Alaska
Fisheries Science
Center

National Marine
Fisheries Service

U.S DEPARTMENT OF COMMERCE

AFSC PROCESSED REPORT 2006-01

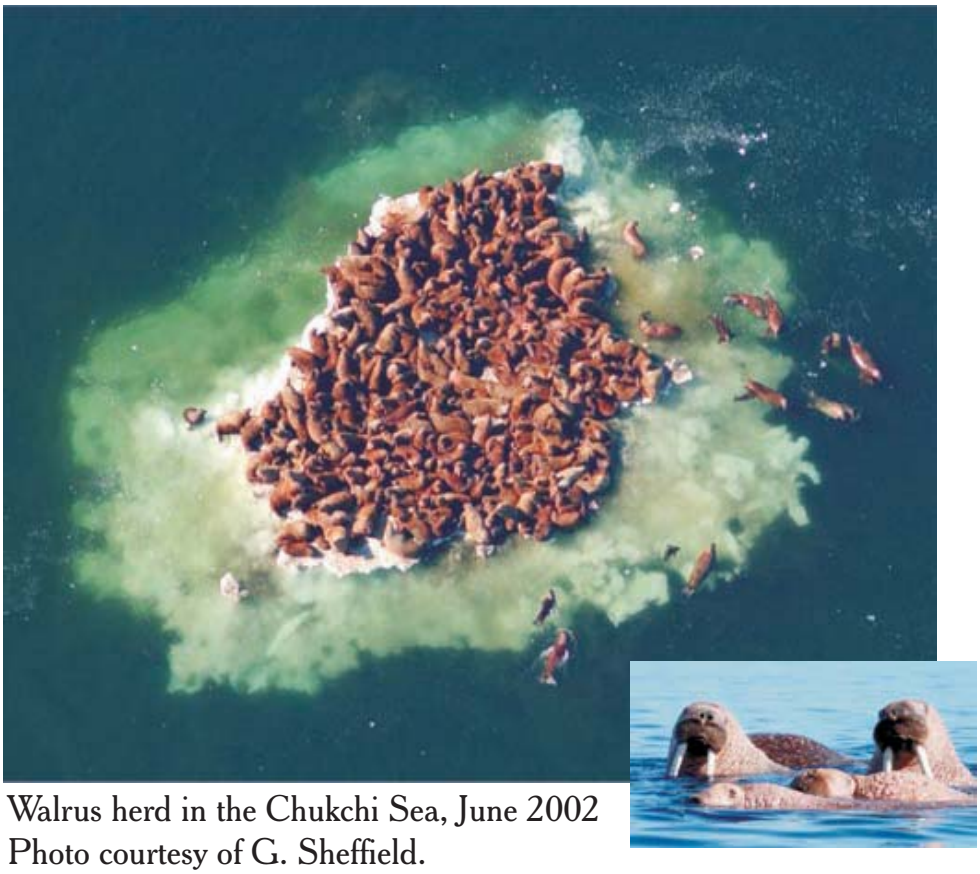
Climate Change and the Bering Sea Ecosystem

An Integrated, Interagency/Multi-Institutional Approach

February 2006

Climate Change and the Bering Sea Ecosystem:
An Integrated, Interagency / Multi-Institutional Approach

Workshop held 8 April 2005
Seattle, WA



Walrus herd in the Chukchi Sea, June 2002
Photo courtesy of G. Sheffield.

February 2006

Suggested citation: Bering Sea Interagency Working Group. 2006. Climate Change and the Bering Sea Ecosystem: An Integrated, Interagency / Multi-Institutional Approach, Workshop held 8 April 2005, Seattle, WA. AFSC Processed Rep. 2006-01, 30 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, 7600 Sand Point Way NE, Seattle WA 98115

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Executive Summary

On 8 April 2005, scientists from federal and state agencies, nongovernmental organizations, academic institutions, and research sponsors met in Seattle, Washington at NOAA's Alaska Fisheries Science Center to share concerns regarding observed changes in the Bering Sea ecosystem. Changes have been observed in the distribution and persistence of sea ice, in species distribution patterns, and in the recruitment or survival of yearlings of some upper trophic level species. The group reviewed recent changes and events, and posed core research questions that need to be answered to improve our understanding of the changes and their potential consequences on the Bering Sea ecosystem and the people that depend on its resources. Representatives from each agency or institution stated their areas of interest and responsibility. Finally and most importantly, the group proposed a strategy to begin a coordinated, integrated research approach for investigating the Bering Sea ecosystem and its living marine resources. This strategy begins with the establishment of a working group that will meet at least annually to coordinate the multi-institutional research effort.

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INTRODUCTION

The eastern Bering Sea ecosystem is a valuable and valued national resource. It supplies jobs, food, and exports for our national economy, cultural and economic subsistence to Alaska Natives and habitat for living marine resources. Approximately 40% of all U.S. fish and shellfish landings occur in the Bering Sea (NRC 1996). The Bering Sea is also directly or indirectly the source of over 25 million pounds of subsistence foods used by nearly 55,000 Alaska residents (BEST 2004, 2005). Thirty-eight species of seabirds (40 - 50 million birds) and 25 species of marine mammals are supported by the region's productivity (PICES 2004).

Change is an inherent aspect of marine ecosystems; however recent changes in the eastern Bering Sea have concerned scientists. The eastern Bering Sea, a marginal ice zone in recent times, appears to be warming and the ice and associated cold bottom waters are retreating to the north (Overland and Stabeno 2004). Since 2001, there has been less sea ice and warmer temperatures than in the late 1970s. Relative to 1995, depth-averaged summer water column temperature has increased 2° - 3°C in the last couple of years. The spring (and fall) transitions now occur much earlier (later) than previously, resulting in a much longer summer calm period, with potentially reduced input of nutrients into the surface waters.

Change has also been observed at the lower trophic levels (i.e., where food is produced for the entire food web). Productivity at the base of the food web is not directly measured routinely, but indirect measurements suggest that primary production may be changing. In addition, even if production levels are not changing, phytoplankton communities have changed. For instance, in the late 1990s coccolithophore blooms

began to appear in the mid- to late summer (Iida et al. 2002). More recently a harmful algal species (or several species) has been observed, again in summer. The composition of zooplankton, tiny invertebrates that are the link between primary production and fish and birds, has also changed. One cold-water species, *Calanus marshallae,* has been conspicuously absent from the southeastern middle shelf domain in recent summers, and the total biomass of zooplankton appears to have decreased in the last 4 years (Napp et al. submitted).

The composition of Bering Sea forage fishes (e.g., juvenile walleye pollock and Pacific cod, capelin, and Pacific herring), an intermediate link in the food web, have also undergone recent changes. The salient ecosystem change occurring in the North Pacific Ocean and Bering Sea in the last three decades is the 1976-77 regime shift. A widely cited example of its biotic effects has been the shift in forage fish from energy-rich species such as capelin to leaner fish such as pollock and cod based on small mesh trawl surveys since 1953 in the Gulf of Alaska (Anderson and Piatt 1999). Time series for Bering Sea forage species are shorter. Standard bottom trawl surveys have been conducted on the Bering Sea shelf since 1982. Sandfish were abundant in the early 1990s and again in the early 2000s; Pacific sand lance and stichaeids (a small benthic fish) have been uncommon since 1999; eulachon have been common all years; and capelin have been uncommon all years except 1993 (Walters 2004). A Bering-Aleutian Salmon International Survey (BASIS) has annually sampled the epipelagic zone since 2000. Dominant epipelagic species during daylight are young-of-the-year walleye pollock, juvenile and adult Pacific herring, and juvenile salmonids; the notable temporal change has been a substantial increase in relative abundance of pollock and salmonids since 2002

(E. Farley, AFSC, NOAA pers. comm.). Changes in abundance, distribution, and energy content of forage fish potentially affect the ability of apex predators (e.g., Steller sea lions, northern fur seals, and seabirds) to grow, survive, and reproduce.

Changes in the finfish and shellfish communities have occurred since the 1980s, but these have included both increases and decreases in overall abundance and changes in species composition. Walleye pollock and Pacific cod abundances have fluctuated but remained at high levels. Flatfish, as an assemblage, are at high levels, but individual species have changed their relative importance (e.g., Greenland turbot has decreased in importance and arrowtooth flounder has increased). Recruitment of sockeye salmon stocks has been strong with the exception of the Kvichak run; some runs of chinook and chum salmon have shown reduced recruitment in the Yukon and Kuskokwim Rivers (Kruse, 1998). Crabs, in particular, are at low levels relative to their peak in biomass in the late 1980s / early 1990s, and all Bering Sea stocks are considered overfished. Snow crab, the dominant species, has been decreasing, and there is evidence that populations may be retreating to the north with the cold bottom water (Orensanz et al. 2004).

Growth and recruitment of marine mammals and seabirds, as apex predators, integrate many of the changes in marine food webs. When ample food is available, survival of the youngest stages is generally highest; while when food availability is low, natural mortality and disease claim more chicks and pups. At present there are alarming trends in some populations. For example, northern fur seals and Steller sea lions are near their historical lower limits. Sea otters in the Aleutian Islands have declined by approximately 70% between 1992 and 2000, and recent surveys indicate that the decline is continuing. Pacific walrus use of terrestrial haulouts is changing, with some haulouts

in Bristol Bay having been virtually abandoned in recent years. Reports from subsistence hunters suggest shorter and more difficult spring hunting seasons than in the past due to changing ice conditions. Similarly there is much concern about ice-dependent seals (i.e., ring, spotted, bearded, and ribbon) that require ice for different parts of their life history (molting and pupping). There is also concern that the retreating ice is transporting some benthic-feeding, ice-dependent seals and walrus away from suitable feeding grounds (e.g., shallow, productive benthic habitats).

Seabird populations are also showing signs of change, some of which are likely a response to the effects of climate change. For example, populations of the two most abundant piscivorous seabirds on St. George Island (thick-billed murres and red-legged kittiwakes) declined after the late 1970s regime shift and then increased after the late 1980s regime shift.

Core Questions

In response to concern over the observed changes, representatives from interested agencies and institutions met to form the Bering Sea Interagency Working Group. After documenting changes observed by their scientists, the group constructed a set of core and ancillary questions for which answers were needed (see below). In addition, the group identified critical gaps in our knowledge of the Bering sea ecosystem. The questions will guide future research to understand the changes. The answers to the questions will allow the group to advise stakeholders on the scope and potential magnitude of the changes.

1. How does the Bering Sea ecosystem respond to climate variability and how will it respond to climate change?
2. Is the warming of the Bering Sea that we are presently observing part of decadal variability or is it a long-term secular trend?
3. Can we predict the affects that the warming and changing sea-ice dynamics will have on the biological resources of the Bering Sea (commercial, subsistence, ecological, and protected)?
4. What measurable factors (physical, chemical, and biological) serve as the best indicators of ecosystem change at different trophic levels and different spatial / temporal scales?

Ancillary Questions

Atmosphere-Ice-Ocean System

- How has the current climate warming affected the distribution, abundance, phenology, and structural characteristics of sea ice and the sea ice edges?
- Is the present warming in the Bering Sea related to a reduction of sea ice in the Arctic Ocean?
- Can we construct a nutrient budget for the eastern Bering Sea shelf (from Bering Strait to Unimak Pass)?
- Will changes in the transport through the Aleutian Island passes impact the heat content and nutrient supply of the eastern Bering Sea?

Lower Pelagic Trophic Levels

- Do early ice-associated phytoplankton blooms favor benthic communities, while late blooms in May / June favor pelagic communities?
- Do climate-mediated temperature changes have a significant impact on coupling between phytoplankton and zooplankton grazers?
- How will climate warming affect the production and species composition of plankton communities on the eastern Bering Sea shelf?

Lower Benthic Trophic Levels

- How will changes to the distribution, abundance, phenology, and structural characteristics of sea ice and the sea ice edges affect the productivity and species composition of benthic communities?

Forage Fishes

- How will climate warming affect the production and species composition of the forage fish assemblage for the eastern Bering Sea?
- How will changes in the forage fish assemblage propagate up the food web to apex predators?

Birds, Fish, and Mammals

- How will changes to the distribution, abundance, phenology, and structural characteristics of sea ice and the sea ice edges affect habitat availability for ice-dependent birds, and mammals?
- How will climate-mediated changes in the timing, abundance and type of water column production affect the productivity of the benthic and pelagic food webs?
- How will changes in ice distribution (including the cold pool) affect the distribution of fish populations?
- Will changing climate alter the ecosystem's carrying capacity and change current predator-prey relationships?

Indicators

- What is the relative impact of natural and anthropogenic perturbations on these ecosystem indicators and indices?

Information Gaps

- Coordinated ocean ecosystem observations that adequately sample physics and lower trophic levels.
- A good ocean circulation model for the eastern Bering Sea.
- Broad-scale observations of essential benthic habitat, including measures of productivity and community structure.

- New data on the at-sea distributions and abundance of seabirds, and better access to historical data;
- Adequate time series of seabird diets for both planktivores and piscivores.
- Habitat requirements for key species (commercial and / or ecological).
- Accurate, sensitive, and easy to measure indicators of ecosystem change.
- Predictive knowledge of ways that changing temperatures affect the productivity and composition of communities at different trophic levels.
- Basic information on ice-dependent marine mammal abundance, distribution, and population trends.
- A comprehensive sea ice database for Alaska's coastal seas that is derived from regional sea ice charts recorded during the past five decades.
- Linkages between sea ice features and types, and the changing nature of marine mammal habitats of choice

Agency / Institution Areas of Interest and Responsibility

Each participating organization of the working group has a set of responsibilities and particular areas of interest. All currently support and/or perform research in the Bering Sea. This approach of the working group is to leverage the strengths of these organizations to achieve the maximum gain in understanding, insight, and prediction for the Bering Sea ecosystem. All of the organizations have a common interest in measuring and understanding how the Bering Sea marine ecosystem may change in response to natural perturbations such as climate change, and as a result of human activities such as

commercial fishing. The following is a short description of each organization and their research goals in the Bering Sea.

Alaska Ocean Observing System (AOOS)

Alaska Ocean Observing System (AOOS) is a regional association developed to respond to the call by interagency Oceans.US for regional implementation of the Integrated Ocean Observing System (IOOS). AOOS's mission is to improve our ability to rapidly detect changes in marine ecosystems and living resources, and predict future changes and their consequences for the public good. When fully developed, AOOS will serve as the Alaska regional node for a national network of observing systems. It will systematically deliver both real-time information and long-term trends about Alaska's ocean conditions and marine life. It will also provide public Internet access to cost-free data and information on coastal conditions (e.g., ocean temperature). Last, it will supply tailored products to meet the needs of mariners, scientists, industry, resource managers, educators, and other users of marine resources. AOOS anticipates a Bering Sea monitoring program in the region of at least $1 million annually, if funding is approved by Congress.

Bering Ecosystem Study (BEST; NSF)

The National Science Foundation has been supporting the planning and development of the Bering Ecosystem Study (BEST) program, which is intended to develop an understanding of, and ability to predict the effects of climate change on the marine ecosystems of the eastern Bering Sea and the people dependent on its marine

resources. This program is envisaged as initially a 3-5 year effort with the potential of being extended for up to 10 years if the science questions warrant. The initial phase of BEST is expected to focus on the effects of the diminishing sea ice cover on the type, amount and timing of primary production and its fate as it moves through either the pelagic or the benthic food webs to upper trophic level organisms, including fish, seabirds, marine mammals and people. BEST will be an end-to-end program with interests in climate forcing of the physical environment of the Bering Sea, and interests in the consequences of climate change to people and their ability to respond to change. The final size and direction of the program will be determined by the quality and focus of proposals submitted. There was an Announcement of Opportunity to submit proposals in late Fall, 2005 with the intention of commencing field work in Spring 2007. BEST is anticipated to be a component of the NSF contribution to the International Polar Year (IPY) program. BEST is also a part of SEARCH (Study of Environmental ARctic CHange) and of the new International GLOBEC (Global Ocean Ecosystems Dynamics) Regional Program, Ecosystem Studies of Sub-Arctic Seas (ESSAS). It is hoped that BEST will be supported with between $2 and $4 million annually, and in addition, will have 2-3 months of icebreaker time and 3-4 months of use of an ice-strengthened ship each year.

NOAA Alaska Fisheries Science Center (AFSC)

The Alaska Fisheries Science Center (NOAA-National Marine Fisheries Service, U.S. Department of Commerce) operates under a number of legislative mandates including the Magnuson-Stevens Fishery Conservation and Management Act, the

National Environmental Policy Act, and the Marine Mammal Protection Act. It is responsible for the federally managed fish species (mostly groundfish) and marine mammals (all except walrus, sea otter, and polar bear) in Alaska. Science conducted by the Center's research staff is focussed on applied aspects of the Bering Sea, Gulf of Alaska, and Arctic Large Marine Ecosystems. Scientists at the Center have been active in Bering Sea ecosystem research and annual stock assessment with individual projects ranging from physical-biological interactions at lower trophic levels, to population dynamics of fish and mammal populations to climate-ecosystem research.

The Center currently has a Climate and Ecosystems funded project. The North Pacific Climate Regimes and Ecosystem Productivity project investigates climate-ecosystem interactions in the Bering Sea (FY05, $1.2M; FY06, $1.2M, FY07, $2.0M; FY08, $4.0M, level funded thereafter). In addition, the AFSC proposed to NOAA an additional program, Loss Of Sea Ice (LOSI) that would start in FY08 ($2.0M). The latter (proposed) program would provide the funding needed to extend fish assessment surveys farther north, begin annual assessments for ice-dependent seals, and model the population dynamics of new species that may be managed if fishing is extended farther north. The Center has available ship time on two different NOAA research vessels, the *Miller Freeman* and *Oscar Dyson*.

NOAA Pacific Marine Environmental Laboratory (PMEL)

The Pacific Marine Environmental Laboratory is part of the Oceans and Atmospheric Research component of NOAA. The laboratory is engaged in a variety of climate, ocean chemistry, physics, and geology projects. The Ocean Ecology Research

Division has partnered with NOAA's AFSC for over 20 years to conduct applied research on fisheries oceanography. This research has focussed on the Gulf of Alaska, Aleutian Islands, and Bering Sea ecosystems leveraging base funding with grants from NOAA's Coastal Ocean Program, North Pacific Research Board, and the Gulf Ecosystem Monitoring program. PMEL is a world leader in mooring technology, and is one of the few institutions actively maintaining biophysical moorings in the Bering Sea. PMEL partners with AFSC on use of the *Miller Freeman* and *Oscar Dyson* and annually charters University-National Oceanographic Laboratory System (UNOLS) vessels for some of its research.

North Pacific Research Board (NPRB)

North Pacific Research Board's mission is to (1) understand the dynamics of the North Pacific marine ecosystem and the use of its resources, (2) manage and protect healthy, sustainable fish and wildlife populations, and (3) forecast and respond to changes in the ecosystem through the integration of various research activities, including long-term monitoring. It began funding projects in the Bering Sea in 2002 using an adaptive Integrated Ecosystem Research Plan to guide funding decisions. It has funded projects on a variety of subjects including lower level productivity, habitat, fin-fish and shell-fish stock assessments, marine mammals, seabirds, climate change and ecosystem modeling. Most projects are still in progress and can be viewed at http://nprb.org/research/index.htm. The amount of funds granted by NPRB varies annually, but the Board expects to be able to award approx. $2 - 4M each year for the next 10 years for ecosystem research in the Bering Sea, including funds for ship time.

University of Alaska, Fairbanks (UAF)

The University of Alaska, the major state-funded institution of higher learning in the State of Alaska, has 10-15 faculty and research staff in the School of Fisheries and Ocean Science interested in Bering Sea process studies. Current and past research in this region includes: physical oceanographic measurements, nutrient cycling, primary productivity, zooplankton ecology, benthic communities and population dynamics, and ecology of larval and juvenile fishes. The University operates the R/V *Alpha Helix.* Plans for an ice-strengthened ship to replace the R/V *Alpha Helix* have been developed and are awaiting Congressional approval for construction.

U.S. Fish and Wildlife Service (FWS)

The U.S. Fish and Wildlife Service (U.S. Department of the Interior) has a number of legislated authorities. It is the trust agency for all migratory birds, has management responsibility for sea otters, Pacific walrus and polar bears, and it manages refuges in and adjacent to the Bering Sea (Alaska Maritime National Wildlife Refuge [NWR] which includes the Aleutian Islands; St. Matthew Island, and portions of the Pribilof Islands archipelago; Togiak NWR; Yukon Delta NWR; and Izembek NWR). Most of the Nation's seabirds breed in the Bering Sea, and the FWS is dedicated to maintaining healthy, diverse populations of seabirds. Along with its many partners, the FWS plans to continue monitoring populations, productivity and diets of seabirds breeding in the Bering Sea. The Service is also responsible for regulating and monitoring the spring and sport harvest of migratory birds.

The FWS has and conducts active population based studies on polar bears, Pacific walrus and sea otters in close cooperation with the U.S. Geological Survey. All three species are harvested for subsistence and are important cultural resources. The FWS monitors the subsistence harvest and works closely with Alaska Natives to address subsistence related questions and develop management strategies. Information from long-term data sets of subsistence harvest and information from Alaska Natives may provide insight into long-term ecosystem changes. Monitoring programs for seabirds and other species in refuges can provide response information on upper trophic levels for comparison with changes in physical parameters. Existing long-term monitoring for seabirds and marine mammals could be greatly enhanced by having geographically appropriate monitoring data for physical and biological oceanography and atmospheric variables.

Last, but not least, the FWS manages threatened, endangered, and at-risk species. Species dependent upon resources in the Bering Sea during key life history stages include: the short-tailed albatross, Steller's and spectacled eiders, Aleutian shield fern (known from a single location on Adak Island in the Aleutians), southwest stock of northern sea otter (proposed as threatened), Kittlitz's murrelet (under evaluation for potential listing), and yellow-billed loon (under evaluation).

U.S. Geological Survey (USGS)

The U.S. Geological Survey is responsible for providing the Nation with critical geological, geographic, biologic and hydrologic information and serves specific needs of the Department of the Interior (DOI) and its land and resource managers. The Bering Sea

ecosystem supports important marine mammal, migratory bird and fish resources managed by the DOI, and the USGS has active research programs in this region to provide understanding needed to conserve these resources. These programs include a remote-sensing component and field-based programs on walrus, seabirds, seaducks, and Pacific salmon. The USGS also has capabilities in mapping benthic habitat and monitoring habitat change using sonar, video, sampling, and oceanographic instrumentation.

U.S. Arctic Research Commission (USARC)

The U.S. Arctic Research Commission was established by the Arctic Research and Policy Act of 1984. Its seven members appointed by the President advise the President and the Congress on Arctic research and policy. The marine geographic responsibility of the Commission includes the Arctic Ocean and the Beaufort, Chukchi, and Bering Seas, and the Aleutian Islands chain. The main duties of USARC are to: develop and recommend an integrated national Arctic research policy, assist in establishing a national Arctic research program plan, review Federal research programs and recommend improvements in the coordination of those programs, recommend improvements to Arctic research logistics, recommend improvements to U.S. and international Arctic data sharing and dissemination, and cooperate with the Governor of the State of Alaska and the appropriate State agencies. USARC serves as a voting member of the North Pacific Research Board and the Alaska Ocean Observing System, and as an advisory member of the North Slope Science Initiative. One of the key USARC priorities during the past two decades has been the enhancement of research in

the Bering Sea region. USARC has long been concerned about the lack of integration of observations from many programs and projects, and the absence of emphasis on the ability to predict changes in the Bering Sea system.

AN INTEGRATED APPROACH

To conclude, the working group proposed the rationale and initial details of an integrated research approach on the Bering Sea ecosystem. This integrated approach will allow maximum efficiency of resources and will speed progress on understanding the recent changes to the ecosystem.

All of the represented organizations support and/or perform research in the Bering Sea. Each has limited resources that even when combined is far less than what is needed to develop a truly comprehensive understanding of ecosystem functions. Understanding these functions is necessary to improve our ability to predict change in the ecosystem and its resources brought about by warming and loss of sea ice. Therefore, it is imperative that these organizations communicate and coordinate their research and monitoring programs to avoid unnecessary duplication. It is also necessary for them to work together to leverage technical and fiscal resources to support research in the Bering Sea. This is especially timely given the International Polar Year slated for FY 07-08.

Each of the participating organizations has different strengths and missions. An integrated, multi-organization approach would use the strengths of the various organizations to achieve the maximum gain in understanding, insight, and prediction for

the Bering Sea ecosystem. There are several specific ways that we can work together to achieve this goal.

- One has already happened: nine organizations have come together to form a body of representatives who have begun the think about how to combine the intellectual capital of the different organizations.

- Coordinate planning and funding mechanisms. Coordination of internal planning, announcements of opportunity, and notification of decisions will allow us to build a science plan that covers all the critical areas and keeps investigators informed of who they need to talk to for project coordination. This will minimize redundancy and make certain that critical areas are not left uncovered.

- Establish interdisciplinary working groups that cross over organizational boundaries and put scientists working on related projects in direct communication with each other. Leadership for these working groups would be distributed among the organizations and the organizations would provide strong encouragement to their funded scientists to participate.

- Integrate research results by sponsoring an annual meeting (or sessions at the annual Alaska Marine Science Symposium or North Pacific Marine Science Organization, PICES) to promote communication among Bering Sea ecosystem projects. Subsequent to these scientific sessions, the coordinating organization

would encourage the integration of research by supporting special issues in scientific journals that emphasize the latest results of ecosystem research relating climate to ecosystem change in the Bering Sea.

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APPENDICES

APPENDIX I

Workshop Participants

Representatives of the following organizations held a preliminary workshop on 8 April 2005 in Seattle to discuss research and monitoring activities needed to address the implications of the loss or reduction of sea ice in the Bering Sea over the next few decades:

John Bengston**	NOAA Alaska Fisheries Science Center (AFSC)
Eddie Bernard*	NOAA Pacific Marine Environmental Laboratory (PMEL)
Lawson Brigham*	U.S. Arctic Research Commission (USARC)
Doug DeMaster*	NOAA Alaska Fisheries Science Center (AFSC)
Anne Hollowed**	NOAA Alaska Fisheries Science Center (AFSC)
George Hunt, Jr.*	Bering Ecosystem Study (BEST)
David Hyrenbach*	Bering Ecosystem Study (BEST)
David Irons**	U.S. Fish and Wildlife Service (FWS)
Mark Johnson*	Alaska Ocean Observing System (AOOS)
Molly McCammon*	Alaska Ocean Observing System (AOOS)
Lyn McNutt	University of Alaska Fairbanks (UAF)
Rosa Meehan*	U.S. Fish and Wildlife Service (FWS)
Jeffrey Napp*	NOAA Alaska Fisheries Science Center (AFSC)
Karen Oakley*	U.S. Geological Survey (USGS)

James Overland	NOAA Pacific Marine Environmental Laboratory (PMEL)
Clarence Pautzke*	North Pacific Research Board (NPRB)
Phyllis Stabeno**	NOAA Pacific Marine Environmental Laboratory (PMEL)
Terry Whitledge**	University of Alaska Fairbanks (UAF)
Francis Wiese**	North Pacific Research Board (NPRB)
Denis Wiesenburg*	University of Alaska Fairbanks (UAF)

*Agency Lead

**Working Group Members

APPENDIX II

Bering Sea and Climate Change Working Group Terms of Reference

Purpose and Need

The climate and oceanography of the Bering Sea are changing. The southeastern Bering Sea shelf has warmed in recent years and seasonal sea ice has been absent for the last 4-5 years. This warming trend could fundamentally change the marine ecosystem and affect the abundance and distribution of commercially-fished species such as pollock, cod, salmon, and shellfish, recovery of protected species of marine mammals such as Steller sea lions and northern fur seals, and the availability of resources to Alaska Native subsistence hunters. We need to know how the Bering Sea ecosystem functions, and how it may change as a result of the anticipated warming and loss of sea ice. Resource managers must be provided with the knowledge necessary to advise commercial and subsistence users in the Bering Sea about how the resources on which they depend may change over the coming years.

Several organizations support and/or perform research in the Bering Sea. Each has limited resources that even when combined is far less than what is needed to develop a truly comprehensive understanding of ecosystem functions and improve our ability to predict change in the ecosystem and its resources brought about by warming and loss of sea ice. Therefore, it is imperative that these organizations communicate and coordinate their research and monitoring programs to avoid unnecessary duplication, and work

together to leverage technical and fiscal resources to support research in the Bering Sea. This is especially timely given the International Polar Year slated for FY 07-08.

Working Group Participants

Representatives of the following organizations (with lead and point of contact identified, if different) held a preliminary workshop on April 8, 2005 in Seattle to discuss research and monitoring activities needed to address the implications of the loss or reduction of sea ice in the Bering Sea over the next few decades:

Alaska Ocean Observing System (AOOS)	Molly McCammon (Mark Johnson)
Bering Ecosystem Study (BEST; NSF)	George Hunt (David Hyrenbach)
NOAA - AFSC	Doug DeMaster (Jeff Napp)
NOAA – PMEL	Eddie Bernard (Phyllis Stabeno)
North Pacific Research Board (NPRB)	Clarence Pautzke (Francis Wiese)
University of Alaska Fairbanks (UAF)	Denis Wiesenburg
U.S. FWS / USGS	Rosa Meehan
U.S. ARC	Lawson Brigham

Each point of contact will either be or will designate a representative to serve on a working group to follow up on recommendations identified below.

Each organization has an interest in research and monitoring in the Bering Sea, where it is estimated there is roughly $30-50 million spent on research and monitoring

annually. This includes extensive surveying and monitoring by NOAA, FWS, and AOOS, as well as a diverse portfolio of research by NPRB and NSF. NOAA implemented a program in FY04 specifically designed to study the influence of climate change in the North Pacific (NPCREP), funded at approximately $1.2 million. This program was intended to complement several on-going or planned NSF programs, included SEARCH, SBI, and BEST. It is anticipated to be funded at about $4 million when fully supported in FY08.

NPRB has nearly $11 million invested in 42 projects that relate to various ecosystem components of the Bering Sea and may support an additional $2-4 million in research annually. AOOS anticipates a monitoring program in the region of at least $1 million annually, if funding is approved by Congress. FWS and USGS conduct seabird counts regularly at seven colonies and on a 3-5 year cycle at eight additional sites, as well as monitor populations of walrus, sea otters and polar bears. NOAA conducts routine surveys and assessment studies on Bering Sea living marine resources, including groundfish, rockfish, juvenile salmon, forage fish, crab, Steller sea lion, northern fur seal, harbor seal, ice seals, gray whale, northern right whale, and humpback whale. UAF performs significant marine ecosystem research based on funding received from NPRB, NOAA, NSF, and other sources. The BEST program, with anticipated funding of $1-3 million per year from NSF, will emphasize how climate change will impact sustainability of fisheries. USARC is interested in all research being conducted from the Aleutians northward, particularly as it relates to climate change and recession of sea ice, as well as international Arctic programs.

Clearly there is a critical need to integrate to the extent possible the interests and research programs of these organizations to maximize the utility of data and the efficiency of data collection. As will be explained below, three immediate needs were identified during the workshop. The first is the coordination of NOAA's **L**oss **O**f **S**ea **I**ce in the Bering Sea (LOSI Program) and NPCREP with the NSF-sponsored BEST program. The second is the need for NPRB to develop an integrated ecosystem research program for the Bering Sea which will be funded through its annual requests for proposals (RFP) starting this fall for FY06. The third is the need for AOOS to further refine its Bering Sea/Aleutian Islands observing strategy in anticipation of FY06 funding in December.

The working group also needs to begin developing core hypotheses for an integrated Bering Sea research and monitoring effort during the International Polar Year (FY2007-2009), and determine in a general way, which funding entity will be responsible for which aspect of this effort. These efforts must have input from the region's broader community of stakeholders and resource users, as well as be coordinated with state (e.g., ADF&G) and local (e.g., Norton Sound Sustainable Fisheries) entities.

Schedule and Deliverables

Working group members will meet as necessary at their own expense to develop and provide the following products:

1. *First draft working paper for 16 May 2005 BEST meeting in Victoria, BC*

   The working group will develop a 5-7 page first draft of an integrated planning document for presentation at the BEST Implementation Meeting on 16 May 2005. This will be a first step in identifying core hypotheses and overlapping areas of interest. It will identify major questions concerning the ecosystem and what we would like to know five years from now, particularly as it relates to BEST. It will begin to lay out an approach to dividing up the funding responsibilities for a comprehensive, integrated program. The BEST implementation plan should be ready in June and a request for proposals may be released by NSF in November 2005.

2. *Second draft working paper for 30 June 2005*

   The working group will develop a second draft document by the end of June. It will be about 10-15 pages and will include additional details of integrated planning for ecosystems research and monitoring in the Bering Sea over the next 5 years. It will begin to lay the foundation for research and monitoring priorities to be identified in the NPRB RFP this fall and the AOOS Bering Sea/Aleutian Islands observing strategy for FY 06.

3. *Additional activities of the working group*

The working group will continue to work over the summer and beyond to ensure that marine ecosystem research in the Bering Sea is coordinated, that information is shared, and that a coherent program of monitoring and research is accomplished, particularly as we plan for IPY. The working group also will provide an invaluable sounding board for NPRB as it develops its Bering Sea Integrated Ecosystem Research Plan.