctic subcommittee and ESMWG; final report to NOAA SAB

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