Sustaining the Bering Sea Ecosystem

A Social Science Research Plan

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Introduction

This science plan articulates a vision and approaches for social science research as a component of the Bering Ecosystem Study Program (BEST 2004). This plan seeks to initiate research to elucidate the dynamic relationship between the Bering Sea ecosystem and the humans who constitute an integral component of that system. To do so, this plan delineates a research program focused on three broad themes:

1) Impacts on humans: how past, current, and possible future changes in the Bering Sea ecosystem affect the health and wellbeing of human communities living and depending on this region for subsistence, employment, and cultural survival.

2) Human impacts: how changing human uses of the Bering Sea region affect the natural cycles of this ecosystem by moderating and/or accelerating systemic changes.

3) Dynamics of human and non-human natural systems: how the human-environmental dynamic has changed through time and may change in the future due to internal and external opportunities and pressures.

These themes are developed in the context of a community-driven approach that attempts to prioritize the concerns, goals, and interests of Bering Sea residents and other stakeholders of the region. Long-time residents and non-resident users of the Bering Sea, including Alaska Native communities with deep cultural and economic connections to the region, have the most at stake in planning for the uncertain future of the Bering Sea environment. This plan, therefore, was developed to focus significant research around their questions, which in various ways center on issues of sustainability (of resources, economic opportunities, ways of life, and culture itself). The central question for many Bering Sea residents during an initial planning workshop in March 2004 was "How are we going to survive?" This sentiment reflects the deep concern and anxiety many feel in facing unpredictable and potentially unprecedented climate changes, and the cascade of ecological and social consequences that could follow. It is also a sentiment anchored in the realization that the scale and organization of social, cultural, and political systems have been changing in recent decades as rapidly as the climate, affecting the structure of possible responses to environmental change as never before. The question also points to the practical need to come up with plans for the future that will provide the best future possible.

The research envisioned by this plan will provide a foundation for resident communities, regional corporations and tribal councils, industry stakeholders, resource managers and policy makers at various levels to plan for and face the future with less uncertainty. To accomplish this goal, research must be developed with attention to concrete and practical outcomes. New approaches are needed, such as statistical and systems modeling to clarify the dynamic relationships within and between linked complex systems. Multiple sources of data need to bridge relevant scales of time and space. For example, we envision the incorporation of traditional knowledge and western scientific data towards the understanding of settlement and land use, social networks, community leadership, resource sharing, economic markets, diet, health and demography, and the integration of already existing data into the data collection and analysis process. In this social science effort and in the broader Bering Sea Ecosystem Study (BEST) of which it is a part, synergies must be exploited that harness the strengths of multiple disciplines toward common purposes. For this reason, the research anticipated in this plan will generally require interdisciplinary teams/projects that include a modeling component and that focus on one or more of the research themes defined in this plan. It will also require collaboration and partnership with Native and non-Native residents and stakeholders in the Bering Sea.

Vision

The Bering Sea is changing from an ice-dominated to an increasingly open water system. Changes in the ecosystem observed in recent years include uncharacteristically large blooms of primary producers, changes in the ranges of fish, mammals, and birds, unpredictable weather, loss of seasonal pack ice in some areas and changes in the physical characteristics of the ice in others. Because the Bering Sea ecosystem is of great physical, biological, social, economic, and cultural importance, these observations have raised concern among Bering Sea residents and non-residents alike. Understanding how the system functions, and how humans can sustain the Bering Sea ecosystem and be sustained by it, requires research that recognizes the place of humans in the ecosystem, taking a holistic approach to its interconnected features. Such research should take place at many scales, with many focal areas, and with many approaches. The vision for *Sustaining the Bering Ecosystem* is to understand how the region's resident communities and other stakeholders can continue to participate in a changing ecosystem.

BOX 1: Key questions expressed by Bering Sea residents at the **Humans and Environment Community Forum** *meeting in March 2004*

- What does the connection to the Bering Sea mean to residents?
- How are communities going to survive?
- How can we save ourselves and the Bering Sea?
- How did we get to where we are today?
- What factors will influence the future?
- What future do we want?
- How can we get there?

Guiding philosophy

This plan has been drafted through the collaboration of Bering Sea residents (primarily Alaska Natives) and non-resident stakeholders, social scientists, and natural scientists. This process was driven by the need for integrated science that will generate crucial information to serve the needs of Bering Sea communities, regional managers, and policy makers at various levels as they seek to sustain and be sustained by a productive Bering Sea Ecosystem that supports the diversity of organisms that are of commercial, subsistence and cultural importance. We recognize that the culture and self-definition of residents of the Bering Sea is of vital importance to the sustainability of Bering Sea communities. With their long histories, many Bering Sea communities depend on the region's products not only for economic well-being but also for cultural identity, integrity, and spirituality. The residents of the Bering Sea include a diversity of peoples with different histories and goals. While we pay particular attention to the needs of indigenous communities, we recognize and address throughout this plan the varied and interwoven interests of other groups as well (e.g., non-resident fishers, representatives of non-local fishing and freight companies, cruise ship operators, tourist companies, resource managers, and policy makers, among others).

Above all, we believe that a community-fostered science process must involve awareness of:

- The closely linked relationships between people and the Bering Sea, especially its renewable resources.
- The material, cultural, and spiritual relationships between people and the land, sea, and weather of the Bering Sea.
- Sources of power, authority, and knowledge that condition adaptation and resilience to environmental variability.
- Relationships among Alaska Native cultures and between those cultures and non-Native cultures.
- The guidance of knowledgeable elders in the process of defining research needs, exploring relevant local and traditional knowledge, and communicating results to affected communities.
- The significance and dignity of traditional knowledge, wisdom, and ways of life in establishing priorities and procedures.
- The need to bridge the gap between a declining population of elders and those of the younger generations who now typically are responsible for the administration of local villages.
- The need to train younger generations to become leaders in basic and applied research, especially through the recruitment of students from Bering Sea communities with a special stake in the development of Bering Sea research.
- People's concerns of and hopes for the future as a guide to the prioritization of research questions.

- A practical approach that works towards relevant goals in achievable increments.

"How are we going to survive?"

This plan was developed initially out of the results of a workshop with Bering Sea residents in March 2004. Two days of discussion exposed a series of practical concerns and goals for Bering Sea human-environmental research, many of which form the core themes for this plan (see "A Community Engaged Approach" below and Appendix 1). At the workshop, one of the most explicit and strongly stated concerns of residents was "How are we going to survive?" This question reflected fears about the vulnerability of communities to

- potential loss of subsistence resources and cash employment
- exposure to contaminants in food, water, and the surrounding environment
- emigration of community members from villages to distant urban centers
- influx of shipping traffic and its possible effects on traditional resources
- loss of social and cultural structures and activities that hold communities together such as access to traditional foods and education of younger generations in traditional ways and language

The unifying theme underlying these concerns is one of the limits of resilience to change. In the past, many of these communities were able to adapt successfully to change, though not always without a struggle. In the current context of global scale politics and economics, it is unknown how resilient modern Bering Sea communities are to the environmental changes threatening the Bering Sea today. This uncertainty results partly from the unprecedented nature of current and projected climate changes and in part from the relative novelty of the current socio-political and economic dynamics affecting Bering Sea communities. For example, environmental changes that in the past would have posed modest challenges may in some cases prove more difficult due to constraints imposed by management policies and structures of land tenure. At the same time, access to state, federal, and international scale social, economic, and political networks may in some cases provide avenues for adaptation unavailable in the past.

This modern, global-scale interaction pattern also means that communities located on the Bering Sea are not the only ones impacted by changes there. These interactions lead to additional concerns about potential changes in fish distributions, changes in the structure of fishing industry, changes in the ocean conditions that make fishing unpredictable or travel unsafe. Research is needed to assess the implications of climate and ecosystem change on subsistence, employment, public health, civic infrastructure, social networks, and resource management – and on the dynamic interrelationships between these arenas. Such research will help to inform community members in addressing one of the guiding questions from the March 2004 workshop: "what future do we want to have and how can we get there?"

Scientific Statement of Purpose

The over-arching goal of the Bering Ecosystem Study (BEST) is to understand the effects of climate variability and change on the Bering Sea ecosystem. To the people who are simultaneously a part of that ecosystem and rely on its productivity for life and work, climate change and its effects are among the top concerns. Change in climate, such as the general warming documented for the past thirty years, alters the distribution and characteristics of sea ice, weather patterns, productivity and spatio-temporal availability of marine resources, and a host of related factors. These physical and ecological changes affect the ability of Bering Sea communities (residents and non-resident users) to access marine resources and the safety of doing so. They alter the structure of economic opportunities and challenge the maintenance of cultures whose traditions reflect dependence on subsistence resources. Shifts in harvested target species or harvest strategies may also result in unintended impacts to the ecosystem. All communities living and/or working in the Bering Sea worry about how climate change will affect human activity in the region, including **subsistence hunting and fishing opportunity, commercial fisheries and other economic development, public health and safety, policy/management, and, more generally, community survival and resilience**. In short, these are the areas in which communities feel most vulnerable to environmental change. *These topics form the primary themes for organizing social science research as part of BEST.*

Climate influences physical environment and the marine ecosystem of the Bering Sea through a series of linked processes including atmospheric, hydrological, and physical oceanographic processes, primary production, and food web dynamics. These processes and the mechanisms that underlie them are the foci of the natural science component of BEST, as well as the ongoing work of agencies like the Alaska Fisheries Science Center (AFSC/NOAA), US Fish and Wildlife Service (FWS), the North Pacific Research Board (NPRB), the USGS, and Alaska Department of Fish and Game (ADF&G). To understand human vulnerability and the resilience of communities living and working in the Bering Sea more fully, research is needed that considers the social, demographic, economic, political, and public health contexts of Bering Sea ecosystem change. This context influences options and choices concerning subsistence harvesting, participation in commercial fisheries and other jobs, immigration/emigration, education, nutrition, health, and safety.

While research has been conducted for many years and by different agencies and organizations on subsistence and commercial harvests (in some cases including the cultural significance of subsistence) and the social, economic, and public health issues of Bering Sea communities, very little of this research is sufficiently interdisciplinary or sufficiently synthesized to allow for the assessment of community vulnerability and/or resilience to environmental changes of the magnitude observed in recent years and projected for the near future. Successful assessment of community vulnerability and resilience will require dynamic and integrated research that links various social and natural science disciplines and methods. It also requires partnering with both resident and non-resident communities (villages, tribal councils, Native corporations, CDQ groups, fishing boat operators, fisherman's associations, shippers, etc.) to ensure that adequate focus is given to issues of greatest concern for them, and to provide the greatest

opportunity for community-based observations and traditional knowledge to contribute to research synthesis.

Scope

The goals of this social science plan require that supported research address a wide spectrum of information about human interactions with the Bering Sea environment to make the scope of the plan broad and inclusive.

Area of Interest

For a variety of reasons specified in the BEST science plan (BEST 2004), the Bering Ecosystem Study program's natural science will focus most of its attention on the eastern Bering Sea region from the Alaska Peninsula north to St. Lawrence Island. Because the social science related to BEST (discussed in this document) is intended to be collaborative with the natural science, it is expected that most social science supported under BEST will occur in roughly the same area and/or among communities engaged in activities there. Some projects may expand beyond this area into the Aleutians and north to the Bering Strait region in an effort to examine human-environmental interactions in comparably more open water and more ice dominated regions of the Bering Sea. Social science research under BEST on the Russian side of the Bering Sea is not anticipated, but could be justified as part of comparative research.

Spatial Scales

The Bering Sea covers a broad geographic region where local, national, and international interests affect residents, compelling researchers to recognize the diversity of the region. Locally, individual groups are concerned with their villages, fishing grounds, hunting areas, or cultures, while simultaneously tied to the concerns of the broader region. Because of this, research that focuses on the Bering Sea area will have to range from local to basin-wide (and broader) scales, and will have to engage a wide variety of people and places.

Local effects could include changes in the productivity of subsistence fishing and hunting locations or in the spatial distributions of productive fishing or hunting locales. Human impacts to ecosystems are most pronounced at the local scale where over-harvesting, pollution, industrial development, and other activities have their most rapid and definitive environmental footprint. Local ecological changes might affect family organization and function, self-sufficiency, equal opportunities for subsistence goods and income employment. Local effects also accumulate across larger regions affecting industries and cultures. At broader regional scales, communities around the Bering Sea have long been integrated through kinship, economic orientations, shared language and heritage, collective governance, business relationships, and interest in environmental protection. Therefore, any effort to understand the human dimensions of environmental change in the Bering Sea needs to take into account multiple scales of systemic integration within and between ecosystems and society.

Despite political boundaries, the many parts of the Bering Sea basin are connected ecologically, biologically, culturally, and economically. This means that at some level the important dynamics will only be resolved through international research efforts. While the focus of natural and social science within BEST is in the eastern Bering Sea

within the territorial waters of the United States, it will be necessary to maintain a view to the broader Bering Sea environment and human pattern. This is especially true because actions and policies implemented for part of the Bering Sea may well affect the environment, economy, and people living and working in other parts.

Temporal Scales

Because people have lived in the Bering Sea region for thousands of years, information that is available over long temporal scales about the ecosystem and human communities can be used to answer questions about the past, present, and future of the Bering Sea ecosystem. We anticipate research into both the past and present as part of BEST social science.

Alaska Native communities have a long history of interaction with the Bering Sea ecosystem. Their predecessors dealt with environmental changes of varying amplitudes in the past. These precedents can provide clues to the range of strategies and the extent of community resilience to environmental change. Archaeology and biological anthropology have begun to clarify some of these interactions, strategies, and vulnerabilities especially in other regions of the world (e.g,. Kirch REF, McGovern et al REF; Moseley REF). More systematic study is necessary to identify climate and ecosystem changes in the past, to characterize intensity, duration, and extent of these changes and how people responded or were affected by them. Archaeological deposits contain evidence to track both environmental change and human responses. Paleontological and palynological approaches in consort with archaeology provide efficient means to characterize past environments and to map changes in ecological conditions (such as sea ice extent and character; see Davis 2001).

Oral histories and other forms of local and traditional knowledge (LTK) also reveal environmental change and human-environmental interaction at various scales. The temporal resolution of these kinds of information is much higher than that of archaeological and paleoecological data and is particularly useful for considering change over scales of decades to several generations, and some information is often preserved over longer time ranges. Historical documents are also particularly useful sources for some observations extending back between 100 and 200 years in the Bering Sea.

Another reason to include a retrospective dimension to Bering Sea ecosystem research is that current cultural systems, adaptive strategies, and social responses carry with them a substantial inheritance from the past. Even with dramatically altered social and economic conditions in the modern period, many communities in the Bering Sea maintain cultural traditions of considerable time depth, some of which were developed in response to environmental and social variability. Understanding the development of these traditions will be important to turning these strategies to advantage and to minimize conflicts between Native and Western oriented solutions or between "internal" or local practicalities and "external" policy and management perspectives.

Thus, research that looks into the past at various time scales can address such questions as:

- How did the Bering Sea ecosystem and local communities come to be the way they are today?

- How did people in the past adjust to climate change, and how flexible were they to changes in their environment?
- How has human use affected Bering Sea ecology over time?

Contemporary information is also needed on the organization, motivations, knowledge, and skills of contemporary people and communities to understand ongoing trajectories of change and to predict possible social responses and affects in the future of the Bering Sea ecosystem and its people. Contemporary data on demography, community health and structure, education (both formal and informal), political organization, and other dimensions of modern life can provide the highest resolution information about community dynamics and integration with the ecosystem.

Interdisciplinarity

The scope and scale of the research proposed by this plan make interdisciplinary work essential to this program, both within the social sciences and between the social and natural sciences, as each discipline and perspective brings a unique combination of expertise, ideas, and points of view. The interaction of many lines of data and expertise will help develop a holistic view of the relationship of human-environmental dynamics in the Bering Sea ecosystem, bringing the overall program into position to better contribute to adaptive solutions. Included in this notion of interdisciplinarity must be active engagement with local communities and stakeholders of the Bering Sea. In many cases this will require a kind of inter-cultural interdisciplinarity both uncommon and often uncomfortable to non-resident researchers, but which will make the difference between research projects that are successful in making positive contributions to the Bering Sea future and those that do not. It will require meeting community leaders, hearing their concerns, and learning how their perspectives and situational/cultural knowledge can contribute to the scientific enterprise.

Background

Humans and the Bering Sea Ecosystem

The Bering Sea is characterized by a deep central basin and two continental shelves: a narrow northwestern shelf along the Kamchatka Peninsula, and a wide eastern shelf that runs from the Alaska Peninsula to Russia and the Bering Strait. Because the Bering Ecosystem Study program will be focused on the eastern Bering Sea shelf and coastal region (due to logistical and financial constraints), we narrow our discussion to that region. The eastern shelf can be divided into southeastern, central, and northeastern portions, and these areas vary in their oceanographic characteristics, weather and seasonality, fresh and saltwater mixing, extent of sea ice, influences of currents, tide strengths, storminess, and the likely effects of climate change. The regions are all dominated by climate variability at scales ranging from weekly to decadal and millennial (BEST 2004 and references).

People living in these regions contend with environmental change on a daily, seasonal, and interannual basis, and they have learned to adapt to environmental variability through technology, culture, social structure, infrastructure, and partnerships with other regions. People living in the Aleutian Islands live on small, steep-sided

volcanic islands, and exist in a temperate, though often stormy, environment. In contrast to the Aleutians, around Bristol Bay and the Yukon-Kuskokwim Delta people live in lowland areas where sandy beaches, dune formations, barrier islands, and variable (but declining) seasonal sea ice dominates the coastline. Further north, the Bering Strait region is characterized by treeless tundra, snow, and now declining and increasingly seasonal sea ice for much of the year. The environmental and climatic variability discussed here influence the types and abundance of resources that are available to people in each of these regions, how easily those resources are harvested, and the ways in which people have adapted to these environments.

Modern Bering Sea communities depend on the Bering Sea ecosystem to varying degrees and in various ways. One of the most critical dependencies for all groups is the extraction of marine resources. Aleut communities living in the Aleutians and Lower Alaska Peninsula rely on the marine ecosystem for subsistence and fisheries employment. Those on the Alaska Peninsula also have access to terrestrial resources to supplement their predominantly maritime economies. Like Aleut communities, Yup'ik communities of the eastern Bering Sea coast rely on the marine ecosystem for access to marine mammals, fish and fisheries employment. Fish are important subsistence resources for communities from the Y-K Delta to the Bering Strait (Yupik and Inupiat), but in the past fewer commercial fishing opportunities have been available there. That is changing with an expanding crab fishery and the development of the Community Development Quota (CDQ) program that gives Bering Sea villages' access to the commercial fisheries in the eastern Bering Sea. Access to commercial opportunities might change further with the predicted loss of seasonal ice if the high productivity fish stocks of the southeastern Bering Sea move into a warmer north Bering Sea. Residents of St. Lawrence Island and Little Diomede Island continue to depend to a greater degree than others on the subsistence harvest of marine mammals (seal, walrus, and whales). Many communities also depend on cash supplementation through production and sale of art made of marine mammal products. Collectively, these adaptations depend almost exclusively on access to marine resources. Though outside the target area for the BEST program, similar relationships and dependencies between people and the Bering Sea ecosystems are found on the Russian side of the Bering Sea.

In addition to communities located on or adjacent to the Bering Sea, there are many other communities in Alaska and other states which rely on extraction of commercial fish species for economic opportunity and production. Commercial fisheries of the Bering Sea are one of the largest in the world, producing fish for worldwide markets. Target species include salmon, halibut, herring, ground fish, crab and other shellfish. These fisheries produce employment for both residents and non-residents. The fisheries also support service and processing industries in Bering Sea communities and contribute to the economic success of a range of fishing enterprises from family businesses to multi-national corporations.

Reliance on the Bering Sea does not end with subsistence and commercial harvests of Bering Sea resources. Many communities depend on the Bering Sea for movement to and from hunting and fishing locations, for social and economic interaction with other communities, and in some cases for temporary residence (e.g., camping on ice, or living on fishing boats). Climate and its effect on sea ice, ocean currents, and storms

affect the ability of people to carry out subsistence work, navigate, travel, and live safely on ice and water.

To rural Alaska Native people and others who live and work on the Bering Sea, the stability and "health" of the marine ecosystem is of vital concern. Economic infrastructures, long-standing cultural practices and deep-seated spiritual values are tied to this marine system. The cultures of Bering Sea Native peoples were forged through centuries and millennia in association with the rhythms of this system, and much of traditional culture was developed to help communities weather environmental changes. Unfortunately, some feel that these cultural traditions have been eroding for decades, largely in response to outside economic and social forces, leaving communities with fewer cultural adaptations for coping with change than were once built into their cultures. There is a growing effort throughout rural Alaska to strengthen traditional cultural values and structures, while simultaneously taking advantage of new opportunities and requirements of a globally interconnected world. This has led to some positive changes, such as increased educational and technical capacity, which allows Alaska Natives to work with and lead research in and beyond their communities and to engage in resource development and infrastructure management. This capacity allows for greater self-determination and autonomy than many communities have had since European contact.

Unlike the commercial and industrial sectors involved in the Bering Sea, for Native communities especially, but also for many non-Native residents, the value of the Bering Sea marine ecosystem derives not simply from the monetary income that can be derived from it, or from the subsistence foods that it supplies. To these people, the Bering Sea is a way of life, it is a homeland, and it is part of their cultural and spiritual life. The strength of this bond has and will influence the choices that people make as they seek to navigate the climatic, ecological, economic, and socio-political changes that they face. Understanding the cultural diversity and multiple systems of value and adaptation in the Bering Sea region is essential to any attempt to understand how people will be affected by ecological change in the Bering Sea.

Human History and Culture in the Bering Sea

Colonization and ancient history- Initial colonization of Western Beringia took place at least 15,000 years ago (Hoffecker and Elias 2003). Soon after colonizing Western Beringia, people traveled from Siberia to Alaska, and these early Americans may have specialized in terrestrial large mammal hunting as they crossed the Bering Land Bridge (Dumond 1978) or they may have been more maritime oriented people, moving by boat around the Beringian basin and down the Pacific coast towards North America (Arutiunov and Fitzhugh 1988; Dixon 1993). The date of first sustained settlement of the eastern Bering Sea region is not clear because few archaeological sites have been found (many may lie submerged on the current Bering Sea shelf following post-glacial sea level rise). The evidence is nevertheless clear that people had established themselves from the Bering Strait to the Aleutian Islands by the end of the Pleistocene, around 10,000 years ago. People have occupied the region ever since.

Among the first inhabitants of the Bering Sea region were those who settled the western shores in Kamchatka and eastern Siberia. The Koryak, Itelmen, Chukchi, and Siberian Yupik are the extant indigenous peoples living in these areas today. These groups have maintained close ties to the native people of coastal Alaska (Arutiunov

1988), and have retained their ethnic identities and many traditions while integrating to various degrees into Russian/Soviet/post-Soviet society. Before Russian contact and the introduction of agricultural goods, all groups hunted, fished, and gathered resources from their regions. Many had specialized reindeer herding economies or specialized in sea mammal hunting (seal, walrus, and whale). Most of these groups have retained some aspects of their traditional subsistence cultures even in the face of modernization and urban settlement (Kerttula 2000).

On the eastern side of the Bering Sea, Aleut, Yup'ik, Siberian Yupik, and Iñupiaq people today descend from long histories of economic, social, and cultural reliance on the Bering Sea system for physical and cultural survival and spirituality. The development of cultural traditions throughout the Holocene before and following European contact is represented in archaeological remains, oral history, historical documents, and ethnographic descriptions. These data sources preserve information on environmental change and human adaptations that is of direct bearing on the evolution of the Bering Sea ecosystem in both its human and natural components, and on the unique culture and heritage of Bering Sea's Native communities (Ackerman 1988; Fitzhugh 1988; Fitzhugh and Kaplan 1982; McCartney 1995, 2002).

Alaska Native Cultures of the Bering Sea – Aleuts have nurtured a distinctly maritime society for at least 9000 years (Aigner and Del Bene 1982; Dumond 2001; Knecht and Davis 2001) ultimately extending from the southwestern Alaska Peninsula along the Aleutian chain as far as the Commander Islands, as well as on Pribilof Islands in the southeast Bering Sea. Because the majority of Aleuts inhabit treeless islands without large mammals, they have had a near total dependence on the sea for mammals, fish, and birds, and have made use of boats for travel and hunting since they first moved onto the Aleutian Chain. Archaeological and ethnographic evidence show that prehistoric and contact era Aleuts had complex social organization, ranked societies, large longhouses, intricate artwork, and engaged in endemic competitive warfare and slave raiding with neighboring regions (Dumond 1987, Fitzhugh 1988; Jochelson 2002; Maschner and Reedy Maschner 1998; Townsend 1980, 1983). Today, the Aleutian economy continues to depend on the sea for subsistence, and this region supports some of the world's largest fisheries providing economic opportunities and infrastructural support to most Aleut communities. Aleuts were heavily impacted by Japanese and American hostilities in World War Two, when the entire Aleutian population was moved to temporary camps on the mainland, homes were over-run or bombed, and military bases established. As a result, several of the islands contain military debris and the possibility of contamination and unexploded ordinance. Nuclear tests on Amchitka during the Cold War continue to raise concerns for resident subsistence and commercial harvesters in the area. A legacy of the military operations in World War II, one of the most active ports for the Bering Sea fisheries emerged at Dutch Harbor in the eastern Aleutians. Today many Aleut participate directly or indirectly in the commercial fishing activities as fishing captains and crew, employees in processing plants, or service providers for the fleet.

The territory occupied by the Central Alaskan Yup'ik stretches from the upper Alaska Peninsula and Bristol Bay to the Yukon-Kuskokwim Delta. Subsistence for communities in this region has long included fishing for salmon and hunting of walrus, seal, beluga whales, birds, and some land mammals. Unlike other cultures in the Bering

Sea, large cetacean whaling was not an integral part of this culture because of the lack of access to the migration routes of grey, humpback, and bowhead whales. The Central Alaskan Yup'ik are known for their complex artwork, design styles, and elaborate festivals, which are maintained as important aspects of Yup'ik culture today (Fienup-Riordan 1983, 1996; Fitzhugh 1988, Lantis 1971). Today, many communities are engaged in commercial fishing for salmon, pollock, crab and other target species. Communities of the Yukon-Kuskokwim Delta have become particularly concerned about diminishing salmon populations and the effects of this loss on their subsistence and way of life (NRC 2004)

St. Lawrence Island/Siberian Yupik are distinguished from other Yup'ik groups by language, subsistence practices, cultural characteristics, and geography. Sea mammal hunting is a vital part of St. Lawrence Island economy, social life, and culture. Whales, walrus, and seals are all taken from boats at the ice edge, and these hunts have been integral to social organization: related to organization of hunting crews, long-distance trade partnerships, and food sharing are all dependent on successful sea mammal hunts (Fitzhugh 1988; Harritt 2001; Jolles 2002; McCartney 1995, 2002). Many of these traditions can be traced back more than 2000 years on St. Lawrence Island where the earliest archaeological evidence for definitively Eskimo cultural traditions are documented (Bandi 1969; Collins 1937; Dumond 1998; Harritt 2001; Jenness 1928; Larsen and Rainey 1948; McCartney 1995). Since travel to the Russian coast resumed in 1988, ties have been renewed with kin and other fellow Siberian Yupik on the Chukchi Peninsula. Today, the two communities on St. Lawrence Island (Gambell and Savoonga) maintain traditional subsistence activities, including the bowhead whale hunts for which they are well known, as well as harvests of walrus, ice seals, polar bear, sea birds and their eggs. Economic opportunities are scarce and people often supplement their subsistence lifestyles through the production and sale of ivory carvings and other artwork,

The Iñupiat live on Seward Peninsula, Little Diomede Island (in the Bering Strait) and farther north, and their environment and lifestyle is often described as unpredictable because of the long and difficult winters (Fitzhugh 1988). People in this area have developed ingenious adaptations to the cold, and they have long depended on sea ice for travel, hunting, and other activities during much of the year (Giddings 1960; Harritt 2001; Jenness 1928; Ray 1992). Similar to the Siberian Yupik of St. Lawrence Island, the Inupiat today hunt whales, walrus, seal, and polar bear but, with the exception of the Little Diomede Island people, also make use of caribou and other terrestrial resources as part of their seasonal subsistence activities (McCartney 1995). Fish are taken for subsistence in rivers, and a crab fishery is developing in some areas.

Most of these rural communities already face tremendous challenges such as high rates of unemployment, substance abuse, and suicide. Despite greater opportunities for higher education and employment elsewhere, most residents prefer to live close to relatives and in familiar surroundings. The subsistence lifestyle provides a strong bond to most Native residents, and is credited for its healthfulness and its importance to cultural identity and integrity.

Recent History: Colonization, Extraction, and Commercialization – It is impossible to understand contemporary cultural diversity in the Bering Sea without also discussing

the history of colonization, resource exploitation, and commercialization that has characterized the last two and a half centuries. Within years of Bering and Chirikov's "discovery" of Alaska in the late 18th century, fur hunters, whalers, and traders began exploring Alaska for untapped economic opportunities (Black 2004). Soon after its establishment, the Russian American Company (RAC), driven by the market in sea otter and fur seal fur, took charge of social services in the region, employed many Alaska Natives, and introduced a cash economy and new language. At the same time they introduced European disease and initiated the destruction of many fur bearing animal populations (Fitzhugh 1988). Russian and Siberian immigrants often married local Alaskans, had children, and introduced Eurasian technologies and ideas. A significant outcome of this process was the introduction of the Russian Orthodox Church, which is strong in many places in the Bering Sea region today (Black 1984, 2004; Fitzhugh 1988; Oleksa 1992; Smith 1980). The RAC also relocated Alaska Native populations around the North Pacific, transplanting significant numbers of Aleuts to the fur seal colonies of the Pribilof Islands, establishing mixed Aleut and Kodiak Alutiiq communities in the Kuril Islands and California Channel Islands, and along the coast of the Pacific Northwest (Krashenenikov 1972, Ogden 1991; Shubin 1994)

Following the sale of Alaska to the United States in 1867, Euro-Americans rushed into the territory pursuing quick wealth through exploitation of natural resources (whales, fish, gold, oil, timber, etc.). More often than not, these immigrants ignored, neglected, or abused indigenous populations in the process. Whaling for bowhead whales brought a regular flow of ships through the Bering Sea/ Bering Strait and into regular contact with Inupiaq communities beginning in the mid 19th century (Bockstoce 1986; Cassell 1988, 2000). As whaling declined towards the end of the 1800s, the gold rush brought thousands of prospectors to the Bering Sea coasts on their way up the major rivers of Alaska, almost instantly creating major population centers at places like Nome where small Native populations previously lived in relative isolation (Cole 1983; Marshall 1991; Spence 1996). Dutch Harbor became a major way-point for ships heading to the gold fields and trading posts expanded there and in places like Bethel to supply the extractive industries and the indigenous communities with goods from outside. The canning industry made southern Alaska a "commercial fishing paradise" beginning in the late 19th century (Roppel 1986). At the same time, missionaries of many denominations expanded their efforts to Christianize native populations throughout the late 19th century setting up posts in communities around the eastern Bering Sea (Fienup-Riordan 1988; Renner 1979; Tower 1988). Naturalists and anthropologists also began to explore the region in the late 19th century (Fitzhugh 1988).

Despite the activities at hot spots like Nome, Dutch Harbor, and Bethel, the Bering Sea region remained sparsely populated until the Aleutian archipelago became one of the most important military battlegrounds of World War II (Garfield 1995, Hays 2004). A US military and civilian support force of more than 40,000 quickly moved into Dutch Harbor and eventually other bases along the chain. US and Japanese forces battled for control of the islands, seen as a stepping stone pathway onto the American continent (Rourke 1997). Dutch Harbor and the associated village of Unalaska were bombed by the Japanese and at least one populated island was occupied by the Japanese, with the Aleut occupants sent to POW camps in Japan (Mitchell 2000). In response, the American government forcibly removed the entire Native Aleut population from the Aleutian

Islands, confining them in internment camps in Southeast Alaska for the duration of the war (for which the federal government has since officially apologized and made financial reparations; Kohlhoff 1995; USCH-CJ 1994).

The advent of the Cold War had numerous affects on the Bering Sea region and peoples. In the 1960's and 70's, the United States used the Aleutian Islands as a nuclear weapons testing ground, exploding three devices including the largest underground nuclear explosion ever conducted by the United States (Kohlhoff 2002). St. Lawrence Island witnessed the establishment of two bases and a major radar station (all since abandoned and recently removed). The Iron Curtain divided the Iñupiat of Little Diomede from their relatives across the Bering Strait on Big Diomede. The latter were moved by the Soviet government to the mainland, and families have only been able to reconnect recently. The border also cut off Little Diomede whalers from access to the right whale migration route, preventing them from hunting these whales for many decades (McCartney 2003). Since the end of the Cold War, US-Russian relations in the area have been characterized by increasing cooperation on issues such as subsistence whaling, fisheries enforcement, and search and rescue operations.

In 1976, the Magnuson Fishery Conservation and Management Act claimed the area between 3 and 200 miles off shore as the Exclusive Economic Zone of the United States (Rigby et al, 1995). In the Bering Sea, this had the effect of Americanizing the lucrative off shore fisheries, which had previously been fished by vessels from Japan, Russia, and Korea (Chitwood 1969). Crab and other shellfish, herring, halibut and groundfish all contributed to growth and development of certain fishing ports in the region, which now operate as service hubs to other settlements. Immigration of workforces from around the world, particularly Mexico and the Philippines, to jobs in on-shore processing plants has changed the ethnic make up of these fishing hubs from varying proportions of Alaska Natives and Caucasians to diverse international micropolises. Non-hub villages have been less directly affected by this change in the fisheries. The advent of Community Development Quota (CDQ) Groups, a program which reserves a portion of Bering Sea commercial fisheries harvest rights for Western Alaska villages, has substantially increased the involvement of local Natives in these fisheries, through capital investment, labor, and income for development projects.

Non-fish marine species are also still important to the residents and non-resident users of the Bering Sea. Marine mammals remain the mainstay of the diet in many Native villages. Though a number of species are protected under the Marine Mammal Protection Act and the Endangered Species Act, there are exceptions in both of these laws for Alaskan Natives engaged in subsistence. Marine mammals (pinnepeds and cetaceans), together with birds, are also an important draw for ecotourists who visit the Bering Sea along with recreational fishers and sports enthusiasts. There has been concern that some of the commercial fisheries are interfering with the recovery of populations of certain non-fish species through competitive interactions (Steller sea lions), or bycatch rates (albatross, Yukon-Kuskokwim salmon), and management efforts aimed at protecting these species.

Managing a fair and sustainable aquatic ecosystem for residents and non-resident users of the Bering Sea is challenging enough without global climate change. The eastern Bering Sea is now a cultural crossroads where commercial fishing, oil development,

military activities, sports hunting and fishing, eco-tourism, and many other activities have drawn people from all over the world to live and work in and around the region both permanently and seasonally. As a result, the sustainability of the Bering Sea region has become an international concern culturally, socially, and economically.

While the economic, cultural, and social contexts of life have changed through time – most rapidly in recent centuries – the Bering Sea has been a platform for human survival and cultural elaboration for thousands of years. As a result, there is a long record of human accommodation to changing climate and ecology in this region. In some cases, and for some people, change has brought new opportunities (new food sources, better traveling weather). Perhaps more often change has led to greater uncertainty and periods of significant adjustment. People have also had their own impacts on local and regional ecosystems, some of which have had unintended negative consequences (e.g., pollution of streams, degradation of stock populations) and others of which are viewed more positively (e.g., conservation measures, development of new fisheries). These human-environmental interactions played out and continue to play out at various scales of space and time. Ongoing and future ecological variation will not be easily understood simply as a product of climatic forcing, just as ongoing and future social, economic, and political changes cannot be inferred directly from climatic and ecological functions. The Bering Sea ecosystem should properly be viewed as a point of intersection between natural, social, and cultural interactions.

Human Responses and Contributions to Environmental Change

According to the Arctic Climate Impact Assessments and ecosystem studies done in the Bering Sea region, people can anticipate a number of drastic changes to arctic/subarctic environments both in the near and distant future (see BEST 2004, Hassol et al. 2004). These changes will affect a wide range of people, and may modify the types of hunting and harvesting that are possible, the commercial availability and distribution of target species, the types of infrastructure that are viable, transportation and shipping, and people's understanding and knowledge of their environment.

Archaeological evidence shows that, over the last 15,000 years, people settled the peri-glacial and post-glacial Beringian landscape and gradually expanded their range of specialized adaptations for hunting, fishing and gathering on the tundra, and migrated into the spreading interior forests, along the rapidly flooding southern Bering Sea rim, and ultimately around the ice-bound northern, eastern and western margins of the basin. This process was complete by at least 5000 years ago, and human communities have used every stretch of Bering Sea coast since that time.

Given their long history of occupation in the region, indigenous groups have experienced and adapted to many long- and short-term cycles of climate and environmental change in the Bering Sea region. Some of these changes may have been comparable to current trends, though none are likely to have been as rapid or of the magnitude predicted for the next 50-100 years. Through this history of human occupation, climate has oscillated on millennial to decadal time scales. Many of the longer-scale oscillations are recorded in the paleoclimatic, paleoecological, and archaeological records (Ager 2003, Anderson 1978, Bradley 2000, Colinvaux 1981, Hoffecker and Elias 2003). Some of the shorter scale fluctuations are especially evident in historic and instrumental records of the last century as well as some new high-

resolution records that extend back a few thousands of years (e.g., Finney et al. 2002). Recent research suggests that many of the short term cycles are linked to processes in the Pacific and Arctic basins, such as the Pacific Decadal Oscillation (PDO), the Arctic Oscillation (AO), and the Southern Oscillation (BEST 2004, 13-14 and references). Many of the shorter-scale climate changes as well as the recent unprecedented warming are documented in the local and traditional knowledge (LTK) of Bering Sea residents and non-residents (e.g., Krupnik and Jolly 2002a).

Thus, human response to environmental and climate change in the Bering Sea region is documented in archaeological, ethnographic, and historical (written and oral traditions) sources. Limited research with these sources indicates that communities in the past have experienced climate driven changes in vegetation, animal availability, beach erosion, storminess, and ice cover (Black 1981, Davis 2001, Elias 2001, Hassol et al. 2004, BEST 2004, Krupnik and Jolly 2002a, Loughlin and Otani 1999, Marcy 1998, Mason 1984, 1998, 2001, Mason and Jordan 1993).

Records of past human engagement with climate and environmental change can provide critical information about how people in the past were affected by climate induced changes and how they responded both more, and less, successfully. We need to know more about how changes in the abundance of resources affected hunting techniques and the ability to sustain communities. We need a better understanding of how settlement and mobility strategies changed as a result of changes in prey fields or seasonal ice patterns. Beyond these issues, we need insight into how people responded socially and culturally to environmental changes and challenges. And research is needed that can make what is learned about past responses relevant to contemporary challenges and concerns.

To understand how current populations may be affected by environmental change, we also need better understanding of how environmental change and patterns of resource use interact. We need better data on how people live and work around the Bering Sea, and on what physical or ecological changes would mean for their lives. Research that seeks to understand the potential effects of climate change in the Bering Sea ecosystem, including its physical characteristics, impacts on higher trophic levels, and interactions with human activities, will help those living and working in the Bering Sea region to anticipate, plan for, and accept change (see Schaaf 1995).

The BEST science plan (BEST 2004) outlines a number of concerns facing the Bering Sea ecosystem as the climate changes: the sustainability of marine resources for commercial and subsistence use, changing productivity in the Bering Sea, and the speed of environmental change occurring in this region. Alaska residents and non-resident users are fearful that their economic and cultural systems will suffer under such large-scale change, and some feel they have not been able to adapt quickly enough to environmental change (Krupnik and Jolly 2002a). Loss of hunting culture, declining food security, and health problems are all concerns among Native groups, as is the potential increase in commercial shipping activity and oil drilling as sea ice diminishes (Appendix 1; Hassol et al. 2004). Changes in biogeography and productivity of commercial fish species are also concerns for non-Native and non-resident groups working in the Bering Sea fisheries. Such concerns can be addressed through a cooperative approach that considers a variety of human groups from an ecological point

of view, and that works directly with stakeholders to help anticipate change and to develop adaptive strategies.

While not significantly discussed in the BEST natural science plan, it is important to address potential interacting effects on the ecosystem of climate change and human exploitation, as mediated through management institutions. BEST (2004) describes the scientific question of top-down vs. bottom-up ecosystem regulation. Whenever there is top-down regulation, human exploitation, which is generally near the top, affects the entire ecosystem. Heavy human use could also affect the timing of ecosystem shifts from bottom-up to top-down regulation, if people are consistently taking a lot off the top. In other words, there is a scientific rationale for the concerns that local residents have expressed about the ecological implications of heavy commercial harvesting, just as there are for concerns about climate change.

Guiding Research Questions and Themes

Research Questions

Because humans participate actively in the Bering Ecosystem, BEST research needs to attempt solutions to broad questions like:

- How might environmental change affect subsistence and commercial opportunities in the Bering Sea and the ability of groups to travel on ice and ocean?

- How will communities (families, villages, regional organizations, boat captains and crew, cooperatives, processors, operators, managers, and policy makers) respond to these changes?

- How will these changes in human use of the Bering Sea have reciprocal impacts on the Bering Sea ecosystem itself? (local, regional, or system-wide and relate to increased or decreased catch rates, pollution, and settlement)

To answer these questions, we need to answer many more detailed questions related to the following themes or topics.

Research Themes

1. Subsistence

Definition

Subsistence in this document follows the definition provided by the U.S. Federal Government in the Alaska National Interest Lands Conservation Act:

> "[T]he term "subsistence uses" means the customary and traditional uses by rural Alaska residents of wild renewable resources for personal or family consumption as food, shelter, fuel, clothing, tools or transportation; for making and selling handicraft articles out of non-edible byproducts of fish and wildlife resources; for barter or sharing; for personal or family consumption; and for customary trade." (ANILCA 16 USC §§ 3113)

Alaska Natives in the Bering Sea region have traditionally made a living through subsistence activities, primarily hunting, gathering, and fishing as well as the manufacture of tools, arts and crafts from products of subsistence resources. Use of subsistence practices to sustain communities has depended on environment conditions, available technology and knowledge, and social organizations. While the Bering Sea coastal environment is rich in wild marine resources and some terrestrial resources, the availability of food is vulnerable to weather, climate change, and hunting pressures, factors which have been observed both in ancient and recent contexts (Hassol et al. 2004, Black 1981, Krupnik and Jolly 2002; Mason 1984, Yesner 1998). To cope with these problems and make the best use of their environment, people have developed the techniques to harvest a wide spectrum of resources, and subsistence success continues to rely on the ability of people to adjust their subsistence technologies and strategies (Davis 2001, Rousselot et al. 1988).

While starvation was not alien to Alaska Native groups before contact, group hunting, food storage, and sharing helped people to cope with irregularities in subsistence production. These practices remain an important part of Alaska's Native cultures today – as important for maintaining cultural identity as for providing food. Many people continue to rely on subsistence practices to survive, but the global economy has added other dimensions to survival in the Bering Sea region (Dames and Moore 1978, Langdon 1986, Tuck 1986, Wolfe 1984). Within rural communities, food sharing is a convention of great importance that helps the children, elderly and unfortunate to survive. Where unemployment and underemployment are the norm, subsistence production is the pressure valve that helps communities cope nutritionally and culturally. Sharing is also an important component of cultural and interpersonal connections to community members living outside of their traditional villages. Subsistence foods are regularly delivered to relatives in distant places where members have moved for formal schooling, employment, marriage, or the chance of a different or better life. Other necessities of modern life (such as boat and snow machine parts, tools, hunting equipment, clothing, and Western foods) commonly flow back to rural villages under systems of fairly generalized reciprocity (Sahlins 1972). The subsistence lifestyle also imposes a strong pull on wayward community members who often find it hard to adjust to lifestyles and the alien Westernized cultures of cities and towns far from the Bering Sea. Subsistence in the modern context is complex and interwoven with economic, demographic, health and political dimensions. *It is clear that subsistence will play an important role in Alaska Native communities' resilience to future changes. It is also clear that changes in access to subsistence resources could strongly affect this resilience in ways that we do not yet comprehend.*

Subsistence activities in the Bering Sea region are extremely vulnerable to changes in climate and ecology, and changes in these systems will echo through the region's communities. Marine resources are sensitive to climate, and are likely to be significantly affected by habitat loss, increased competition, hydrological changes, sea ice loss, and access to nutrients (Hassol et al. 2004, BEST 2004). These changes will in turn result in decreased availability for subsistence harvests of some resources and may also make other resources more accessible, at least in some areas. Government regulations add another dimension to resource availability: endangered species listings, fishing restrictions, and other environmental protections restrict access to resources. Subsistence is fundamentally interwoven into community physical and social well-being, and restriction of these activities poses both cultural and economic problems (Langdon 1986). Traditional communities often identify themselves as subsistence hunters and gatherers, and much of their cultural activity revolves around this concept (Berger 1987, Borre 1991, Bosworth 1995). Loss of this identity is of major concern among Alaska's Native communities, and has played an important role in legislation, studies of environmental change, anthropology, and other research. Understanding the potential effects of climate/environmental change on subsistence activities in the Bering Sea region is of immediate importance because it has the potential to alter subsistence lifestyles, to make communities more or less vulnerable, and to strengthen or further erode cultural cohesiveness. Subsistence concerns will influence legislation, scientific research, traditional activities, and Bering Sea society.

Research Questions

- How will changes in weather, ice, water temperature and marine species affect subsistence opportunities in the Bering Sea and the ability of groups to travel in pursuit of subsistence resources?

- If an ice-free Bering Sea develops in the near future, how will that affect communities currently dependent on sea-ice adapted subsistence resources? Given that much of the 25 million lbs of mostly meat harvested annually in the Bering Sea is hunted on, around or in the sea ice, what are the implications of loss of sea ice to the capacity of rural residents to maintain subsistence lifestyles?

- How do different communities use subsistence resources? How do these uses differ by geographical location (e.g., relative to sea ice boundaries), by ethnicity (e.g., Iñupiat, Siberian Yupik, Yup'ik, Aleut, Filipino settler, European settler), by socioeconomic status, by access to commercial opportunities? And how are these communities likely to change in response to environmental and social changes? What are the most important economic, social, and cultural goals that guide subsistence decisions? What kinds of knowledge, sources of information, and risk calculations are used to estimate the safety of harvest forays?

- How have climate and environmental changes in the past affected humans living on the Bering Sea? What can be learned about past adaptive successes and failures that can be used to better understand contemporary and future conditions?

Answers to these questions will require information from the natural science teams in BEST relating to the ecosystem dynamics of climate, atmosphere, ocean, ice, and biological processes. They will require information on past and current subsistence practices and their variations with differing environmental conditions. They could include archaeological investigation of past subsistence lifeways and how those changed with environmental changes documented geologically and comparing those with recent and modern practices. They should include synthesis of historical sources (written and oral) about more recent responses to change. They should involve data compilation from existing studies and data sets (e.g., ADF&G subsistence profiles) and partnering with subsistence communities to further refine information about how those communities engage in subsistence. And they should involve modeling of the dynamic coupling of human and natural components of the ecosystem related to subsistence production.

These questions require studies of decision making and choices between strategic alternatives. Research into individual and cultural value systems and their flexibility will help to clarify how subsistence harvesters make decisions about what, when, and where to harvest. Partnership with rural subsistence communities will facilitate the development of local and traditional knowledge (LTK) data sets that can be used by community members and researchers to preserve knowledge and to understand how that knowledge influences subsistence opportunities. Studies of how knowledge is commonly passed on within communities could help to identify critical educational mechanisms that may be vulnerable to social change and that should be preserved to insure that subsistence remains viable as a strategy of physical and cultural survival. Because subsistence pursuit in the Bering Sea involves inherent hazards that may increase with changes in climate and environment, it will be important to study how people assess the risks of subsistence activities, how these assessments are conditioned by cultural values, and how risk calculations are influenced by social and economic forces from beyond local communities.

2. Commercial Fisheries and other Economic Development

Background

Crab, groundfish, halibut, herring, salmon, scallops and other species all contribute to the commercial fishing economy of the Bering Sea. Over half of the total volume of fish consumed in the US is taken from the Bering Sea, with fishing operations ranging from small independent family owned vessels, to multi-vessel fleets owned by large corporations. Vessel sizes range from under 26 feet to over 300 feet (for catcher/processor vessels). Fish are landed at seafood processors from Norton Sound south to the Alaska Peninsula and Aleutian Islands. Statewide, about 5 billion pounds of fish are landed each year, with an average ex-vessel value (varying according to market and harvest conditions) of around 1 billion dollars (NOAA 2003).

Some of these fisheries have been in operation for a long time; nearshore commercial fisheries such as salmon, cod and herring, have been in operation for more than 100 years. Domestic offshore fisheries developed later with the declaration of the US exclusive economic zone in 1976 and with the subsequent Americanization of the fleet. In other fisheries, such as scallops, technological development has enabled growth

more recently. In all cases, the particular fishery is articulated with certain locations (some in the Bering Sea and some not) through vessel ownership, financing, crew labor, marine support and supply services, and fishery access rights.

In 2003, groundfish fisheries accounted for 54% of the ex-vessel value of commercial fisheries in Alaska. Shellfish and salmon accounted for 16% and 15% respectively (Hiatt et al. 2004). The groundfish fishery in the Bering Sea is notable among US fisheries for its high volume of sustained production, a preponderance of large catcher-processor vessels, a quota-based system of harvest rights, and the Community Development Quota (CDQ) program which allocates a portion of the fisheries (cod, crab, halibut, pollock, and bycatch) for the benefit and development of 65 communities located within 50 miles of the Bering Sea coastline. Salmon is also critically important in the region; more than 42% of the state's salmon harvest earnings were generated in southwest Alaska in 2004 (Windisch-Cole 2005).

Commercial fisheries have experienced dramatic change in the Bering Sea in the past. The collapse of the crab fisheries and subsequent rise of the groundfish fisheries is the most well-known example of such change, often attributed to climate regime shift in the region. Economic adjustments driven by global climate change will likely include both loss of some current opportunities and gain of new ones. Change may affect location of settlements and services, social and economic relationships, infrastructure, global markets, employment, income, the transfer economy, safety and many other socioeconomic dimensions of human activity in the Bering Sea.

In addition to commercial fisheries, other economic activities in the Bering Sea include tourism, shipping, mineral extraction, and military operations – all directly and indirectly tied to the state of the Bering Sea and its ecological dynamics. A warming Bering Sea is likely to generate a number of changes in Bering Sea development. Existing and abandoned facilities may become increasingly vulnerable to storminess and coastal erosion – threatening capital investments, the health of the ecosystem, and the people who live by it. Changes in the costs and benefits of economic activities are likely as ice free transport and milder temperatures prevail for longer periods during the year. In the event of an ice-free arctic shipping route, most international shipping traffic using this route will pass through the Bering Sea, increasing the possibility of impacts to subsistence harvesting and commercial fishing and quality of life for Bering Sea residents. Increases in mineral and oil exploration and extraction may generate new jobs and capital expenditure in Bering Sea communities. The negative effects of mineral development on the Bering Sea ecosystem and human health in an area of melting permafrost, reduced sea ice, and increased coastal exposure are currently unknown. Future Environmental Impact Statements (EIS) preceding proposed developments need access to sound scientific information about the ecological dynamics of the Bering Sea and the human connection to it if they are to accurately assess the impacts of new developments.

Research Questions

- How will changes in weather, ice, water temperature and marine species affect commercial fisheries opportunities in the Bering Sea, including seafood harvest

and seafood processing, and the ability of vessels to travel in pursuit of commercial fishery resources or in shipping product from the region?

- If an ice-free Bering Sea develops in the near future, what are the economic costs and sociocultural impacts of substitutions for the potential loss of subsistence resources in purchase, transport, and distribution of alternatives?

- How might climate/environmental change affect the character and location of commercial fisheries, and what effects might this have on communities. For example, if climate change forces an expansion or shift of commercial fisheries north of the Y-K Delta into Norton Sound and the Bering Strait, how are local communities prepared to respond? … how are fishers likely to respond? … how is the fishing industry set up to respond?

- How do commercial harvesters, seafood processors, and hired labor (crew or processing workers) make decisions about their participation in the fishing industry (e.g., harvest strategies, capital investment, employment decisions)? What are the most important economic, social, and cultural goals that guide decision processes? Given their decision bases, how is environmental change likely to affect current practices, and how will those changes affect the economic, social, and cultural condition of families, communities, and businesses?

- What indirect and/or cumulative economic and socio-cultural effects will changes in commercial fisheries in the Bering Sea have?

    - Communities
    - Global markets
    - Support sector

- How will changes in weather, ice, water temperature and marine species affect other economic development in the Bering Sea, including tourism, recreational fisheries, shipping, mining, military operations, and other resource extraction? And how might those operations affect the Bering Sea ecosystem and communities in the area? For example, how does mining wastewater discharge affect salmon habitat and recruitment? What are the short-term and long-term economic and social implications of mineral extraction facilities?

- What kinds of knowledge, sources of information, and risk calculations are used to make decisions with regards to commercial enterprises in the Bering Sea? What variables drive risk-prone vs. risk-averse decisions? How will these calculations affect commercial responses to climate change?

Answering these questions will require information from the natural science teams in BEST relating to the ecosystem dynamics of climate, atmosphere, ocean, ice, and biological processes. They will require information on past and current commercial fishing practices and operating costs and their variations with differing environmental

conditions. They require research into economic decision making and the market forces affecting the fisheries and other economic activities practiced or anticipated in the Bering Sea. They should involve data compilation from existing studies and data sets and partnering with industry to collect currently unavailable information on vessel costs and earnings. And they should involve modeling of the dynamic coupling of human and natural components of the ecosystem related to commercial production.

3. Public Health and Safety:

Background

While people flourished in the difficult Bering Sea climate for thousands of years before the arrival of Europeans, they were nonetheless vulnerable to a variety of health problems (Laughlin and Aigner 1974, Stewart 1979, Zimmerman et al. 1984, Keenleyside 1998, Fortuine 1989). Environmental conditions played an important role in injury and the spread of disease among Alaska Natives before European contact. This is seen in pathologies found in ancient skeletal remains, as well as the difficult living conditions and subsistence practices described by European travelers (Veniaminov 1984, Khlebenikov 1994). With the arrival of European traders, whalers, prospectors, miners, and missionaries, epidemic disease spread quickly and decimated native populations and devastated communities. While not universally destructive, the introduction of alcohol and tobacco made many people more vulnerable to disease, addiction, violence, social stress, injury, and neglect. Epidemic disease continued to spread among Alaska Native populations through the 20th century with the spread of influenza, tuberculosis, smallpox, typhoid, and venereal diseases (Fortuine 1989). While Alaska Natives were often able to deal with the ailments and challenges presented by the arctic environment for thousands of years, European epidemics caused an unprecedented population decline within only decades. Fighting global ailments, modern pollutants, and integrating Native concerns into the American health care system continues to challenge local communities in the 21st century.

In many ways, the increase in health problems has been balanced by improvements in health care since the 18th century (Fortuine 1989, Amer. Public Health Assn. 1984), but there are still persistent concerns about growing health problems among Alaska's rural communities that appear to be a result of modernization and globalization (Katz 2004). These include contaminants and parasites in traditional foods (AK Div. of Pub. Health 2003); types I and II diabetes (CDC Working Group); community-borne pathogens (Funk 2003); HIV/AIDS (Barney et al. 2004, Duran and Walters 2004); heart disease and high cholesterol; adult and childhood obesity (Story et al 1998); substance abuse (Fortuine 1989); and waste management (Suk et al 2004, Amer. Public Health Assn. 1984). These pressing health issues warrant immediate research for both current and future Bering Sea populations. While these are typical concerns across America and many other parts of the world, the interaction of these public health factors with unique dimensions of diet, sanitation, and life-styles in the Bering Sea make them directly relevant to the changes in the Bering Sea ecosystem.

Social and ecological changes have influenced public health substantially, in terms of nutrition, food quality, and environmental quality. Wild foods such as sea

mammals, fish, shellfish, birds and berries sustained Native populations for thousands of years and continue to contribute importantly to rural diets. This subsistence diet has many health benefits (low cholesterol, low rates of heart disease and diabetes, etc). At the same time, Bering Sea residents have increasingly come to depend on imported store-bought foods, often with inferior nutritional and health benefits (Nobmann 1997). Participation in a cash economy has forced many people to give up some or all of their traditional harvest activities because of time and economic constraints, but for many traditional subsistence foods remain important and are linked to social and emotional health (Nowak 1977, Langdon 1986). For example, wild foods are transported from village to inland urban centers to maintain cultural connections. Environmental change has altered the availability of many traditional foods, and government regulations have affected the timing, quantities, and methods of harvests of some hunting and fishing practices. As a result of these changes, many people are beginning to lose the health benefits associated with a traditional diet, and increases in heart disease, diabetes, obesity, tooth decay, and other food-related diseases have been reported during the last fifty years.

Natural and human induced changes in the environment have raised concerns about contaminants in native foods, water quality, and air quality. Industrial toxins that move north from more southerly latitudes may contaminate the air and water, and make their way into subsistence foods through atmospheric and hydrological pathways. Increased levels of primary production in the Bering Sea, as witnessed in 1998 for example, could also increase exposure to natural biotoxins (such as those that cause paralytic shellfish poisoning). In addition, as sea ice is lost, increased industrial activity and travel will raise the likelihood of environmental pollution and contamination within the Bering Sea. While it has been argued that the contaminant levels in Bering Sea subsistence foods are not currently threatening subsistence consumers, there is concern that with climate change this problem could increase (Middaugh et al. 2001, AK Div. of Pub. Health 2003). Such increases could rival the health crisis affecting the eastern arctic, where pesticides and heavy metals are concentrated at critical levels in the subsistence foods of Northern Canadian and Greenlandic peoples (Cone 2005; Van Oostdam et al. 2004).

Environmental change will alter access to traditional foods and the pathways through which biotoxins and pollutants enter or cycle through the Bering Sea system. It is currently unknown how these contaminants will affect Bering Sea populations, though it is likely that health will be vulnerable to changes in the ecosystem. Alaska Native health has not been widely studied, and understanding the relationship between traditional health practices and modern health concerns may help to address Alaska Native health problems in the context of changing natural and social environments.

In addition, physical safety is a public health issue for those living and working on the Bering Sea. Changes in known patterns of sea ice, currents, and water conditions can lead to increased threats to public safety either directly through more challenging marine conditions, or indirectly through a lack of detailed knowledge about how the changed ecosystem is likely to behave, or an increased willingness to take risks in order to continue activities that were formerly less risky. On the other hand, climate changes could make living and working in certain parts of the Bering Sea physically safer, and/or make search and rescue operations easier to conduct.

Research Questions:

- How could changes anticipated in the Bering Sea ecosystem aggravate or alleviate public health problems? How has community health been affected by environmental changes in the past? How might future changes in the Bering Sea climate, ecology, and human use alter health risks? How resilient are different health care approaches to changes in the environment?

- How is public health linked to subsistence and commercial food consumption (nutrition value, natural and anthropogenic source contamination)? What are probable economic, social, and public health consequences of shifts in the balance of subsistence and store bought foods? What vulnerabilities do Bering Sea residents face from global environmental diseases such as avian flu and West Nile virus?

- In what ways are communities dependent on sea ice as a platform for subsistence harvests, transportation and maintaining contacts with other communities? How will changes in sea ice distributions and the predictability of that movement affect these activities? How will safety of fishing, shipping, and tourist operations be affected by changes in ice density and distribution, weather, and currents?

Changes anticipated in the Bering Sea ecosystem have the potential to influence health problems. For example, management of pollution and endangered resources could reinvigorate the use of traditional foods and relieve some food related health problems. At the same time, expanding commercial activity in the region could make Bering Sea residents more vulnerable to problems associated with petrochemicals and other pollutants, destruction of food resources, and other potentially negative side effects of commerce. Additionally, expanded industry could elevate population densities, which require enhanced infrastructure. These factors could bring improved health care to the arctic, but could also pose threats to general health in the region. A better understanding of past health care management, traditional diets and health care, resident Native and non-Native health needs, and the effects of change in the arctic on human health will be useful for evaluating the effectiveness and resilience of Bering Sea communities.

Safety of movement over ice and water is an even more direct issue in the study of human interactions with the changing Bering Sea. Recent accidents have been attributed to changes in ice and weather conditions that exceed the capacity of historical knowledge to interpret. Should the Bering Sea become ice-free combined with expected (and currently observed) northward shift of the Aleutian Low, increased storminess can be expected in the region with attendant hazards to fishing and boat operations in the Bering Sea. With the recent trend in warming and thawing of permafrost, erosion is fast becoming a major problem in coastal areas, where approximately 85 % of Alaskan communities are located. Erosion is currently causing tremendous social, economic, cultural, and physical impacts that need to be understood as they relate to public health and welfare, social integrity, and adaptive response. Reduction of ice-cover coupled with loss of permafrost will increase the rate of coastal erosion in the eastern Bering Sea and

Bering Strait, where communities like Shishmaref and Ingalik (Little Diomede) are already facing problems of crisis proportions.

Health and safety are important concerns among all Bering Sea residents, and will become increasingly prominent issues as globalization and climate change affect this region. Because of the tight interconnection between environment and public health, BEST natural and social science will be critical components of the recommended public health research.

4. Policy and Management:

Background:

Resource management, both formal and informal, is a vital nexus in human interactions with the Bering Sea ecosystem. It affects the ways in which humans impact the ecosystem, and also the ways in which human use of the ecosystem interacts with the social and economic system. Effective management can support health and economic well-being. It requires effective information flow between constituencies and sound information about climate change and its impacts on the system to be managed.

Several management regimes operate in the Bering Sea. The major division is the international boundary between the United States and Russia. In the United States, management is divided between the federal and state governments, depending on species and location, and further divided among agencies in both governments.

Management regimes in the Bering Sea region range from highly effective and respected (the Alaska salmon fishery and the Bering Sea/Aleutian Islands pollock fishery, are two of only eleven fisheries worldwide to be certified by the Marine Stewardship Council as "sustainable" [http://eng.msc.org/]) to problematic and controversial (e.g,. crab, Y-K salmon bycatch, fur seal, and sea lion). Responsiveness to environmental change, equity for and among user groups, protection of habitat and non-harvested species, and the determination of management goals and priorities are among the topics that arise repeatedly in discussions about resource management in the Bering Sea. The diversity of management regimes presents a wealth of possibilities for comparative research.

During the past century, notable changes have occurred in Bering Sea marine resources, which management regimes have sought to affect in different ways and through different approaches (NRC 1996). With future changes anticipated to continue and accelerate, the timing of change, of management action, of equipment investment, of acquisition of necessary skills, and other aspects of resource management and use are key considerations for any attempt to predict and mitigate the dynamics of human-ecological interaction into the future. A responsive management system - such as that in operation for salmon - may be able to reduce human impacts in times of scarcity, but economic impacts may be severe for fishermen who have invested in boats and other gear with expectation of reliable harvests over longer periods. Review of past and present management approaches and their effectiveness may illuminate current and future challenges allowing greater capacity for developing appropriate courses of action for the future.

The responsiveness of management regimes and their ability to anticipate large-scale environmental shifts are currently unknown. Resource use strategies that promote

flexibility and adaptability are more likely to succeed than ones that rely on stability, provided that changes do not exceed adaptive capacity. Distinguishing local anthropogenic (e.g., fishing pressure, local pollution), distant anthropogenic (e.g., long-range contaminants, GHG emissions), and natural (e.g., Pacific Decadal Oscillation, seismic activity) causes of environmental change is likely to remain problematic. Effective management responses may require identifying causal factors (e.g., to stop local pollution) or may simply require adapting to the new conditions (e.g., changing harvest patterns or regulations). An assessment of past changes and responses together with an assessment of plausible future changes may identify strategies and structures likely to be effective in the future.

Considerable research has been done on aspects of resource management and use in the eastern Bering Sea. The structure and function of management regimes is well documented, and most regimes have abundant and detailed records of their activities. Information about responses and impacts prior to the establishment of formal management policies is more dispersed and likely less complete, but its documentation and analysis will add considerably to understanding of the implications of change for the Bering Sea ecosystem and its people. And relatively little existing work has addressed questions of how management can effectively deal with large-scale environmental change or how local (especially residential) Bering Sea communities are affected by management policy developed at the regional scale.

Other federal and state policy arenas are also important to the past, present and future of Bering Sea ecology and society. Education policy for example has had important consequences for rural Alaskans. Traditional education sometimes conflicts with federal and state schooling requirements. For example, policies affecting the distribution of schools and educational resources privilege some segments of the rural population over others. Students who have to move away from home to an available school can have fewer opportunities to join in and learn subsistence practices. Any attempt to model the human effects of Bering Sea environmental change needs to include the legal and political context and its potential volatility.

Research Questions

- How are communities affected by state and government policies designed to manage natural resources, foster economic development, raise education levels, or otherwise? How do different levels of policy and management interact and what are the implications for community resilience to environmental change? How might different management structures affect community vulnerability and adaptability under environmental change?

- How do management policies that regulate exploitation of the ecosystem interact with climate variability and change to affect the long-term productivity and structure of the Bering Sea ecosystem? What are the implications of existing management policies on expanded or transformed fisheries due to loss of sea ice and warming of Bering Sea waters?

- How might environmental change affect current resource management issues? How might current resource management policies and decisions affect the Bering Sea environment Bering Sea communities? For example, how does availability or lack of funding to communities affect resource management?

- What makes co-management agreements between federal and state resource managers and rural communities and collectives more or less effective for wildlife populations and for the human communities harvesting them?

- How vulnerable are communities or their surrounding environments to aging infrastructures?

Comparative studies of the structure, functioning, and effectiveness of various management regimes will help assessments of how they are likely to adapt to a changing environment. Studies of responses to and impacts from changes in the past will place current and anticipated changes in context. Analysis of anticipated changes and potential impacts to resources and their users will provide a basis for assessing resource management needs, priorities, and challenges in the near future. And study of the legal and political system may be important for contextualizing the solutions available to individuals and communities responding to change.

5. People and Communities

Background

Residential communities in the Bering Sea are a central focus of this science plan. Communities are at the nexus of ecosystem, subsistence, commercial activities, public health, and policy as they articulate the physical, social and cultural 'ground zero' of Bering Sea change. Communities are held together by members' common goals and beliefs, traditions, and attachments to each other and to particular places. Communities provide social support structures for individuals and families, created and defined by collective or managed response to challenges confronted in the broader natural and social world. Communities change in response to many factors, including new challenges and opportunities facing its members. When confronted with external challenges, communities often provide opportunities for individuals to work together to meet those challenges. The balance point between adaptation and maladaptation to a crisis is the threshold of vulnerability. Identifying the threshold of vulnerability to any particular kind of threat is important to planning for an uncertain future, assigning research priorities, and allocating effort to meet those challenges. Defining that threshold in any particular situation requires knowledge of human articulation with the natural environment, the ways that communities are organized demographically and culturally, how those organizations facilitate collective response, and the larger economic, social, and political networks in which communities are embedded.

Research Questions

- How are communities vulnerable to change in the coupled human-natural ecosystem? In what ways are different communities socially and economically vulnerable to changes in the availability of subsistence and/or commercial species? … to changes in the distribution, duration, or character of sea ice? … to changes in sea level, storminess, or permafrost?

- What complexities in the socio-economic systems provide resilience to these changes? What factors promote or impede resilience? For example, how do economic structures and programs at different scales interact with social and cultural values held by different communities of Bering Sea residents and users? How do different social configurations (e.g., family and community structure, kinds and modes of education, divisions of labor, information and commodity exchange networks) and formal institutions (e.g., international treaties, federal and state policies and regulations, government agencies, CDQ groups) provide stability or instability in the face of certain or uncertain changes in subsistence and economic returns.

- How have people dealt with environmental uncertainty and change in the past? How are they adapting to such uncertainty now, and how might they in the future?

- What dynamics control human population changes in permanent and seasonal residents and users of the Bering Sea? How are these tied to environmental parameters studied by BEST? How are they tied to economic, political, and social variables? How have populations changed in the past in relation to fluctuations in climate and ecology? Under current and expected future conditions, are some villages more likely than others to remain viable, thrive, or decline? What is driving the urban Native population explosion, and how might this effect Bering Sea public health and social, cultural, and economic systems? What are the consequences of population migration within and beyond the Bering Sea region?

- How does local understanding of the ecosystem (including humans) and its fluctuations shape people's reactions to change? What social, cultural, political, historical, ecological, and other factors play important roles in responses to change?

- How have people been affected by climate and ecological change in the past? What evidence can we generate about changes in sea ice extent from archaeological middens? How have these changes affected the people who lived in these areas?

- How do long-time residents or long-term visitors to the Bering Sea witness environmental change? What knowledge exists that can put current climate and ecological change into historical perspective? How can we integrate this knowledge with instrumental knowledge generated by natural science in BEST? Related to this, how can we involve Bering Sea residents and users in the collection of data to complement research using ship based measurements?

Answering these questions requires varied research approaches and perspectives. A particularly important source of information and analysis will be the perspectives of local Native and non-Native residents on these questions. People act based upon their understanding of situations. This understanding is likely to be shaped by many factors, including their knowledge of the past, their perception of the forces that influence the ecosystem and its people today, and what they have learned from one another or from others (e.g., the research community). A first step to understanding local perspectives is to understand the components and relationships that are recognized in the regional system, for example by building conceptual models. Comparing local conceptual models with the models used by others (e.g., researchers, managers, etc.) can help identify commonalities and differences, suggesting areas for further discussion and research. Cultural consensus analysis (e.g., Miller et al. 2004) is one approach to such comparisons, providing a foundation for addressing the implications of differing perspectives or for acting on common understanding. It is also important that Native and non-Native residents of the Bering Sea be involved in the research advocated here, not simply as subjects of analysis, but as partners included from the beginning in the development and exploration of hypotheses, contributing varied and complementary methods and insights. This will allow the inclusion of community perspectives and approaches that will enrich the scientific process.

Because the coupled human-natural system is a complex one operating at many different scales of space and time, research is needed to assess the extent to which local understandings are appropriate to the scale of challenges potentially facing local communities in the future. To do this, researchers need to integrate knowledge across what are often widely separate domains: local understandings of environment and society, with the diverse fields of natural and social science.

A Community-Engaged Approach

Recently, researchers working in the Arctic and Subarctic have recognized the importance of including indigenous and other local perspectives in the study of environmental change. The rewards of the partnerships between indigenous communities and scientists are well exemplified in works such as "The Earth is Faster Now: Indigenous Observations of Arctic Environmental Change," edited by Igor Krupnik and Dyanna Jolly (2002a). In this volume, nine case studies from Alaska to Labrador explore the environmental knowledge of arctic people along with the unique cultural ways of knowing and sharing that knowledge that have developed over centuries. As studies such

as those reported in their volume have shown, environmental science ignores, at its own risk, the rich, complex, and long term perspective of indigenous knowledge (see also Bielawski 1996; Huntington 2000b; Noongwook 2000; Pungowiyi 2000; Riedlinger and Berkes 2001).

Beyond the benefits to science of including indigenous perspectives, it is also increasingly recognized that scientists cannot continue to approach indigenous communities (directly or indirectly) with the attitudes born of Western colonialist history. In Arctic and Subarctic science (as elsewhere), native communities have more often than not been treated indifferently, if not contemptuously, by researchers from outside. Research and policy agendas developed in response to global, national, state, or industrial concerns tend to ignore or sideline the legitimate interests of rural or otherwise marginalized indigenous communities. Krupnik and Jolly (2002b:3) state:

> Current environmental change is part of a larger group of challenges and changes that people face as northern residents. To many people on the ground, their daily concerns about weather and sea ice shifts are hardly separated from other critical issues, such as oil and mineral exploitation, contaminants, animal rights campaigns, and land-claim negotiations.

Few research projects take such a broad view, with the result that much of the research that is conducted and reported provides little benefit to these groups – indeed, it often supports economic and political agendas that disenfranchise indigenous people in various ways. And frequently the communities are not even briefed on the research results.

In an explicit effort to redress these failings and to create a more inclusive model for research in Arctic and Subarctic regions, the development of this science plan included Bering Sea resident community members from the beginning, following the lead of projects and programs that have reflected or incorporated local and indigenous concerns (e.g., Adams et al. 1993). This is intended to ensure that the science conducted within the *Sustaining the Bering Ecosystem* Program is of greatest importance to the communities with the most direct and most lasting stake in the Bering Sea system. To this end, the organizing committee initiated the planning process with a community workshop in Anchorage (March 25 & 26, 2004). The workshop included 14 Bering Sea residents (several with formal scientific credentials), 10 non-resident social scientists, and 1 non-resident natural scientist (Appendix 1). [1]

The workshop's primary function was to elicit initial ideas from the resident participants to frame a draft agenda for this social science plan. The meeting was productive and resulted in a set of guiding questions, parameters (geographical, temporal, and topical), approaches, community needs (educations, communication, research support and infrastructure), and research topics (Appendix 1). Concerns of the community participants ranged broadly and seamlessly from the foundational issues of climate and

[1] This group came together to share their individual perspectives on the issues facing Bering Sea communities and approaches to research that could help communities adapt to the challenges they are facing or anticipate. While the group was generally representative, participants were not selected by their communities as representatives and would not intend that their input into this process be seen as more than individual input. Subsequent community meetings are needed to get additional feedback on the organization of this plan and its recommendations. One such meeting is planned for February 2006.

ecology that are central the to the BEST natural science plan (BEST 2004) to subsistence, employment, infrastructure, resource management, health, and politics. Much of the discussion turned on the ways communities must be better informed and involved in the research that affects them. Participants of this group continued to provide critical input as this science plan developed. In the long run, the science proposed under this plan is expected to benefit from community partnership and participation. In turn, resident communities will benefit from the science, as they seek to protect their continued survival in the Bering Sea ecosystem.

Box 2: Research themes of interest to Bering Sea residents linked to climate and ecological change:

- Ecological health/stability
- Climate change and loss of sea ice
- Affects on modes and hazards of travel
- Availability of subsistence foods
- Availability of traditional/culturally important resources
- Changing economic opportunities; economic vulnerability
- Development and its beneficial and detrimental impacts on environment and communities
- Environmental contamination
- Public health
- Social vulnerabilities/ resilience (adaptability)
- Education
- Resource management
- Migration
- Preservation of language and cultural knowledge

The list of research themes that emerged from the community workshop (Box 2) touches on a number of overlapping concerns and interests. These themes formed the foundation of the Research Themes section above. As Bering Sea residents of the workshop were drawn primarily from Alaskan Native communities, their interests related strongly to concerns about the ability of their communities to maintain their livelihoods and cultural traditions around the Bering Sea. While the development of this plan has involved many resident community members, the shape of this plan is also influenced by the interests of non-resident stakeholders, especially non-resident commercial fishers who have themselves considerable economic and cultural stake in the sustainability of the Bering Sea. [2]

Community Partnerships:

Changes in the Bering Sea climate and ecosystem will most directly affect the people who depend on the region and its surrounding areas. These groups have a

[2] Alaskan Natives and other residents work in all of these industries along side non-residents. The groups are divided throughout this document on the basis of residency because the interests and concerns of residents (especially Native communities) about the status of the Bering Sea ecosystem are often broader than and different from those of non-residents.

legitimate interest in scientific research of the area. They also can provide observations, thoughts, and questions drawn from their intimate experiences with the Bering Sea that will be vital to shaping research and identifying important patterns that may not be readily apparent from conventional scientific instrumentation. Recognizing cultural and spiritual values and practices, developing cooperative agreements, supporting community-driven research, and making research applicable to local communities are all fundamental goals of the BEST social science program and present a unique approach to research that is expected to become increasingly important in the future. Partnership between stakeholders and scientists will be essential for developing increased understanding of socio-ecological dynamics of the Bering Sea ecosystem, trajectories of change, and how best to plan for changes. *Accordingly, effective communication between scientific teams and the people who live and work in the Bering Sea region should be an explicit goal of every project. An active commitment to communication from the inception of research through to the reporting of results will fulfill the important goal of addressing those issues that are important to the communities and conscientiously integrating scientific research with local concerns.*

Box 3: Local and Traditional Knowledge

"Despite all the attention currently being given to climate change globally and in the Arctic, indigenous perspectives are all too frequently overlooked… Understanding and addressing climate change simply cannot be done without incorporating their specific and detailed views." (Huntington 2002:xxi)

"It looks increasingly obvious to polar scientists, Arctic residents, and the general public alike that Arctic indigenous people have a special stake in modern studies of global environmental change. They also have a lot to contribute—when and if they are given the chance and the appropriate means to participate fully in the ongoing global change discourse." (Krupnik and Jolly 2002b:2)

A frequent topic in discussions of community involvement is that of local and traditional knowledge (LTK)[3]. LTK can be a topic of research, a method for research, a means of achieving community involvement, a bridge between social and natural sciences, and many other things. First and foremost, it reflects the ways in which local and indigenous residents see and understand their world, based on years and generations of observations, insights, and the need for accurate information to provide for themselves, their families, and their communities. For the purposes of this research plan, LTK is all of these things, and thus cuts across many of the sections of this document. Here, we draw attention to the significance of

[3] LTK is also known by various other phrases such as traditional ecological knowledge, TEK, traditional knowledge and wisdom, indigenous knowledge. We follow the lead of the North Pacific Research Board and use LTK because it includes both Native and non-Native persons and their knowledge.

LTK in understanding the Bering Sea and its people and in conducting research in the region.

LTK offers a wealth of information about the Bering Sea and wisdom about the role of humans in the ecosystem. Harvesting that information requires close cooperation with communities and individuals in the region, which in turn requires developing a shared purpose and sense of trust as the distinction between researcher and research subject gets blurred. LTK offers a view of the natural world over time and space beyond what can be captured from scientific records. It also shows the ways in which people perceive their environment, which is a crucial component of any effective resource management strategy. Studies that involve LTK can add breadth and depth to our understanding of the system, its function, and its human dimensions.

At the same time, studies that involve LTK can promote the development of more effective partnerships with the region's communities. When scientists and local residents work together, sharing information and seeking answers to common questions, they are far more likely to understand and respect one another's talents and perspectives. In so doing, they lay the foundation for collaboration not only in individual projects, but also across overall research programs and beyond. In this way research may offer greater benefits to the individuals and communities in whose areas it occurs, helping them share their knowledge and concerns with others, learn from those with different knowledge, and chart the course for their own futures.

With this in mind, we encourage researchers involved in "*Sustaining the Bering Sea Ecosystem*" and BEST more generally to consider how to engage LTK in their studies and develop/strengthen partnerships between holders of this knowledge and experienced scholars.

Methods and Perspectives:

Documenting change in the Bering Sea ecosystem and its human components is the driving force behind BEST social science, and can be done from many perspectives including anthropology, archaeology, sociology, geography, economics, fisheries and marine science, ecology, and climatology using a number of lines of evidence, including observations from local and traditional knowledge and oral histories, indigenous monitoring programs, historical records, surveys, focus groups, participant observations, census and other population data, instrumental data, and sample collections (for physical and biological oceanography, for example). Scientists have been establishing a baseline for understanding the environment and its relationship with humans and their economic and social activities, while local communities have observed change for generations and share these observations through stories, oral histories, and cultural traditions. All groups

have an interest in protecting the future. Combining approaches to documenting change in the Bering Sea region has become increasingly important and is now an integral part of the BEST program.

1. Archaeological, Paleo-anthropological, and Paleo-ecological Research

Archaeological data if properly developed and analyzed has the potential to extend historical analysis of environmental change and human response back orders of magnitude earlier than historical and instrumental sources. As a complement to contemporary, high temporal resolution analysis of physical, biological, and social trends, archaeological research can reveal longer term processes and cycles of change. These analyses can provide clues to ecological successions to be expected if current trends continue. Because archaeological deposits include evidence of correlated natural and human changes, it is possible to use them to understand how environmental change has stimulated human response in the past. These observations can provide baseline data for modeling possible responses to future environmental changes under modern conditions. A particularly salient object of archaeological analysis relevant to the BEST emphasis on loss of sea ice is change in the distribution of sea ice and open water through the presence/absence of ice-adapted marine mammal species. An example in reverse is the discovery of ice adapted fauna from archaeological middens in the eastern Aleutians (Unalaska Island) that included bones of polar bear, walrus, bearded and ring seal dating to 4500 years ago (Davis 2001). Where acceptable to descendent communities, it is also possible to study human biological and epidemiological consequences of environmental and demographic changes in the past from preserved human tissues (e.g., Rubicz et al 2003). Paleoecological studies defined broadly to include retrieval and analysis of pollen cores, tree-rings, animal and plant remains (inn or out of archaeological deposits), and coastal geomorphology/ stratigraphy can help reinforce archaeological and paleo-anthropological analyses, providing proxy data for past climate regimes. Of direct relevance to BEST research, these data can reveal past variation in temperature (air and marine), salinity (marine), rainfall, storminess; food web length, and marine productivity (Anderson et al. 2003; Finney et al. 2000, 2002; Hirons 2001; Hirons et al 2001; Mason and Jordan 1993).

2. Local and Traditional Knowledge –Native and non-Native users of the Bering Sea have developed extensive place-based knowledge about Bering Sea physical and ecological dynamics and change (e.g., Huntington et al. 1999, Oozeva et al. 2004). Elders and other "old-timers" who have lived, fished, and traversed areas of the Bering Sea for decades have observed changes on inter-decadal time scales that provide a context for and complement to instrumental data of higher temporal resolution but often lower spatial resolution. Multi-generational residents (esp. Alaska Natives) have oral histories that can extend these records of change back many generations (Kawagley 1995). Traditional knowledge collection and synthesis requires the cooperation of knowledge holders who are most willing to share their insights when they can expect a beneficial outcome from that sharing (e.g., Huntington et al. 2002). Social scientists and resident communities have been successful in developing ecological knowledge partnerships that are designed through respectful collaboration, in a model in which knowledge is not "captured" or "taken" from the community, but rather shared and

developed into mutually beneficial resources that when integrated with other scientific data sources can be especially useful for community and scientific purposes (e.g., Kofinas et al. 2002). We recommend that mechanisms be built into BEST for the formation of such ecological knowledge partnerships that can serve as hubs of coordination for the comparison and integration of traditional knowledge and BEST natural science within resident communities. We also recommend that similar information cooperative or networks be established in fishing communities.

3. Ethnographic analysis – Ethnographers study communities through participant observation, individual and focal group interviews, and linguistic analysis. These methods can reveal information relating to the organization of activities, interactions in social, political, and economic networks, and the structure of value systems that guide proximate decisions and actions. Related to BEST, ethnographic research is desirable focusing on subsistence traditions, practices and technologies; engagement in wage employment and the cash economy; investment strategies; travel over land, sea and ice; and the importance of these and other activities to communities. Alaskan ethnography has focused on these same types of issues for decades, but the rapid environmental changes occurring in the past few decades demands renewed efforts in this area, as communities are already observing and responding to environmental changes. A relatively unexplored domain of ethnographic research that should be encouraged within the BEST framework is ethnographic research into the commercial fishing industry (both Native and non-Native).

4. Economic Analyses and Modeling– Any effort to understand the implications of environmental change on communities of Bering Sea users requires collection, analysis, and modeling of economic conditions, networks, and structures. This includes study of the dynamics of mixed subsistence and cash economies in rural and transient (e.g., fisher) communities, transfers of cash and goods (e.g., subsistence products, equipment, and supplies) between households, communities, and rural-urban dyads as these transfers affect risk distributions, and concentrations or dilutions of wealth and opportunity. Changes in ecological conditions are expected to force changes in redistributive mechanisms and structures of economic opportunity. Ethnographically sensitive, economic models need to be developed that can be coupled to ecosystem models to better understand the implications of expected or possible future environmental conditions on subsistence and commercial users. These models should also seek to predict conditions that might provoke increased or decreased human impacts on natural systems (e.g., increasing numbers of fishing boats in the Bering Sea to take advantage of greater fishing opportunities might result in elevated pollution and bycatch, while loss of price for fishing and a depressed fishery would have the opposite effect).

5. Social and Demographic Analysis– Related to economics, research is needed to understand changes among the populations of Bering Sea communities. Important to the question of the survival of rural lifeways in the Bering Sea is an understanding of the basic structure of communities – composition, rates of growth, marriage and migration, birth and death rates, sex and age profiles – as these relate to cultural, economic and other conditions. Demographic models could be coupled with economic models to understand

complex interrelationships, and plan realistically about policy outcomes. Between communities, and within any one community, wide variations often exist in the extent to which different individuals and families depend upon different environmental, economic, and social resources. Interviews, surveys, and secondary analysis can sharpen the focus of general concerns about environmental impacts: who will be most affected, and how?

6. Public Health Implications of Bering Sea Change – An important focus arising from attempts to understand the human dimension of Bering Sea ecological change concerns understanding and predicting the consequences of a changing natural and social system to the health and welfare of Bering Sea residents and non-resident users. Changes in access to quality subsistence foods, for example, has significant implications for public health, where economical replacement foods might be of lower quality (e.g., junk food consumption has already had a negative impact on some local communities), or where subsistence foods may become more contaminated. Likewise it would be important to study the infrastructural capacity of rural Alaska to support health care under changing demographics and economics driven by a changing Bering Sea ecosystem. Local ecological change is also a likely outcome of changing population distributions, development projects in some areas and abandonment of others.

7. Managing for Change – Subsistence and commercial activities in the Bering Sea, like elsewhere in Alaska waters, are heavily managed at the national and state level by processes that are at best marginally sensitive to ecological dynamics, social variability, or cultural difference. BEST social science can provide an important service by studying processes of resource management and modeling their implications for different communities of users under changing environmental conditions.

8. Modeling – Understanding the resilience of modern Bering Sea dependent communities encourages a combination of modeling. Modeling is needed to describe the possible linkages between the ecological system and the human system in their varying dimensions. Practicality dictates that this modeling effort be focused on a limited set of interactions between natural and human systems and within the social systems (e.g., economy, demography, health, law and politics). Some dimensions, such as subsistence and commercial resource extraction, infrastructure vulnerability, and public health affecting people living and working in the Bering Sea may be more central to modeling efforts, while others, such as state or federal policy mechanisms may be best modeled as external constraints on the systems that are more dynamically linked to Bering Sea ecology. We envision 1) comparative statistical analyses and 2) dynamic system modeling as critical tools in the economic, social, and demographic modeling, and in developing broader models that can integrate with ecological models from the natural science teams under BEST.

9. Comparative and Integrative studies – One of the goals of BEST is to integrate many aspects of Bering Sea research. Comparative research is encouraged as effective means towards interdisciplinary and intercultural integration of data and understanding. Such studies along the Bering Sea coast, across different ecosystems within and beyond

the region, and among different groups of people will be useful for integrating individual case studies into the larger goals of BEST and for making research widely applicable and relevant. Comparative studies addressing the significance of climate impacts and social changes, of observations of changes and management strategies, and of economic opportunities will be informative for all communities in the Bering Sea, and will encourage interaction and communication.

Integrated analysis of information from different disciplines and observational frameworks, within common time and spatial dimensions, will yield new insights into the changing Bering Sea ecosystem and its human component. BEST's goal is to assemble data and facilitate synthesis research to enhance understanding, cooperation, and the potential for useful predictions about the region's future. Interdisciplinary collaborations fostered through workshops, comparison of findings, and construction of statistical and social-ecological systems models will be critical to meeting this goal fully.

Broader Components of Research Related to BEST.

Education:

Education is an important component of the BEST social science program because it will be an integral part of interdisciplinary research, community participation, cooperation between locals and scientists, and in the development of research in the future. Education can come in many forms: formal and informal, through community schools, providing research experiences for undergraduate and graduate students, providing internships, and a wide variety of other opportunities. Such opportunities will be important for creating community partnerships and a sustainable research program, and for empowering local communities to research and manage their own ecosystems. Contrary to common expectation, community engaged research also requires education of non-local scientists to the customs and concerns of host communities. We strongly recommend that BEST scientists seek out cross-cultural orientations, and familiarize themselves with established community protocols before engaging in significant community-related research.

Information Sharing:

The flow of information among BEST researchers and affiliated communities will be vital for the success of this research program, and is a priority for the organizers and participants. Sharing information among researchers and communities, with agencies and managers, and internationally will require managing different languages, cultures, and disparate access to modern communication. Successful use of the information generated by research will also require strong partnerships and communication protocols, as well as good data management, data sharing, and archiving to ensure the future of this research program and its applicability. An issue of considerable concern at the March 2004 workshop with Bering Sea residents was the inadequacy of effective communication between outside researchers and the communities in and around

which they work. By bringing communities into the research process as partners from the beginning of research planning and question development, we believe communication can be fostered to the mutual benefit of all.

Toward a Holistic Understanding of the Bering Sea Ecosystem: Coupling Natural and Social Science

This plan is a guiding document developed to recognize a pressing need for social science research to more fully understand the dynamics and social contexts of Bering Sea ecological change. To be effective, the research advocated here should be integrated as much as possible with studies of the linked climate, oceanographic, and marine ecological systems. These natural science dimensions are the focus of the BEST science plan (BEST 2004), as well as research efforts supported by a number of other Federal and State agencies (e.g., ASFC, NPRB, ADF&G). The BEST science plan focuses natural science efforts towards understanding the dynamics of climatic forcing on ecological primary and secondary production in the Bering Sea marine system. This social science plan emphasizes the link between the human and natural systems, focusing on the engagement of Bering Sea residents and the strengths of relevant social sciences such as human ecology, anthropology (archaeology, ethnography, biological anthropology, medical anthropology, ecological anthropology), economics, political science, psychology, sociology, and public health.

The natural and social science plans were developed separately, in part because of the much earlier start of the natural science planning process, but ultimately neither plan can succeed in achieving a comprehensive synthetic understanding without collaboration and integration across the natural-human interface. It is the greater understanding of human-environmental interactions in the context of a pressing social need for this understanding that makes this cross-disciplinary collaboration exciting and worthwhile. For this reason, the BEST natural science plan (BEST 2004) and this social science plan will be merged and synthesized in implementation, integrating the natural and social sciences towards a common understanding of the Bering Sea ecosystem from physical processes to people. A draft Implementation Plan is already developed that brings these plans together for an initial focus on issues surrounding loss of sea ice in the eastern Bering Sea (see http://www.arcus.org/Bering/).

There is a tendency in science to segregate the world into research domains that inhibit the understanding of complex wholes. The artificial barriers to synthetic research are nowhere more pronounced than between studies of the "natural" world and that of the "social" one. With the addition of a social science component, BEST follows recent momentum (e.g., NSF Biocomplexity - Coupled Natural-Human Systems) to overcome these disciplinary and thematic boundaries and bridge the natural and social science domains towards a more complete understanding of ecological dynamics in the Bering Sea. To facilitate integration and synthesis, this plan encourages interdisciplinary field research and modeling of the complex and interconnected natural-human systems. It is only through coupled human-natural models (conceptual, systemic, and/or quantitative) that we will be in a position to significantly understand the dynamics of the Bering Sea ecosystem, to make meaningful decisions about what to protect and how, and to provide

communities the information they need to make informed choices about how best to defend their livelihoods, health, and culture in a changing world.

BEST Social and Natural Science: A Strategy for Coordination:

The BEST Science Plan (natural science) recognizes the enormous social and economic influences the Bering Sea ecosystem has on local areas, the United States, and on the world. Fish catches, job availability, Native subsistence practices, infrastructure, and other important economic and social activities will be influenced by the physical and biological changes described in the BEST natural science document (BEST 2004) as well as the anthropogenic ones discussed here. BEST social science will provide necessary research on the relationship of socio-economics and climate change in a variety of contexts, as well as possible solutions to problems facing social and economic systems in the Bering Sea region. Combining these research plans will be vital to survival of communities and commercial enterprise in this region.

The following points summarize the holistic potential of BEST as an integrated approach to physical, natural, and social science and the logistical issues of this program within the field of Bering Sea research supported or conducted by various agencies and organizations:

1. BEST (natural and social science combined) presents an ambitious vision for the integration of ecological research from physical oceanography to social science – with an explicit effort to direct scientific discovery towards meaningful application to problems that Bering Sea users may face under continued climatic warming and loss of sea ice in the Bering Sea.

2. BEST science will focus on oceanographic processes from physics to secondary production (zooplankton, forage fish, and birds) and on human integration with the Bering Sea system especially in the role of humans as commercial and subsistence users of and migrants through the system. Because several other agencies collect upper trophic data (e.g., stock assessments for commercially valuable fish species, protected marine mammals, and some birds: e.g., Alaska Department of Fish and Game's Subsistence Division[ADF&G]; NOAA's Alaska Fisheries Science Center [AFSC], including the Alaska Marine Fisheries Service [AMFS] and National Marine Mammal Lab [NMML]; the U.S. Geologic Survey [USGS], and U.S. Fish and Wildlife Service [USFWS] among others), new data collections on non-human upper trophic portions of the Bering Ecosystem will not be an explicit focus of BEST as program to the extent that BEST is identified as an NSF sponsored program; however, it is expected that BEST researchers will seek to partner with researchers in these other agencies or otherwise draw from these existing data sets to study the ecosystem effects of "bottom-up" forcing from the lower levels to people and "top-down" forcing influenced by human participation in the system. This effort follows growing interest in model coupling or integration through natural and social systems (e.g., NSF's Biocomplexity in the Environment, Coupled Natural and Human Systems [CNH] Initiative).

3. In an effort to strengthen the "end-to-end" science that BEST envisions, we must work to establish partnerships and a coordinated vision among other agencies with scientific responsibility for studying the parts of the system that are expected to be neglected by any NSF funded BEST initiatives. An established inter-agency working group has been formed to help coordinate Bering Sea research towards an integrated understanding of the Bering Sea ecosystem. This group convened in July 2005 with representatives of BEST, AFSC [AMFS & NMML], USGS, USFWS, as well as the Alaska Ocean Observing System (AOOS), NOAA's Pacific Marine Environmental Laboratory (PMEL) to facilitate the integration of Bering Sea Research over the next several years. This group is well positioned to help Primary Investigators explore these partnerships. Coordination should be attractive to researchers working on both the lower and upper margins of the "upper trophic" marine species. For example the linkage between zooplankton/forage fish to commercially important fish, and critical subsistence species of fish and marine mammals so important to BEST is one that should be of great interest to NMFS and NMML scientists seeking to develop ecological models and management plans for these species. Likewise, the relationships between upper trophic marine organisms and people should be attractive to managers and management based science.

4. A unique contribution of this plan to BEST is not only a social science dimension, but a relationship between scientists and Bering Sea user communities. Because the BEST social science planning effort started with Bering Sea residents, the goals and interests developed in this plan provide an opportunity for all of BEST to develop science and outreach that is tuned to the needs of Bering Sea users. While the initial stages of this plan were focused on establishing a relationship with Alaska Native residents, this focus is expanding to include non-Native settlers, fishers, and other users. This focus on community goals and interests is not limited to social science but instead establishes an expectation for communication between all BEST scientists and the people who live and work in the Bering Sea throughout the implementation of BEST.

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Appendix
Community Forum: March 25-26, 2004

This Appendix contains an outline of the March 2004 Community Forum that initiated the development of this science plan preceded by an abridged version of a letter sent to the Forum members explaining the outline.

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26 March, 2004

Dear Friends.

The following is a revised version of the notes from the Humans in the Bering Sea Ecosystem Community Forum which was convened at the Sheraton Anchorage Hotel on the 25 and 26 of March, 2004. We were pleased that all of the participants were able to join us at such short notice, especially the elders James Charles, Charles Johnson, Anthony Murculief, Luther Nagarak. We were also sorry that we were not able to get participants from all areas of the Bering Sea, and look forward to continued feedback as we move this process forward.

Our goal in this meeting was to begin to talk about the kinds of research that would best serve the interests of the resident communities of the Bering Sea, as these residents are the most directly engaged in and dependent on the Bering Sea system. With the start made at this meeting, we hope to be able to develop a research plan for the National Science Foundation that will initiate responsible community centered research and partnerships between communities and research. If successful, this plan will receive approval for funding, and the NSF Arctic Social Science program will be able to start funding research proposals within a few years. Beyond that goal, we hope that this process provides a model for future collaborative research in and around Native communities… a process that will continue to improve as we learn how to do it better.

The following notes are provided to help participants communicate the goals and points of discussion of the meeting to other community members and researchers. We hope to receive additional ideas for building these notes into a draft of a science plan that benefits Bering Sea residents and starts with resident concerns and interests.

Once again, we would like to thank all of the participants: Elders and other residents of the Bering Sea as well as the non-resident social scientist. Many of these participants traveled far from home with little advance notice. We honor your willingness to make this sacrifice and look forward to your continued participation as we move this process forward.

Humbly and Respectfully,

The Organizational Committee

Mary Pete, Henry Huntington, Ben Fitzhugh
with oversight and guidance by Anna Kerttula

Notes resulting from March 24,25 Bering Sea Community Forum Workshop. Participants included: James Charles, Charles Johnson, Anthony Murculief, Luther Nagarak, Patricia Cochran, Adelheid Herrmann, Jennifer Hooper, Allen Joseph, Mary Pete, Karen Pletnikoff, Meryl, Towarak, Margaret Berger, Linda Buckley-Green, Ben Fitzhugh, Matt Ganley, Victoria Goffman, Henry Huntington, Anna Kerttula, Dennis O'Rourke, Kate Reedy-Maschner, Gay Sheffield.

Suggested Titles

- Sustaining the Bering Sea: An Indigenous Perspective
- Sustaining the Bering Sea: A Community Driven Approach
- The Bering Sea is Our Life
- Humans are a Part of the Bering Sea Ecosystem

I. Guiding Philosophy and Vision

- Spirituality: The place and self-definition of residents of the Bering Sea is of supreme importance. A community-fostered science process must involve awareness of the
    - Relationship to the renewable resources from the Bering Sea
    - Relationship to land and sea and winds
    - Source of power, authority, and knowledge
    - Relationship to others, language, tradition
    - Following guidance of the elders
        - Understanding, recognizing the dignity of, and incorporating traditional knowledge
    - Need to involve younger generations
    - Hopes for the future

- Community Driven Questions: The best research imaginable is research that addresses questions of critical importance to affected communities and other interests. There can be no more important group in the Bering Sea ecosystem than the resident Native Alaskan communities whose livelihood and cultures depend on the health and sustainability of this ecological system. We believe that science framed around resident Native interests and concerns and that recognizes Native sources of knowledge will generate better and more useful science.
    - What are communities interested in?
    - What hypotheses come from community observations and knowledge?

- Information for planning: The goal of this plan is to provide information for communities to meet their planning needs.

- Decolonializing research, empowering resident communities to guide and partner in Bering Sea research.

II. Guiding Questions from a community perspective:

- What does the connection to the Bering Sea mean to residents? (Adelheid Herrmann)
- Are communities going to survive? (Allen Joseph)
- How can we save ourselves and the Bering Sea? (Allen Joseph)
- How did we get to where we are today? (group)
- What factors will influence the future? (group)
- What future would be ideal? (group)
- How can we get there? (group)

III. Scope (Geographical, Temporal, Topical)

- International Issues: Different parts of the Bering Sea are connected, ecologically, biologically, culturally, economically

- Comparative studies : Important to compare what is happening in different regions and through time.

- Information Flow: We need to encourage research that will help us to communicate between cultures on important research issues and ways to address them (linguistics, psychology, culture)

- Spatial Scales:
  Need research that will range from local to Bering Sea wide scales

- Temporal scales:
  - Past (at various scales) to answer question: How did Bering Sea ecosystem and communities come to be the way they are today?
  - Present: What is happening now?
  - Future: How can we predict or forecast possible changes so communities are better able to make decisions (Where are things going?)

IV. Focus on Approaches to Research

- Documenting Changes: Oral histories, establishing baselines, monitoring impacts, protecting the future
- Information Flow
- Comparative studies

V. Needs for Education and Communication

- Cooperative Agreements
- Resource Management
- Education and Capacity: Improve ways to communicate between communities and non-resident researchers.
- Spirituality
- Information Flow
- International understanding and communication
- Human factors in environmental studies

VI. Needs for Research Support and Infrastructure

- Coordination and Information Management: need better information about what's been done, who's doing what, data repositories, resource guides for communities.
- Information Flow to and from communities; Info in layman's terms

VII. Resources (within communities, outside communities)

- Tribal/community programs

VIII. Possible Research Themes:

- **Climate Change** (Impacts to salmon, people; Traditional knowledge, observations, wisdom; Variability over time including regime shifts; Changes over time; Impacts of climate change on → Storms; Erosion; Rising water levels; Sea ice; Halibut; Transportation; Risk.

- **Comparative studies** → Along the coast; Across different ecosystems; Climate impacts (relative importance); Social changes (relative importance); Observation of changes; Local mgmt strategies; Resource allocation, harvests; New economic opportunities

- **Ecosystem Studies** (things are interconnected) → Invasive species; Non-commercial species; Non-harvested species; Interactions among species; Trends and Cycles; Behaviors (e.g. Fur seals on Bogslof Island); Habitats; Variations and Variability; Elders knowledge of instruments including people and their actions

- **Human factors in environmental studies** → Place of people and their activities in the ecosystem; Impacts of changes on, for example animals, to people who depend on them; Informing people of how they may be affected, e.g. contaminants; Comparing impacts, e.g., contaminants; Risks vs. benefits; Wild foods; store-bought foods

- **Social Changes** → Role of subsistence; Globalization; Jobs, education; Out-migration; Language, traditions

- **Resilience and Adaptability** → Healthy communities; Dealing with variability; Dealing with surprises; Social networks

- **Socio-economic Studies** → Fisheries; Impacts of fish disasters; Assessing impacts; Evaluating mitigation efforts

- **Economic Development** → Oil and Gas, minerals, tourism, enhanced fisheries; Opportunities, changes (eg. New fisheries, new areas); Impacts to people, relationships, activities; Impacts to environment; How to benefit communities; Infrastructure development (roads, parts); Environmental services (eg. IGAP); Vocational, technical training; CDQ program

- **Health** → Contributions to health; Overall well-being; Impacts of social and environmental change; Traditional means of promoting well-being; Community health and well-being; Health of animals

- **Resource Management** → Allocations; Community role in regulatory process; CDQ's; Conflicts between users and non users; Co-management, cooperation, voluntary groups

- **Information Flow** → Building knowledge in many areas to lay foundation for bridging different ways of knowing; Philosophy; Linguistics; Psychology

- **International and non Bering Sea Connections** → Western Bering Sea management; Importance to Japan of Bering Sea; Lower 48 fisherman; Everyone who is involved; Indigenous cooperation (AIA, Polar bears, ICC); International Bering Sea Forum (like Barents Council eventually?); Access to data including local observations

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Humans and Environment Community Forum
25 - 26 March 2004
Anchorage Sheraton Hotel
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