# BERING SEA ECOSYSTEM

# WORKSHOP REPORT

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## RECOMMENDATIONS OF THE ORGANIZING COMMITTEE

Following the workshop, the Organizing Committee met to review issues raised at the forum and to plan further coordination of ecosystem research in the Bering Sea. The Committee is pleased to submit the following recommendations to the three major agencies, the National Oceanic and Atmospheric Administration, the Department of the Interior, and the Alaska Department of Fish and Game.

### 1. Coordination of Field Sampling Plans

The Committee discussed a 3-step process to facilitate the coordination of agency research projects and cross-placement of scientific personnel on field sampling programs: (i) conduct a research coordination meeting to discuss field plans early each year, (ii) develop an interactive web-site to share research plans, and (iii) annually compile and publish agency research plans in a compendium. The intent of this process is to integrate the current work of multiple agencies, reduce redundancies, and maximize the research benefit of existing agency resources.

***Recommendation--***The Committee recommends that a web-site be used initially to facilitate coordination. Such a web-site can be integrated with the metadatabase project (that is described below) to build a 'living document' on the World Wide Web for sharing information on research planning on a continuing basis. The Committee also recommends that NOAA be designated the leader to undertake the project.

### 2. Sharing of Databases

The Committee agrees that the most efficient means of sharing data is to develop a metadatabase on the World Wide Web. This project has already been initiated by NOAA (by the Alaska Fisheries Science Center and the Pacific Marine Environmental Laboratory) and has been in operation for several months. The Committee agrees that there is no need to initiate another database project. The database already resides in a web-site <http://www.pmel.noaa.gov/bering/mdb/> that is maintained by NOAA's Pacific Marine Environmental Lab.

***Recommendation--***The Committee recommends that work continue on development of NOAA's Bering Sea Ecosystem Biophysical Metadatabase project and that all research projects link their existing databases into it. The Committee also recommends that NOAA remain the lead agency to facilitate the coordination process and maintain the metadatabase.

### 3. Traditional Local Knowledge

Presentations were made by representatives of coastal indigenous people of Alaska. One of the more challenging aspects of finding ways to better understand the Bering Sea ecosystem is to reconcile the apparent dichotomy of western scientific disciplines with traditional knowledge (TK) of indigenous people. Another complication of integrating TK into ecosystem research and management is the notion that such information is regarded as sacred and proprietary to indigenous people.

In addition to TK, the Committee recognizes that efforts are underway by the Minerals Management Service and the North Pacific Fishery Management Council to compile local knowledge of marine resource events that reflect unusual environmental conditions. Such information would contribute additional observations for ecosystem studies.

***Recommendation--***The Committee recognizes that collaboration between western science and traditional knowledge must continue. Various agencies have already invested significant resources into the integration of TK into its process through collaboration between indigenous people and agency researchers/managers. Consideration should also be given to empowering various coastal communities to carry out environmental monitoring projects as a component and/or adjunct of a Bering Sea Ecosystem Science Plan.

**4. Bering Sea Ecosystem Science Plan**

Congress has enacted legislation that establishes an "Environmental Improvement and Restoration Fund (a.k.a. Dinkum-Sands)" to carry out marine research in the North Pacific. Such funds shall be used by the Secretary of Commerce to provide grants to Federal, State, private or foreign organizations or individuals to conduct research activities on or relating to fisheries or marine ecosystems in the North Pacific Ocean, Bering Sea, and the western Arctic Ocean. The legislation also calls for the creation of a North Pacific Research Board, whose purpose is to review and recommend research priorities and grant requests for Secretarial approval.

***Recommendation*--**The Committee recommends that a Core/Planning Group be identified from organizations engaged in marine research and management off Alaska to begin development of an integrated Bering Sea Ecosystem Science Plan. The Group should also recommend an administrative process for soliciting and reviewing proposals supporting the objectives of the science plan.

## INTRODUCTION

Deborah Williams, Special Assistant to the Secretary for Alaska, Department of the Interior, 1689 C Street, Suite 100, Anchorage, Alaska 99501-5151. Ph: (907) 271-5485, Fax: (907) 271-4102.

Good morning everyone. Thank you so much for joining us here today and tomorrow for a very, very important conference. Why are we here? We are here because the Bering Sea ecosystem is, as we all know, the most productive marine ecosystem in the United States. It is also one of the most, if not the most productive, marine ecosystem in the world. We are here because we want to be able to make these same statements about the Bering Sea ecosystem 10, 20, 50 and 100 years from now. We are here because we care about this ecosystem and we want to make sure that there is adequate science to protect the system. Good science will allow managers to make the right decisions about the Bering Sea so that it will thrive for generations and generations to come.

When I was first asked by the Secretary to take a hard look at the Bering Sea ecosystem about a year and a half ago, I was amazed at the statistics that underscore its importance. Most of you in this audience know what those statistics are but, unfortunately, very few people in the rest of the United States do. What are those statistics? As we know, it is the most productive ecosystem in the United States. It provides 56% of the United States' fisheries production – 56%. The total commercial value of the catch out of the Bering Sea exceeded one billion dollars in 1994. The Bering Sea has the largest international aggregation of seabirds in the United States.

I could go on and on and on about its importance, and we will hear much more about its importance from all of the speakers. But we all know it is worth spending these two days to explore what we know, what we don't know, how we can fill the research gaps of what we don't know, and how we can cooperate better, all of us collectively, to make sure that the system is known well enough to manage it successfully.

This conference occurred because of the hard work of a lot of people. I would like to acknowledge those people at this time. An organizing committee was created and the chairs of the organizing committee were Steve Pennoyer and myself. But we don't deserve a lot of the credit. The real credit for this conference belongs to Dr. Loh-Lee Low, to Ron McCoy in my office, to Dr. Joe Sullivan, to Pat Livingston, to Bill Hines and to Susan McNeil. I want to thank all of you. I hope all of the members of this conference have a chance to thank the organizers who put so much time into making sure that we had a successful workshop and that the key players in Bering Sea research were able to join us.

Obviously this workshop would not have happened without your participation. So thank you all for interrupting your schedules to come here. We are all extremely busy and so we greatly appreciate you taking two, three, four days out of your schedule to focus intensely on this critical marine ecosystem.

This conference is timely for many reasons. First, we are seeing signs of stress in the Bering Sea ecosystem. They are signs that make us all want to work harder and draw more attention and research dollars to the Bering Sea, so that these signs of stress can be resolved quickly. The alternative is untenable; we cannot let the problems multiply and create a cascade effect leading to a disaster.

What are some of the signs of stress? Well, several species unfortunately have had to be placed on the threatened or endangered species list lately. Steller sea lions, for example, have declined in abundance by over 80% in the last 30 years. Fur seal populations have declined by 50% since the 1950s. The Adak sea otter population has experienced an annual decline of 40%. Common murres, thick-billed murres, red-legged and black-legged kittiwakes have declined as much as 50% in some regions of the Bering Sea.

Spectacled eiders have declined from 50,000 pairs in 1971 to about 1,700 pairs today. These are blinking yellow lights.

Fortunately, the Bering Sea appears to still be fundamentally healthy. We have the opportunity here with this ecosystem to do something that hasn't been done very successfully in a lot of other places, and that is to insure the health of an ecosystem. None of us want this ecosystem to crash on our watch or on our children's watch, none of us. We have lots of experiences to learn from in other ecosystems, particularly marine ecosystems, which should be applied to this ecosystem. We know there were unfilled research gaps in other ecosystems that helped contribute to less than ideal management decisions. And so we all come here today and tomorrow to identify what we need to know to insure that this ecosystem stays healthy.

This is a great challenge. One of the greatest challenges in my job as the Secretary's representative here in Alaska, is to get people excited about protecting Alaskan ecosystems when they appear to be fundamentally healthy, or when there are yellow blinking lights, but not red blinking lights. It reminds me very much of when I was Executive Director of the American Lung Association. It was often very hard to get people to say, yes, it makes sense to spend $5.00 or $10.00 or $25.00 to help prevent someone from smoking, as opposed to spending hundreds of thousands of dollars once someone is diagnosed with lung cancer or emphysema. People often are more willing to spend those hundreds of thousands or millions of dollars when someone is in the emergency ward with emphysema or lung cancer, than invest in less costly preventative programs.

With respect to the Bering Sea, we are asking people to pay attention to a critical ecosystem that is showing signs of stress, so that we don't have to take this ecosystem to the emergency ward and spend huge amounts of money to resuscitate it. We want just a little more attention and a little more money to make sure that it can remain fundamentally healthy.

Which brings me to the other reason why this conference is very timely. Happily, many people, including Senator Stevens, do fully understand the importance of the Bering Sea ecosystem and North Pacific marine ecosystems in general, and are focusing more attention on them. As probably most of you know, in this year's Department of the Interior's appropriation bill, there was a provision to create a new board, the North Pacific Research Board (NPRB). Senator Stevens put this in our budget. There was a Supreme Court Decision this year, called the Dinkum-Sands case, in which the Supreme Court determined that the United States had ownership of certain offshore lands and entitlement to over 1.6 billion dollars.

Senator Stevens said, look, I think it makes sense to have Congress spend at least half of that money, $800,000,000 to do two things; 80% of the money is to go to Park, Refuge and BLM maintenance and other activities. Twenty percent of $800,000,000, which is a very big number, is to be used for North Pacific marine research. The Senator established a board, a large 19-member board, with representatives from several federal entities including the Departments of Commerce, Interior and State, as well as representatives from the States of Alaska, Washington, Oregon. The board is going to get together and make decisions about how best to spend the money that will be generated from the interest on the fund.

We have the opportunity with this conference to put together our best thinking on how monies should be spent for Bering Sea research. Now, those NPRB monies are subject to annual appropriation. They will just not flow automatically. So there needs to be specific action to insure that the interest generated on the fund will be available for marine research and particularly Bering Sea research. What's exciting about this conference is that we will be able to present to this new board a tremendous start on how those research dollars should be spent.

I am also particularly interested in hearing your thoughts during the next two days on how we can better cooperate and coordinate on Bering Sea research. When I first started taking a hard look at the Bering Sea, I was excited and delighted by much of the research that was occurring, but I did feel that there was the potential for much better cooperation and coordination. There have been improvements in the last year, but we have a long way to go. So I am going to have my ears particularly wide open when we talk about increased opportunities for cooperation and coordination, because under any circumstances we're not going to have enough money to do everything we need to do in the Bering Sea. Cooperation and coordination are absolutely necessary to stretch those scarce dollars to their maximum and make sure that the best research is being done cost effectively.

That is my overview in a nutshell. Thank you again for coming. Thank you presenters for the presentations you're about to make. And please, tomorrow, when we get into our discussion period, please participate and speak up. I look forward to all of your thoughts on the research gaps, on the data gaps, and how we can better cooperate and coordinate our research efforts.

One last note. There is available, and I believe most of you have seen it, a draft White Paper. If you have thoughts about the White Paper, please give those thoughts to me or any members of the organizing committee any time during this conference or afterwards. We would like to finalize that White Paper soon so that we can take the next steps toward institutionalizing better cooperation, coordination and ultimately better-coordinated decision-making.

This conference is focusing on research. We hope to have other conferences or meetings that will focus on some of the follow-up issues and make progress on those issues. As most of you know, next year has been designated as the "Year of the Oceans." There's going to be intense scrutiny both at the congressional level, at the executive level, and at the state level on how we can do a better job with our marine ecosystems. I hope the Bering Sea is used as an example of how we have done many things well and how we can improve in other areas.

So this workshop is step one, a critical step, one that will lead to steps two and three. We look forward to having you all participate in those additional steps. And ultimately, at the end of the day, we'll be able to tell our children that we all participated in insuring the health of the most important marine ecosystem in the United States and one of the most important ones in the world.

Thank you very much.

## KEYNOTE ADDRESSES

### Ecosystem Considerations in Bering Sea Resource Management

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Each of us coming to this Bering Sea Ecosystem Workshop arrives with a history of involvement in issues related to some aspect of marine science and resource management. Some of us approach it from the perspective of academic research driven by questions generated by and of interest to natural and social sciences. Others come from the standpoint of utilization of the abundant but often elusive resources whether oil and gas, fisheries, shipping routes, or military security. Still others are involved in the management of these uses. Finally others come with a broader concern about questions of biodiversity and how to maintain the Bering Sea ecosystem. I think it safe to say, that all who have any knowledge and appreciation of the Bering Sea ecosystem must recognize and respect the Native peoples who have survived by their knowledge of this ecosystem for more than 10,000 years.

At this juncture it appears that a great deal of interest and concern is being focused on the Bering Sea ecosystem. The perspectives range from concerns over how to protect one of the last remaining large marine ecosystems in the world from degradation, to how to use ecosystem principles in improving management of resource extractive resources, to the threat posed by ecosystem considerations as limiting traditional practices or major commercial uses. This range of concerns show that there is significant difference of opinion about whether the Bering Sea constitutes one of the last bastions of intact ecosystems or if it is one of the most threatened.

Before we can address ecosystem considerations it is necessary to come to some common understanding of the spatial and temporal scales we use in thinking about the Bering Sea as an ecosystem. In virtually every spatially oriented definition (a bay, a region, the whole Bering Sea), the winds and currents are part of a global circulation system, the seabirds are largely highly migratory as are numerous species of marine mammals and major fish species (salmon, in particular). Thus, we need a spatially dynamic component to any definition of an ecosystem that we choose. Similarly, the dominant cycle seems to be an annual one for changes in the ecosystem and its components, including its human users.

The Native peoples faced the challenge for survival on a constant basis but strongest felt was surviving the yearly seasonal cycle. To accomplish this feat they ranged widely from their permanent homes. They developed a holistic understanding of the ecosystem over millenia and recorded this information in culture, practices, traditions and wisdom about living in a harsh land and waterscape [Barker, *Always Getting Ready*].

In contrast, our present use and occupation of the Bering Sea ecosystem is primarily to derive income from extractive uses of specific resources. Our focus is primarily on the technologies needed for efficient utilization and, to a limited extent, on assessing the environmental impacts of these activities. For fisheries this is characterized by highly mobile fishing fleets operating on short seasons dictated primarily by market considerations for select species and located in areas of greatest concentration of resources and ease of harvest. Management largely is a race between developing technologies and the ability to assess stocks and implement management measures. For most fisheries, our understanding is based on approximately 30 years of observation of a rapidly developing groundfish and crab fisheries and 70 years for salmon and halibut. Environmental effects of fisheries is little studied, particularly effects on seabed habitats and on other species.

For oil and gas, the activity is heavy on exploration, assessments and estimation of resources and potential impacts. Exploration work, largely seismic, is a relatively short term but area extensive activity. Exploratory drilling is very site specific and, without significant discoveries, also a short-term activity. Production, if any, is site specific and of longer term duration. In order to enter any of these phases, significant advance investment must be made in environmental assessments. Management is stymied by a lack of ability to agree on the likelihood or risk of ecosystem-wide effects from geographically discrete development, production and transport. Some of the resource evaluation work and benthic surveys represent the only data available for large areas and types of resources.

For wildlife protection we observe vast fluctuations in populations of seabird and marine mammal populations that are not explained by harvest rates or other observed mortality. Many of these occurring to species that migrate far from the Bering Sea. Concerns exist on interaction of fisheries and other activities on wildlife protection writ large. To what extent do they contribute to the changes and to what extent are these changes a result of poorly understood long term, large-scale alteration of the climate or ecosystem?

To what extent are we capable of crafting a common understanding of space and time scales and what they mean for understanding a Bering Sea ecosystem - independent of the part of it, or perspective of it from which we start our inquiry? I hope we are capable of reaching far enough outside our particular interests to achieve a broader perspective. If not, I would hope that we can at least start to see our own activities in the context of a broader ecosystem perspective. Even to make this modest step requires significant effort, planning and expense. Ecosystem considerations are part of developing an improved approach to management but they are not a panacea [Edmondson, *The Uses of Ecology*]. Are our institutions capable of responding [Gunderson et al. *Barriers and Bridges*]?

**Western Science and Traditional Knowledge and Wisdom:**
**A Working Proposal for Cross-Cultural and Multi-Disciplinary**
**Bering Sea Ecosystem Research**

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Kelux Exumax, Kelux Kusuthax. The morning tastes good, in the Aleut language. I would like to thank Dr. Low, Deborah Williams, and the conference steering committee for providing a forum for a presentation on traditional knowledge and wisdom, and for inviting me to make the presentation. And I am glad to have another opportunity to speak with you this morning. I would like to preface my remarks by telling you I do not ordinarily write my presentations, since, as I was taught by a wise elder, speaking without the aid of a prepared document allows us to speak directly from the heart. However, I am making an exception in this case because it is my hope that some will distribute this presentation to all interested parties. I also wish to depart from my usual presentation messages in a forum such as this and speak of my own personal truths and insights I have gained from over twenty years of advocating for the Native peoples and the Bering Sea. We have all heard the same speeches too many times and I am sure that many of you feel as I do: I don't want another Groundhog Day! That script is getting old and tiresome.

We all know each other, have been traveling the same road for many years, and share, I believe, a profound concern over the health of one of the world's richest marine ecosystems - the Bering Sea. We have struggled to find substantive ways to address our varied concerns and interests over the obvious distress within this ecosystem: some of us approach it on the level of scientific inquiry and research, some on the level of adjusting and adapting wildlife management policies, and some on a level that speaks to the spiritual and traditional conservation ethics of the indigenous peoples whose history, culture, nutrition, spirituality, and basic economies are inseparably tied to the Bering Sea. All of these approaches are very important. Most significantly however, they are interdependent. One will not work without the other. Any success we have in understanding the complex nature of this ecosystem demands a vigorous effort on all our parts to work more cooperatively.

I have attended countless scientific and Native forums on the issues of the Bering Sea as all of you have. I have discussed the issues with dozens and dozens of scientists, researchers, managers and Native leaders. I have studied as many of the research reports, studies, conference reports, and white papers as I could get my hands on over the past twenty years. I did so in hopes of gleaning some insight into what our challenges truly are underneath the diplomatic language we all have used, with the understanding that there are many truths and that these truths need to be articulated and addressed if constructive change is to occur. I am pushing for change from status quo as one advocate for the Bering Sea residents because the scale and duration of the precipitous and sustained declines of at least sixteen higher trophic species is probably about to take another turn for the worse over the next two years or so. Even if it does not, the scale of ecosystem-wide declines is threatening the very fabric of Bering Sea coastal cultures. Indeed, I would characterize this situation as dramatic enough that it is akin to that of the rainforest people of South America, except this rainforest is in our own backyard.

Part of this truth I am referring to includes the host of daunting challenges that western scientists and policy-makers face, and which must be dealt with if there is to be any coordinated multi-disciplinary and cross cultural ecosystem-based approaches to the problems in the Bering Sea. There is a litany with more political, public, and financial support:

- Different disciplines have different research and data gathering methodologies, making it difficult it not impossible to pursue sorely needed long-term research programs or to even synthesize existing data and findings.

• Funding and research emphasis is inconsistent as administrations and public priorities change, making it difficult if not impossible to pursue sorely needed long-term research programs or to even synthesize existing data and findings.
• Different departments and research institutions must singularly pursue their own respective missions and funding priorities in order to remain on the political radar, to meet their minimum statutorily mandated missions, and to simply survive. Such an environment is not conducive to coordinated research.
• Institutional support of independent researchers is non-existent, lessening the pool of different perspectives.
• Research and information exchange protocols between Russia and the U.S. are inadequate or non-existent for research and managing migratory species or the same species in one ecosystem.
• Data gathering and research methodologies between Russia and the U.S. are different, making comparison of findings difficult if not impossible or very costly.
• Most research and management regimes are single species oriented, which in some cases, results in strong resistance to different approaches; and by the same token, there is a dearth of critical scientific and philosophical debate, or public understanding, of what any ecosystem approach means. Such a situation leaves scientists without support or direction they need to move forward substantively.
• Cartesian-based science and peer group review systems are simply not equipped to validate traditional knowledge and wisdom. It would be unfair to expect this system, which is a quantitative world view based on time series data gathering and computer models, to assess the veracity of information from indigenous systems which are qualitative and unwritten. *Defacto*, this situation disenfranchises the primary stakeholders in the Bering Sea and substantially diminishes access to information which will prove to be invaluable to understanding what is going on with single species and the ecosystem.
• The sheer number of variables impinging on individual species may be untenable in terms of our current scientific capacity to deal with. Given this, we understand how daunting it seems to deal with an entire complex and synergistic ecosystem in a constant state of flux.
• Scientists are put to an impossible test to prove definitively that any particular anthropogenic factor is an underlying cause for adverse fish and wildlife population trends before policy-makers and managers take action.
• Late fall, winter, early spring higher trophic species research is virtually non-existent due to funding limitations and the sometimes extreme human discomfort and hazards posed by conducting research during these times. I know I would not want to be on a small research vessel in the middle of the Bering Sea in January facing 80-knot winds and 40 foot seas.
• Ecosystem monitoring systems for the Bering Sea are nonexistent and therefore changes in key ecosystem parameters that may dramatically affect wildlife population trends are not tied to management decision-making.
• Professional jealousies impede efforts to understand what is happening to different species and the systems or subsystems that sustain them.
• Research funding and programs are frequently reactive rather than preventative or proactive.
• Native peoples and scientists alike, must deal with a historic distrust of each other's intentions and motives (sometimes justifiable, sometimes not), making substantive cross-cultural cooperation extremely difficult at best, and no program exists to deal with these challenges from either side.

This is a litany of real challenges and impediments to any change in status quo, which we cannot expect the scientists and researchers alone to deal with. We must create the public, political and financial support to go along with the commitment of the scientific and Native communities to work together.

What I put before you today is a proposal that accomplishes this; a proposal that combines the vested interests and abilities of Bering Sea communities, the scientific/management/policy-making communities, commercial fisher, and environmentalists. I have no illusions that this body can bring this proposal to fruition even if there was unanimity and a sincere commitment to do so. However, I am providing this to seek your support and to give you a heads up to what I am proposing that the Bering Sea communities strongly advocate for. I invite further ideas and constructive critiques of this vision for the Bering Sea.

I propose that Bering Sea communities be supported in building their own capacity to conduct their own research, exchange information and observations in a formalized and systematic process. By doing so, we will have the unprecedented opportunity to receive useful information throughout the year around an entire marine ecosystem. It can serve as an early warning system of trouble. Systematic observations throughout a wide geographic range can aid scientists in constructing scientific hypotheses perhaps in a more timely fashion, and perhaps follow population trends. It creates a legitimate and meaningful role of stewardship by the people whose cultural viability depends on informed and decisive action.

I propose the establishment of international research centers equipped to conduct demonstration projects of innovative ecosystem and ecosystem monitoring approaches, and cooperative cross-cultural research programs. There should be two primary research centers-one located in the eastern Bering Sea and the other in the western Bering Sea. The centers would be tightly coordinated in terms of research targets, methodologies, and to explore the feasibility and usefulness of mesoscale scientific research approaches in monitoring entire marine ecosystems. This concept has been pioneered in the Bering Sea by the Pribilof Aleuts and Dr. Flint who is now the new director of the Shirshov Institute of Oceanology in the Russian Academy of Sciences. Dr. Flint oversees a thousand Russian marine scientists and he is committed to working in the Bering Sea.

I propose a formalized effort to develop lateral partnerships between coastal communities, secondary stakeholders, federal and state agencies, and environmental organizations which are focused on close cooperation, collaboration, and mutual support for stewardship in the Bering Sea. Given the varied interests in the Bering Sea and the international scope of the issues we are dealing with, a top down approach will not work here. World history is replete with this lesson when dealing with environmental and economic interests. There are some issues that will require a top down approach, so a two-tiered approach is required here - top down and bottom up.

I propose the establishment of a high quality pool of western scientific advisors to the Bering Sea Coalition to explore with us the development of pioneering ways to use indigenous knowledge and wisdom garnered on an ecosystem-wide basis.

I propose the recruitment of coastal school districts willing to work together under the guidance of Native and non-Native scientists (and perhaps the University) to explore development of high school biology programs which sample and monitor nearshore indicators and relevant ecological parameters which can aid in getting the big picture. These school districts would administer identical science projects adjusted for local needs and conditions, tied together by email and the Bering Sea Bulletin Board.

We will be articulating this vision in more detail, as a draft, for distribution to the Bering Sea Coastal communities. It is my hope we will have a forum for these communities to discuss, debate, and change its vision sometimes next year, subject to funding. In addition, we will continue to work with the World Wildlife Fund, which has identified the Bering Sea as one of six sites to focus on and for which they are attempting to raise 10 million dollars. We will continue to work with the Nature Conservancy, which is now exploring the feasibility of raising $700,000 to launch Bering Sea stewardship programs. We will continue to work with Senator Stevens to provide substantial funding for Bering Sea stewardship initiatives over the long term. We will continue to work with the Center for Marine Conservation as it strives to determine its role in the Bering Sea. And finally, we will continue to work with President Clinton's administration in defining their vision for the Bering Sea. Finally I wish to say this: We, the coastal communities, cannot accomplish what we want without you, and you cannot accomplish the task of maximizing understanding of the Bering Sea ecosystem without us. Initially this can be called a shotgun wedding, but ultimately the need for reciprocity will become a desire for reciprocity by all involved. I am convinced of this. All we need is the conviction that change is needed and status quo is no longer acceptable.

Anyone interested in receiving a copy of this presentation, please let me know or contact the conference organizers.

Thank you.

## OVERVIEW OF PAST AND ONGOING RESEARCH PROGRAM PRESENTATIONS

Presentations on past and ongoing research programs were given by agencies and universities involved in Bering Sea research. The purpose of these reviews was first to provide participants with a historical perspective of the types of research that have been performed in the Bering Sea. Another important goal was to give a common understanding of the variety of institutions presently involved in this research and the multiple objectives of the research programs that are now in place. These goals were achieved and will help to provide the basis for defining a common vision for Bering Sea research.

Participants heard from some of the major line organizations of National Oceanic and Atmospheric Administration, Department of the Interior, and the State of Alaska. Additionally, presentations were given by representatives of the U.S. Department of State, Environmental Protection Agency, and the International Pacific Halibut Commission. Research programs in which the University of Alaska played a key role were also outlined along with many of the research partnerships that have been formed between agencies and universities.

It was clear from the presentations given that although agencies and universities are performing research designed to meet their statutory requirements or to attain the goals of specific research programs and partnerships, there were common features to many of the research programs. There was a particular emphasis on monitoring that not only meets the needs of the specific statutory requirements of each organization but also the growing trend to use monitoring to fulfill more ecosystem-based research objectives. It was also evident that the number of multi-institutional, multi-disciplinary research efforts is increasing at a fast pace and many of these efforts have overlapping goals.

Common research themes in the growing ecosystem-focused research programs were to understand: habitat of important species, predator/prey interactions between various ecosystem components, the role of climate in influencing ecosystem production and change, and human impacts on ecosystems. These themes also appeared to be the central focus of future research directions for many of the institutions/programs. These research directions indicate the need for expanded funding of ecosystem-based research, definition of a common research plan, and development of mechanisms for ongoing research coordination among multidisciplinary, multiagency research efforts.

## NOAA - Oceanic and Atmospheric Research (OAR)

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OAR directly funds research in the Bering Sea through two programs, the Arctic Research Initiative and Fisheries Oceanography Coordinated Investigations (FOCI). The former program is administered through the Cooperative Institute for Arctic Research (CIFAR) at the University of Alaska, Fairbanks, and will be presented by Gunter Weller. This report addresses FOCI and its tapestry of collaborative research. The goal of FOCI is to understand the influence of changes in the environment on the abundance of various commercially valuable fish and shellfish stocks in Alaskan waters and to examine the role of these animals in the ecosystem. FOCI research focuses on factors influencing recruitment to stocks of walleye pollock (*Theragra chalcogramma*), with emphasis on early life stages (egg through young of the year), and their associated ecology.

Research is conducted mainly by personnel at two NOAA laboratories in Seattle, Washington: the National Marine Fisheries Service's Alaska Fisheries Science Center (AFSC) and the Office of Oceanic and Atmospheric Research's (OAR's) Pacific Marine Environmental Laboratory (PMEL); and by scientists at several joint NOAA/university institutes, including those at the Universities of Alaska, Washington and Oregon State. Researchers from other academic and research institutes from across the nation have been part of the FOCI effort. Details of the FOCI program (Advisors, publications, researchers, etc.) can be found on the World Wide Web: <http://www.pmel.noaa.gov/foci/home.html> and scientific results appear on the theme page FOCI personnel created for the Bering Sea and North Pacific Ocean <http://www.pmel.noaa.gov/bering/>. The lead scientific guidance lies with the Program Directors at AFSC and PMEL who presently are Drs. A. W. Kendall, Jr. and J. D. Schumacher (the latter retiring on 30 December 1997 and to be replaced by Dr. P. J. Stabeno).

FOCI maintains an ongoing research effort in the Shelikof Strait-Northeast Pacific and the Bering Sea. Between 1986 and 1994, the majority of research conducted by FOCI was in the coastal Gulf of Alaska. Here, FOCI scientists demonstrated their ability to discover how key aspects of the ecosystem operated and to integrate this scientific knowledge into the management of selected living marine resources. FOCI's annual prediction of walleye pollock recruitment is used by the North Pacific Marine Fisheries Council (NPMFC) to manage the commercial pollock fishery in the northern Gulf of Alaska. Within the Bering Sea, FOCI research is integrated with the Coastal Ocean Program's Southeast Bering Sea Carrying Capacity, the National Science Foundation's "Prolonged production and trophic level transfer to predators: Processes at the inner front of the southeastern Bering Sea" and the Arctic Research Initiative. All of these programs have annual funding levels at or above \$1.0 M. The total funding level of FOCI research in the Bering Sea depends on many factors, including shiptime support, shared funding with other programs, research aircraft time and other research in the Gulf of Alaska. Since 1995, FOCI has operated with a budget of approximately \$3.0M per year. These funds come through OAR as FOCI base funds and are enhanced by additional resources from PMEL and AFSC.

FOCI research in the Bering Sea began in 1985 with synthesis of prior research in support of a research cruise into the "Donut Hole" for February, 1986. Much of the background material for this first FOCI expedition into the Bering had its origin in a NMFS workshop on pollock and its ecosystem in the eastern Bering Sea (Ito, 1984). FOCI research cruises continued during 1987-88 with a focus on potential recruitment of larval pollock from the basin (Bogoslof Island) to the eastern shelf. During 1989-90, in cooperation with Minerals Management Service, FOCI research examined the nature of the Bering Slope Current and its exchange with the shelf. Between 1991-96, in coordination with the Coastal Ocean Program's Bering Sea program, FOCI research was guided by recommendations from the 1988

International Symposium on Pollock (Aron and Balsiger, 1989) and included: determination of pollock stock structure in the Bering Sea and examination of its relationship to physical features, and understanding recruitment processes in the eastern Bering Sea. These have direct implication concerning management of the vast resources which exist in US, Russian and international waters. To attain the first objective, field and modeling studies have investigated circulation throughout the deep basin. Another component seeks to establish if genetic "finger-prints" for the different stocks exist. In addressing the second objective, we investigated differences between favorable conditions for survival of eggs and larvae over the deep waters to that over the adjacent shelf. A newly established component, contrasts habitats of juvenile animals in the well mixed coastal domain to those in the two-layer middle-shelf domain. Throughout its lifetime, FOCI scientists have realized the importance of monitoring various aspects of the environment and continues to be a leader in developing and implementing moored biophysical platforms. Observations have provided unique time series of water column temperature, salinity, estimated chlorophyll-a, and phytoplankton fluorescence during ice advance and retreat. Such information is crucial toward understanding the bottom-up dynamics of the ecosystem.

During 1995-96 and in coordination with the Environmental Protection Agency, FOCI research examined circulation around St. Paul Island through both moored observations and model studies. The results indicated that a 'trapped-circulation' existed around the island and was in part driven by non-linear interaction of tidal currents with bathymetry. Since 1996 and in coordination with Coastal Ocean Program's Southeastern Bering Sea Carrying Capacity (SEBSCC) program, FOCI has been conducting long-term biophysical monitoring to develop indicies of the health and status of the region, examining juvenile pollock and growth as a function of habitat. In coordination with ARI, research also been conducted on the Green Belt to better understand its hypothesized prolonged primary production and to examine the physical features associated with this production.

The list of significant findings is vast; there are over 74 papers published in referred journals (see FOCI home page) and even more numerous presentations at national and international workshops and technical reports. FOCI researchers have played a leading role in the discovery of new features of the environment and in the synthesis of this work. The results have been published in the U.S. National Report (Schumacher and Kendall, 1995) and in a new volume for the Bering Sea. The latter is the first compilation that presents a modern interpretation of the physical oceanography of both the eastern and western Bering Sea shelf (Schumacher and Stabeno, in press). This work includes a new understanding of the general circulation over the southeastern shelf, which includes cross shelf flow. The discovery of an across-shelf flow requires re-examination of the processes, which generate the flux of heat, salt and nutrients on the shelf. Also presented are results that suggest that the two primary sources for slope water and nutrients vital to the high productivity of the shelf are flow features associated with the Bering and Pribilof Canyon. The dynamics associated with the later bathymetric feature are now under investigation by a current ARI/FOCI project.

FOCI scientists have played an important role in the establishment, growth and vitality of the North Pacific Marine Science Organization known as PICES. FOCI scientists provided vital input to many of the chapters in the new update and synthesis of knowledge about the Bering Sea [*The Bering Sea: a Summary of Physical, Chemical and Biological Characteristics and a Synopsis of Research*. Loughlin, T.R. and Ohtani, K. (eds.)], in addition to providing leadership in working groups, presentations at the annual meeting and in workshops. These chapters include the first compilation of results that presents the physical oceanography of the Bering Sea basin based on direct measurement of currents as well as the standard interpretation from water property observations (Stabeno et al., in press). Included in this work is a new schematic of the general circulation that establishes the presence of a newly-discovered current system, the Aleutian North Slope Current (ANSC). The ANSC supplies the bulk of the volume transport for the Bering Slope Current and potentially provides a link between the basin and outer shelf. This feature is currently being monitored by a SEBSCC/FOCI project. Another chapter in this volume (Bailey et al., in press) describes the population ecology and structural dynamics of walleye pollock in the Bering Sea. This work provides a synthesis of BS FOCI genetic distributional studies of pollock. The role of sea ice in organizing the Bering Sea ecosystem (Wyllie-Echeverria and Ohtani, in press) and the distribution, species associations and biomass trends of forage fishes (Brodeur et al., in press) are topics of other PICES chapters.

Synthesis of results from the Coastal Ocean's Program BS FOCI (Napp et al., in prep.) provides another example of how cross participation by FOCI's scientists had a marked impact on the status of knowledge of the eastern Bering Sea. Results show that:

1. Pollock spawn in two regimes in the southeastern Bering Sea which offer distinct habitats:
   (a) in the oceanic regime advection is typically strong, but variable and eddies are common, and
   (b) in the shelf regime advection is generally weak, but consistent and the large interannual variability in temperature, sea ice and wind mixing is striking.
2. Spring bloom dynamics vary in the regimes:
   (a) in the oceanic regime variability in plankton is due in part to advective rather than local processes, while in the
   (b) shelf regime complex processes due to ice, stratification, temperature and the timing of storms help regulate plankton production.
3. The regimes provide different feeding habitats for larval pollock:
   (a) In the oceanic regime there are low concentrations of copepod nauplii, dominated by cyclopoids and food for larval pollock may be supplemented by protists, and
   (b) in the shelf regime the low concentrations of copepod nauplii are dominated by calanoids (a preferred prey), however, prey concentrations are still minimal level for feeding, and the low temperatures associated with atmosphere-ice-ocean processes may cause a mismatch between first feeding larvae and maximal prey production.

The conclusion is that a key factor to interannual variability in food for pollock larvae in the oceanic regime is advection, whereas in the shelf regime it is temperature.

FOCI scientists made vital contributions to the development for a future research program on Climate Change and Carrying Capacity (CCCC) of the North Pacific [including the Bering Sea] for U.S. GLOBEC (U.S. GLOBEC, 1995). This document includes a discussion of potential changes in the Bering Sea ecosystem due to climate warming and a companion document describes research needed to be addressed to examine changes in this ecosystem (U.S. GLOBEC, 1996). FOCI also contributes to our understanding of the Bering Sea through the development of both models and technology, including:

1. A numerical model of circulation of the Bering Sea basin and exchange with the North Pacific Ocean which demonstrated that flow instabilities contribute to substantial interannual variability in circulation.
2. Development of an instrumented mooring system designed to withstand the harsh marine environment of the Bering Sea. Included in its suite of measurements are: winds, insolation, air temperature, humidity, salinity and temperature at ten depths, currents from acoustic Doppler current profiler and acoustic current meters, acoustic backscatter, and chlorophyll absorption.
3. Developed relationships between ADCP acoustic backscatter and zooplankton biomass.
4. Developed a mitochondrial DNA probe to discern pollock population differences between the eastern and western Bering Sea and a rapid restriction enzyme assay for mtDNA surveying of a large number of pollock from all populations to allow quick survey of hundreds of individuals and assay of alcohol-fixed larvae.
5. Developed a new method for live-staining protists that are potential prey items for pollock larvae.
6. Developed mono- and polyclonal antibodies to assay the importance of various invertebrate predators on feeding larvae.
7. Developed techniques for distinguishing between Stage I and Stage II nauplii of the copepods *Metridia* and *Pseudocalanus*, prey of larval pollock.

While scientific knowledge is a valuable product of FOCI research, the application of research to management is a critical element of NOAA. In the Gulf of Alaska, FOCI research generated a conceptual model of recruitment of pollock based on the interaction of biological and physical components of the ecosystem. Results from this model are used to forecast recruitment strength of a given year-class. This information is used in the management of this marine resource. In the Bering Sea, we expect that the development of indicies of the biophysical environment that synthesize observations and an understanding of the primary ecosystem processes will eventually be used to forecast strength of pollock recruitment.

One of FOCI's greatest strengths is its ability to integrate scientific knowledge of atmospheric, chemical, physical, biological and fisheries oceanographic processes into a coherent whole. As a result, FOCI scientists are often invited to collaborate on research programs funded by a broad spectrum of agencies. A broader understanding of the Bering Sea ecosystem has been accomplished by the judicious interweaving of externally-funded programs and FOCI base to provide support for research. The ability of FOCI researchers and colleagues to address unusual phenomenon in a timely manner has resulted in elucidation of anomalous conditions which occurred this year, including a massive die-off of shearwaters and a bloom of coccolithophorids in the eastern Bering Sea [Vance et al, submitted; <http://rho.pmel.noaa. gov/vance/seawifs/eos.html>.] While FOCI researchers have shed light on many of the processes that are determinants of ecosystem behavior, this has typically been accomplished with other government, academic and private researchers as a coordinated effort. This approach toward attaining pragmatic goals has been and continues to be highly successful. Many of the aforesaid contributions are now posted on the World Wide Web, including the theme page FOCI helped to create <http://www.pmel.noaa.gov/bering/>. For further information regarding FOCI, contact S. Allen Macklin FOCI/SEBSCC Coordinator, [<Macklin@pmel.noaa.gov>; 206-526-6798.]

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**Overview of NOAA's National Ocean Service**

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Programs of NOS

Management
1. Coastal Zone Management Program
2. National Marine Sanctuary Program
3. National Estuarine Research Reserve System

Science
1. Coastal Ocean Program
2. Long Term Coastal Monitoring and Bioeffects Assessments
3. Strategic Environmental Assessments
4. Coastal Laboratories

Coastal Services Center
1. Remote Sensing
2. Coordinating Delivery of Services

Response
1. Hazardous Materials Response and Assessment (Hazmat)
2. Damage Assessment and Restoration Program

Navigation, Mapping, & Positioning
1. Hydrographic Surveying and Nautical Charting
2. Shoreline Mapping
3. Tides, Water Level, and Current Measurements and Observations
4. Geodesy, Positioning, Remote Sensing

NOS Overview

1. In addition to working for NOAA's National Ocean Service, I also lived on the Bering Sea coast for 10 years in Unalaska/Dutch Harbor from 1979-1989. I first went there to work in a salmon cannery. In later years I worked as a journalist, longshoreman, tankerman, vessel agent, and also served for three years on the Unalaska City Council.

2. I will provide a short, 5-minute overview of NOS before introducing Dr. Robertson, who will provide a report on specific past research and ongoing monitoring in the Bering Sea by NOS. Before that, however, it is important, especially to representatives from coastal communities along the Bering Sea, to have some grasp of NOS programs and where they are located within the Federal Government.

3. The varied programs of NOS share a common theme - they have a distinct coastal focus, which, of course is where the people are.

4. Although some NOS programs conduct long-term scientific research, many programs offer practical scientific, management, and technical assistance for communities and people working and living along the coast.

5. It is the position of NOS that people and communities cannot be considered separately from the ecosystems they inhabit. Many NOS programs aim to mitigate negative anthropogenic impacts on the coast. To achieve this, NOS applies technology and provides tools - to prevent unwarranted harm, to increase knowledge of underlying, natural coastal phenomenon, to encourage wise decision making, to respond to disasters, to monitor long term impacts, and, where necessary and possible, to restore coastal environments.

6. Coastal development and growth, can take a toll on an ecosystem.

a) For the long term, an ecosystem plan must account for and mitigate the cumulative impacts of coastal development.

b) While large concentrations of people are not likely to move to the Bering Sea, it is also true that sub-arctic areas are often highly sensitive to development.

c) Ultimately, having a healthy overall ecosystem requires maintaining communities along the Bering Sea coast that are themselves healthy both economically and environmentally.

7. Our nautical charting program and other navigation services are examples of tools aimed at reducing risk of ongoing human activity. Recent requests have been made to survey and update charts in the North East Bering Sea to ensure that zinc and lead from the Red Dog mine can transit the Bering Sea safely. NOS also has surveys planned along the southern coast of the Alaska Peninsula where most of the fuel moves by tug and barge on its way to Bering Sea communities.

8. NOS also maintains permanent water level stations in Unalaska, Adak, and Nome, but more accurate tidal, geodetic, and coastline data is needed for most of the Bering Sea coast. NOS is researching applications of new technologies that could significantly reduce the cost of gathering and providing such data in remote locations such as the Bering Sea. Improving the quality of the geographic data for the Bering Sea coast is necessary to promote sustainable development. Meaningful ecosystem planning requires making the best use of new technologies, such as Geographic Information Systems (GIS). But such systems will only be of value if they are composed of accurate underlying geographic, geodetic, hydrographic, and related data.

9. One product of our Hazmat office is Environmental Sensitivity Index Maps that inventory and map concentrations of various resources and things like freshwater intakes. These maps can help focus oil spill response efforts and assist planners in deciding which areas should or should not be developed.

10. In cooperation with the Coast Guard, such maps are being prepared for the Pribilofs. The Pribilofs have suffered a series of oil spills, and in this case the plan is to publish the maps in English, Japanese and Russian. A proposal is pending to develop similar maps for the Aleutian Chain.

11. Hazmat also is the scientific support coordinator to the Coast Guard during marine oil and chemical spills. Hazmat representatives are in Unalaska right now responding to the spill from a Japanese tramper that went aground in Summers Bay. Hazmat has responded to more than 50 spills in the Bering Sea during the past 12 years.

12. NOS also administers the Coastal Zone Management Act (CZMA). Communities, boroughs, and Coastal Resource Service Areas along the Bering Sea Coast have developed coastal management plans. NOS provides between $300,000 to $400,000 a year to fund implementation and ongoing planning by communities along the Bering Sea Coast.

13. The CZM program recognizes that most land use decisions are local, but that there are also important federal interests in sustaining healthy coasts. A primary goal is to promote partnerships, communication, and streamlining of various federal, state, and local permitting processes.

14. The CZM program provides an ideal mechanism to foster local involvement in ecosystem planning and management. The CZMA explicitly encourages regional approaches to ocean and coastal resource management and planning.

15. The CZM program promotes wise use of coastal resources, and a balanced approach to coastal development. It encourages broad public discussion BEFORE final decisions are made, a factor that can result in some lively community debates. But such debate can be healthy in the long term, and ideally can lead to consensus among various interests.

16. Our Coastal Services Center is supporting and cosponsoring a number of studies in the Bering Sea. They are collaborative efforts and partners include UAF and NASA as well as other offices in NOAA. Subjects include sediment studies through remote sensing for the Yukon Kuskokwim Delta and Bristol Bay and utilizing satellite and modeling to determine fish biomass in the Bering Sea.

17. The Coastal Ocean Program has sponsored two important studies in the Bering Sea -- the Bering Sea Fisheries Oceanography Coordinated Investigations and the Southeast Bering Sea Carrying Capacity Study. Dr. Vera Alexander will be discussing the ongoing work between UAF and the Coastal Ocean Program a little later.

18. NOS has also participated in significant research efforts in the Bering Sea.

<u>Environmental Research and Monitoring in the Bering Sea by NOAA's National Ocean Service</u>
NOAA's National Ocean Service (NOS) sponsored and performed a large number of research, monitoring, information management, and related activities in the Bering Sea between 1974 and 1992 under the Outer Continental Shelf Assessment Program (OCSEAP). This has led to the development of a large amount of useful and authoritative data, models, and information synthesis regarding the physical, chemical, and biological characteristics of this area and its resources. The results of the OCSEAP studies have been published as an extensive set of reports and the data are archived at and available from NOAA's National Ocean Data Center.

Also, NOS, through its National Status and Trends Program, is carrying out an ongoing monitoring program to assess contaminant levels and effects around the coasts of the United States including the Bering Sea ecosystem. Concentrations of trace metals, organochlorine pesticides, PCBs, PAHs, and anthropogenic radionuclides have been measured in invertebrates, fish, and sediments at a number of sites in the Bering Sea. The results of these measurements show anthropogenic contamination in all areas studied, but usually at relatively low concentrations that are unlikely to cause deleterious ecosystem effects. More elevated levels have been noted in limited areas close to port facilities or mining activities.

## NOAA - National Marine Fisheries Service: Bering Sea Research

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### Bottom Trawl Surveys

The eastern Bering Sea crab/groundfish bottom trawl survey has been performed annually since 1972 and over the same area with the same gear since 1982. This survey encompasses over 465,000 $km^2$ of the eastern Bering Sea shelf and includes 356 stations based on a 20 X 20 nm grid. At each station a trawl is towed for approximately 1.5 nm and the catch is then sorted, weighed, and enumerated by species. Station data such as position and temperature information is also collected. Approximately 300 species of fish and invertebrates may be sampled during a survey. Several of the major species are then measured for length and age readable structures are collected. From these data, estimates of biomass and population, as well as size and age distributions are made.

The estimates obtained from these surveys act as fishery independent estimates of the resources present in the Bering Sea. When combined with fishery data (and echo integrator/midwater trawl estimates for walleye pollock) scientists can evaluate the condition of major stocks of fish and invertebrates to recommend Allowable Biological Catch (ABC) estimates to the North Pacific Fishery Management Council (NPFMC) or other management agencies.

In the case of non-commercial species, these surveys may provide the only estimate for many ecosystem components of the Bering Sea. Trends in population sizes may be compared with environmental data to help answer some of the many questions concerning ecosystem conditions. Over the years survey scientists have made hundreds of sample collections to assist further study by themselves and colleagues around the world. These studies may be to examine life history aspects of fish and invertebrates, chemical evaluations such as the presence of glyco-proteins (natural antifreeze in some cold water animals), or to advance medical research.

Roughly $2.85M is spent annually on bottom trawl stock assessment surveys for groundfish and crab in the Bering Sea and Aleutian Islands and the associated estimates of biomass and population, distribution, and biological parameters.

### Eastern Bering Sea Midwater Shelf Surveys

Midwater surveys of the eastern Bering Sea (EBS) are carried out using a calibrated echo sounding system and the echo integration trawl (EIT) technique for fish abundance estimation. Species and size composition of the midwater fish is determined using a large midwater trawl. The EIT technique is an accepted technique for estimating fish abundance and is particularly amenable to situations where the midwater fish are almost exclusively one species (walleye pollock in the EBS).

Echo integration-trawl (EIT) surveys were conducted over the entire EBS shelf from Unimak Pass to the U.S.-Russia Convention line in 1979, 1982, 1985, 1988, 1991, 1994, 1996 and 1997. The primary objective of each survey was to determine the distribution, abundance and biological composition of midwater pollock on the EBS shelf. In 1979 and 1982, a zig-zag transect pattern was used. Since that time, parallel transects, spaced at 20 nmi intervals have been used. The transect design used since 1991 involves running north-south transects which intersect the trawl locations for the bottom trawl survey. Although the exact area covered has varied between years, the surveys have generally been over bottom depths ranging from about 90 to 460 m and covering the entire shelf from Unimak Island to the U.S.-Russia convention line. Currently, about 100 trawl hauls are completed during each survey. Walleye pollock typically comprise over 98 % of the fish observed (both numerically and by weight). However, the survey design is too coarse and the number of trawl hauls too few to accurately describe the distribution and abundance of less abundant or midwater species. Also, the depth region less than about 90 meters contains few pollock and is not surveyed in most years.

The pollock abundance estimates obtained from these surveys act as fishery independent estimates of the resources present in the Bering Sea. When combined with fishery data and results from bottom trawl surveys, scientists can evaluate the condition of walleye pollock and recommend Allowable Biological Catch (ABC) estimates to the North Pacific Fishery Management Council (NPFMC).

The relevance of direct surveys to understanding the Bering Sea ecosystem and species interactions is obvious. Although process-oriented studies can begin to describe potential interactions between species, the magnitude and importance of these interactions can only be interpreted in the context of large-scale monitoring data. The broader context afforded by long-term programs, including monitoring, permits the interpretation of process-oriented studies conducted on smaller temporal and spatial scales. Even though the direct surveys carried out by AFSC in the Bering Sea require a significant amount of effort, the data will be insufficient to describe potential interaction between the important species in the eastern Bering Sea. Both bottom and midwater surveys are carried out during the summer months. Any comprehensive program that attempts to characterize species interaction in any detail at all must have data to allow an evaluation of the temporal/spatial overlap of the various life stages for each species.

Fisheries Oceanography Coordinated Investigations

FOCI (Fisheries Oceanography Coordinated Investigations) is a joint research project between two line elements of NOAA: National Marine Fisheries Service (NMFS) and Ocean and Atmospheric Research (OAR). It is carried out primarily by scientists at NMFS Alaska Fisheries Science Center and OAR Pacific Marine Environmental Laboratory. The goal of FOCI is to understand the influence of changes in the environment on the abundance of commercial fish stocks of Alaska. We have focused our efforts on walleye pollock stocks in both the Gulf of Alaska and the Bering Sea. The program began in 1984 with about $2 million per year shared between PMEL and AFSC to study the pollock stock in Shelikof Strait, Gulf of Alaska. These funds were augmented by base funds, and NOAA ship time. Some effort as early as 1985 was directed toward pollock in the Bering Sea. During 1991-1996 NOAAs Coastal Ocean Program funded FOCI to conduct a study in the Bering Sea (Bering Sea FOCI) focusing on two important questions regarding pollock: their stock structure and recruitment dynamics. This program was funded at a level of about $1 million per year, and again was augmented by AFSC base funds, and NOAA ship time. Since 1997 FOCI has been involved with a joint project with the University of Alaska, again funded by COP at about $1 million per year, examining the ecosystem of the Bering Sea, particularly focusing on the role of juvenile pollock. During its history FOCI has sought and received funding from other sources, such as NURP, ESDIM, and recently GLOBEC, to supplement its primary funding sources.

Over the years, FOCI has utilized a large number of collaborators from other NOAA elements and academic institutions. For example, Dr. Lew Incze, Bigelow Laboratory of Ocean Sciences, began our zooplankton studies, and Dr. Peter Ortner, NOAA Atlantic Oceanographic and Meteorological Laboratory joined us in the field for a number of years to assist us with advanced plankton sampling equipment. COP research is conducted based on a competitive proposal process. Researchers from Stanford University (Dr. D. A. Powers: pollock genetics), University of Alaska (Dr. Lew Haldorson and Dr. A. J. Paul: zooplankton and larval pollock feeding), and University of Washington (Dr. R. Francis: distribution of pollock spawning, eggs and larvae) participated in Bering Sea FOCI.

FOCI research in the Bering Sea has lead to numerous publications and presentations at scientific meetings. The following are among the key findings in relation to pollock in the Bering Sea ecosystem:

1. The stock structure of pollock in the Bering Sea is complex. There is little gene flow between pollock in the Eastern and Western Bering Sea, and limited flow between the Gulf of Alaska and the various

stocks in the Bering Sea. This has significant implications for management of the Bering Sea: the various stocks may have different population dynamics, and may respond differently to environmental or anthropogenetic influences.

2. Pollock spawn and their eggs and larvae occur in several distinct oceanographic domains in the Eastern Bering Sea. These domains vary in the factors that control production of food for the critical first feeding pollock larvae. For example, in the slope domain, advection seems to cause large variations in the amount of phyto- and zooplankton present at the time that first feeding larvae occur. Over the continental shelf interannual temperature variations during the period of larval occurrence strongly influence the production of prey. (Schumacher covers this in more detail).

3. The area around the Pribilof Islands holds large concentrations of young-of-the-year juvenile pollock in late summer. The complex frontal structure around the islands influences the distribution of these juveniles as well as their prey and the other fish, birds, and marine mammals that feed on them.

Jellyfish have dramatically increased in abundance in the Bering Sea over the last two decades. Concurrent changes in other parts of the ecosystem are not well-known. We have found that juvenile pollock are concentrated near the tentacles of these jellyfish during the day, and leave them to forage at night.

<u>Stock Assessment and Fisheries Ecology</u>

The Resource Ecology and Fisheries Management Division of the Alaska Fisheries Science Center plays an integral role in the synthesis of scientific information required to understand groundfish population dynamics and to supply information critical to fishery resource managers. The North Pacific Groundfish Observer Program provides the expertise necessary to train, place, and oversee the hundreds of fishery observers required annually to monitor commercial fish catch composition and fisheries interactions with marine mammals, seabirds, and other protected species in Alaska. These data are used for inseason management of fisheries and as critical input to groundfish population assessments for determination of acceptable biological catch. A key piece of information for assessing fish populations is fish age. Fish age data are provided through the efforts of the Age and Growth Task from otoliths collected from fishery and survey catches. Ecological information on groundfish diets and ration is provided by the Resource Ecology and Ecosystem Modelling Task. This information is used to improve understanding of marine food webs, build more predictive single-species, multispecies and ecosystem models, and provide advice on ecological implications of fishery management actions. The Socio-economic Assessments Task provides information and analyses to address socio-economic issues that are becoming more important in fishery conservation and management. They are presently planning the collection of fishery cost, earnings and employment data to support their analyses. The exvessel value of Alaska groundfish and crab fisheries exceeds $700 million and the processed product value exceeds $1.5 billion. These fisheries provide important sources of employment and income for many fishing communities. Socioeconomic assessments provide data and analyses that allow better prediction of the effects of fishery management actions on our communities. The Status of Stocks and Multispecies Assessments Task is responsible for preparing annual stock assessments for Alaskan groundfish, conducting research to improve the accuracy of these assessments and their ecological scope and assisting the North Pacific Fishery Management Council in evaluating the potential biological consequences of proposed fishery management measures.

The basic monitoring and data collection efforts of the REFM Division provide essential data to measure direct impacts of fishing on fish stocks, marine mammals, birds, and other protected species. Also, we are increasing our knowledge of marine food webs through the collection of information on groundfish trophic linkages. Management of ecosystems requires the acknowledgment that humans are part of the ecosystem and socioeconomic assessments provide analyses supporting the human dimension of ecosystems. Incorporating these data and other ecosystem data into advanced analyses and models will help us better understand and predict the impacts of fishing, species interactions and climate on fish stocks and ecosystems. These activities are the focus of our present and planned ecosystem research efforts. Present and future research emphases of these groups are to: improve data collections and to decrease uncertainty in prediction by advances in our analytical techniques and our measurement systems.

Marine Mammal Research

The National Marine Mammal Laboratory (NMML) of the Alaska Fisheries Science Center is responsible for advising the NMFS Alaska Regional Administrator regarding the status of pinniped and cetacean species in Alaska waters. NMML works with the NMFS Protected Resources Office (F/PR) in developing the biological basis for the NMFS proposed regime for governing marine mammal-fishery interactions and with North Pacific Fisheries Management Council (NPFMC) to evaluate possible utilization measures in the fisheries. Marine mammal assessments are based on activities which include: determination of stock structure, minimum abundance, net productivity, ways to mitigate fishery interactions, and management actions needed to promote recovery. Although not specifically a part of our research program, NMML pinniped biologists are members of the NPFMC Fishery Management Plan Teams and have been involved in the development of ecosystem considerations as part of the Teams' activities and advice to the Council.

Ecosystem studies focus on feeding ecology, reproductive success, growth and condition, demography, abundance, and the status of prey availability and other environmental conditions. Research on feeding ecology results in estimates of consumption rates that serve as information on empirically observed sustainability within ecosystems. Such information is being used to develop a basis for ecosystem management. Research at NMML provides important information for the development and implementation of ecosystem models. These data are linked with physiological parameters to assess the effects of food availability and hence nutrition provided to nursing pups, changes in foraging behavior, and estimates of the amount of resource consumed by the predator. One particular study, in cooperation with US Geological Survey, the University of Alaska, NMFS, and the Maritime Refuge, involves the linkage between Steller sea lions, seabirds, fish distribution, and fish abundance at numerous sites along the Aleutian Island chain.

Genetic stock identification to determine the origins of chum salmon harvested incidentally in the Bering Sea trawl fishery, 1993 and 1995

In 1993, The Bering Sea "B" season trawl fishery had a chum bycatch of nearly 250,000 fish that coincided with an extremely poor return of chum salmon to streams in Western Alaska. The immediate reaction was that the trawl fishery was wholly or partially responsible for these poor returns, and there were calls for curtailing this fishery. A request was made to NMFS as to whether they could use genetic stock identification to determine the origins of the chum bycatch. The Auke Bay Laboratory of the Alaska Fisheries Science Center and a number of cooperators had developed a genetic baseline for the entire North Pacific that could discriminate by major regions (Japan, Russia, Western Alaska summer-run, fall-run Yukon River, Alaska Peninsula, Southeast Alaska, British Columbia and Washington State). The NMFS Observer Program collected samples from the 1994 and 1995 "B" season fishery and shipped them to Auke Bay for analysis using protein electrophoresis. Results over the two years showed that the origins of the chum salmon in the bycatch were: 32-42% Asian, 29-45% Western Alaska summer and fall run/Alaska Peninsula, and 25-29% Southeast Alaska/British Columbia/Washington State. These results show that this fishery was not harvesting an inordinate amount of chum salmon destined for Western Alaskan rivers, and that the eastern Bering Sea is an important rearing area for chum salmon stocks throughout the Northern Pacific. This project cost about $200k per year.

Bio-Physical Meta-database of the Bering Sea

This is a joint project of the Pacific Marine Environmental Laboratory and the Alaska Fisheries Science Center. The objective of this project is to facilitate and enhance the ability of researchers, managers, students, fishermen, and the general public to investigate and understand the functioning of the complex ecosystem of the Bering Sea. The objective will be realized through locating and assembling an inventory of the extensive biological and physical data collected on the Bering Sea ecosystem (BSE), developing these into an indexed annotated catalog (metadatabase), and making the metadatabase available through various mechanisms. Existing information as well as recently gathered data will be examined. The metadatabase will be made available to users in on-line formats. The on-line form of the metadatabase will provide instantaneous access to the collected information from the World Wide Web in a homepage format. This approach will provide users a real-time direct link back to the metadatabase for querying and viewing data online.

The Bering Sea provides about 40% of the entire U.S. seafood harvest. Our ability to manage these resources, and those of other U.S. fisheries, depends critically on knowledge of how ecosystems function. Scientists that undertake inter- and multi-disciplinary investigations, such as those required of ecosystem level research, must have access to information and data sets that are more complex than those needed by studies that focus on one or two disciplinary areas of study. Data sets suitable for ecosystem research must include information on all important biological and physical components of the ecosystem and relate these often disparate pieces of information together by linking them to some attribute such as common space and time scales. In addition, these must be a mechanism to examine the information in an integrated holistic way.

Centralized access to the metadatabase by investigators with different skills and interests and from many institutions or agencies, is critical to the study of ecosystem processes. It is essential that policies and procedures for uniform data management and rapid exchange be utilized as they will foster linkages between studies on different time and space scales. Also, a free flow of information to all investigators is vital in planning experiments, data analyses, and modeling efforts, and in putting together the broad picture of the relationship between and among the various biological, physical, and chemical data that have been collected.

Compilation of a bio-physical metadatabase of the varied and disparate historical data sets (hydrography to higher predator abundances) in the Bering Sea will offer several benefits to any project related to studying the BSE. The metadatabase should prove useful to individuals undertaking field work, validating simulation models, or collecting data for retrospective analyses. The metadatabase will facilitate past, present and future comparisons of biological processes and their coupling to the physical and biological structure and variability of the environment. Decadal data sets of biotic and abiotic variables will allow the question of climate scale variability to be addressed. It will allow individuals to monitor changes and provide baselines for formulating and testing hypotheses that will advance understanding of the processes that regulate ecosystem production. We anticipate that the products of this project will become more valuable as time passes. Finally, the metadatabase will allow individuals to perform regional comparisons, better define regional differences in forcing and response within the Bering Sea, and the extent to which long-term changes are coherent, throughout the Bering Sea.

**U.S. Fish and Wildlife Service Projects in the Bering Sea Ecosystem**

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Four years ago the U.S. Fish and Wildlife Service adopted an *Ecosystem Approach to Management* of its trust resources. The Alaska Region of the U.S. Fish and Wildlife Service divided the State into 10 ecosystems for management purposes. The Bering Sea/Aleutian Islands ecosystem was identified as one of the priority ecosystems of the U.S. Fish and Wildlife Service. One of the tenant foundations of the U.S. Fish and Wildlife Service ecosystem approach was partnering with other stakeholders in the ecosystem. This basic philosophical approach changed many projects. Others remained the same because of certain trust species requirements. This effort in partnering is still a U.S. Fish and Wildlife Service priority. I believe that the opportunities and benefits for partnering will show themselves during this presentation and those of others at this workshop. With the limited time we have I will concentrate on the major activities of the U.S. Fish and Wildlife Service in this ecosystem. I have prepared a handout, a series of eighteen 1-page fact sheets on the U.S. Fish and Wildlife Service's projects. These do not give results but do provide an atmospheric inventory of what the U.S. Fish and Wildlife Service is doing in the ecosystem. Each fact sheet gives a contact for the individual projects if you desire more information.

Generally, the U.S. Fish and Wildlife Service projects I will describe fall into the categories of monitoring and special studies. Many more activities, such as prevention of rat introductions, law enforcement, harvest surveys, Aleutian Canada goose and Aleutian shield fern recovery efforts, etc. will not be discussed in this venue. I will talk about the trust species the U.S. Fish and Wildlife Service is responsible for: marine mammals, migratory birds, and endangered species.

Sea otters in the central Aleutians have been declining. Work that will be described by Biological Resources Division of the United States Geological Survey shows a major decline at Adak. Further status review, paid for by the Navy, clearly documents a decline throughout the central Aleutians. One of the highest priorities for this work is to complete another aerial survey to document the decline from the 1992 survey. Research by Biological Resources Division of the United States Geological Survey is necessary to determine the cause of the decline. While Biological Resources Division of the United States Geological Survey documented levels of PCBs in Adak otters, the U.S. Fish and Wildlife Service also documented organochlorine contamination in sea otters from Shemya and Adak.

The U.S. Fish and Wildlife Service has a major monitoring program for Pacific walrus that provides a time-series of data, starting in 1977, for walrus haulouts at Round Island, Cape Newenham, and Cape Peirce. Cape Seniavin is a "hole" in this database for monitoring summer haulouts in Bristol Bay. Other walrus monitoring efforts are the tagging and kill data collection that has been occurring along coastal Alaska since 1972. A special study was conducted from 1993 to 1996 at Round Island and Cape Newenham to study walrus behavior. The U.S. Fish and Wildlife Service also monitors polar bears for contaminants at St. Lawrence Island.

Information is being collected annually for selected species of marine birds at breeding colonies on Buldir Island, Kasatochi/Koniuji/Ulak islands, Aiktak Island, the Pribilof Islands, Cape Peirce, Bluff, and Little Diomede (planned for 1998) to monitor the condition of the Bering Sea ecosystem. The strategy for colony monitoring includes estimating reproductive success (e.g., chicks per nest) and population trends of representative species of various foraging guilds (e.g., murres are off-shore diving fish-eaters, kittiwakes are off-shore surface-feeding fish-eaters, auklets are diving plankton-eaters) at geographically-dispersed breeding sites. Productivity is monitored every year and populations are monitored at least every three years. In addition, passerines, marine mammals, food, environmental conditions, and oil pollution are monitored at these sites (Cape Peirce is a site for both walrus and seabirds). Colonies near these annual sites are identified for less frequent surveys to "calibrate" the information at the annual sites. Furthermore, other research projects (e.g., like those associated with evaluating the impacts of oil spills on marine birds) supplement the monitoring database. The value of the marine bird-monitoring program is enhanced by having sufficiently long time-series to describe patterns for these long-lived species. This information enables managers to better understand ecosystem processes and respond appropriately to resource issues.

The U.S. Fish and Wildlife Service, University of Alaska Fairbanks-Institute of Marine Sciences, and the National Marine Fisheries Service have teamed up to characterize the nearshore environments around rookeries to better clarify the relationship between near shore forage fisheries and marine mammal and marine bird rookeries. This is a 6-year program that may lead to a scheme to monitor nearshore forage fish. Due to their responsibilities for conservation of marine mammals and seabirds, the National Marine Fisheries Service and the U.S. Fish and Wildlife Service have ongoing programs to monitor the status of selected species at breeding colonies. Time-series data, which have been collected over the past 20 years, show fluctuations in populations, productivity, and other condition indices. Additional studies, including those conducted by the Biological Resources Division of the U.S. Geological Survey and the University of Alaska Fairbanks-Institute of Marine Sciences, indicate forage fishes comprise the major prey for many marine mammals and seabirds. To understand reasons for observed changes, these partnering organizations agreed to supplement separate ongoing investigations of Steller sea lions and several species of fish-eating seabirds with descriptive surveys of the nearshore marine foraging habitat at six locations on the Alaska Maritime National Wildlife Refuge. Plans are to conduct initial, descriptive marine surveys at one site each year until all six sites have been surveyed, and to resurvey at least one site every year to evaluate inter-year variability.

The Seabird, Marine Mammal, Oceanographic Coordinated Investigations (SMMOCI) began in 1995 near Unimak Pass, in the eastern Aleutian Islands, to supplement ongoing monitoring programs at Ugamak Island (sea lions) and Aiktak Island (murres, puffins, and other seabirds). The following data were collected from the U.S. Fish and Wildlife Service vessel *M/V Tiglax*:

1. At-sea distribution of sea lions and seabirds (observations from the flying bridge)
2. Biomass of prey, including forage fish (acoustics surveys supported by trawls)
3. Oceanographic characteristics of water masses (CTD casts and thermosalinograph on transects)
4. Diversity and prey of bottom fishes (long-line and bottom trawls).

In another attempt to learn about prey species abundance and marine bird productivity, biologists are looking at predatory fish like Pacific halibut, Pacific cod, and sculpins that are opportunistic feeders that sample potential prey for fish-eating seabirds. The Alaska Maritime National Wildlife Refuge is interested in the effect of changes in seabird diets on their productivity and population trends in the Pribilof Islands where a long-term monitoring program is underway. In the summer of 1996, the refuge formed a partnership with the Central Bering Sea Fisherman's Association to evaluate opportunities to obtain stomachs of predatory fish caught at St. Paul in commercial, sport and subsistence fisheries near the island. Due to excellent cooperation from local fishermen, we obtained stomachs from 558 halibut, 35 cod, and 32 sculpins. Few forage fish were found in stomachs of predatory fish in 1996. Interestingly, kittiwakes and murres experienced low reproductive success. It is assumed that in years when forage fish are common in the area, predatory fish will prey on them and seabird reproductive success will be higher. This is funded as a challenge grant on a year-to-year basis.

Other migratory bird projects include winter waterfowl surveyed on Adak, Amchitka, Shemya, St. Paul, and St. George Islands. The monitoring program at Shemya Island was designed to inventory and describe avian and marine mammal species using the island and its near shore marine environment during the winter of 1996/97. This program was a continuation of surveys initiated during the winter of 1994/95 as part of the Legacy Program. An emphasis was placed on species listed as endangered or threatened under the Endangered Species Act of 1973 and those designated as a "species of concern" by the U.S. Fish and Wildlife Service. These data will be used to detect future trends in populations and distribution of species on a local level. When combined with data from other locations, trends can be determined throughout the species' range and will alert managers to potential problems. All funding is "soft money" coming from the Air Force, Navy, or other sources. With the decline in military activities in the Aleutians we believe these surveys will also decline.

To better understand the nature and extent of subsistence migratory bird hunting, the U.S. Fish and Wildlife Service has a cooperative program for conducting harvest surveys in these villages, from the Aleutian Islands all the way to the Northwest Arctic. On the Yukon Delta, Togiak, and Alaska Peninsula-Becharof National Wildlife Refuges in southwest Alaska, the surveys are conducted by Native staff members of each refuge. In the Aleutians, Bristol Bay, Bering Strait, and the Northwest Arctic (NANA) regions, surveys are conducted through cooperative agreements with regional Native organizations and with the Alaska Department of Fish and Game (ADF&G) Division of Subsistence. To date, survey results have been received from over 75 villages, whose village governments also cooperate with the harvest survey. The surveys taken as a whole, provide harvest information on approximately 60 different species of migratory birds and their eggs. These include geese, ducks, swans, cranes, and many species of seabirds and shorebirds. The surveys also include ptarmigan, grouse, and snowy owls.

Special studies on contaminants have also been conducted on migratory birds in the Bering Sea ecosystem. During the winters of 1993-94 and 1994-95, bald eagle carcasses were collected on Adak Island. Cause of death for most of these birds was electrocution from landing on high tension power lines. The study looked at organochlorine pesticide, total PCB and elemental analyses conducted on liver and kidney tissues from these animals. In addition, from 1991-1995, eider (Steller's, spectacled and common) carcasses were collected throughout Alaska and arctic Russia. This study also looked at organochlorine pesticide, total PCB and elemental analyses conducted on liver and kidney tissues from these animals. Another study evaluated chemical exposure and induced effects in a sampling of 20 adult male spectacled eiders collected near St. Lawrence Island. In addition to the spectacled eider, contaminants work, surveys of this threatened species have been conducted in cooperation with Biological Resources Division of the United States Geological Survey (who will discuss these activities).

I hope this overview of our projects in the Bering Sea ecosystem has helped you to understand the extent of our involvement and interest in the biological processes in this region and interest in partnering with Native, state, and federal entities working in the area. With increased stakeholder integration and partnering, those processes will be easier to understand.

**The USGS Biological Resources Division: Research Program in the Bering Sea**

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The Biological Resources Division (BRD) of the U.S. Geological Survey, through the Alaska Biological Science Center (ABSC), California Science Center (CSC), and the Cooperative Fish & Wildlife Research Unit at the University of Alaska-Fairbanks (UAF), has been engaged in research in the Bering Sea for well over a decade. Migratory birds and marine mammals managed by the Department of the Interior have been and continue to be the primary species groups studied by BRD scientists. Because many of these animals are migratory and shared with other nations in the Pacific Rim, the BRD has established cooperative ventures with Russia and Japan to address various aspects of the life history and population dynamics of migratory birds and marine mammals. The BRD research program encompasses pelagic, as well as estuarine habitats within the Bering Sea from the Bering Straits south to Bristol Bay and west through the Aleutian and Commander Islands. St. Lawrence, St. Matthew, and the Pribilof Islands have also been important research sites, as have island and nearshore habitats in the Gulf of Anadyr on the Russian side of the International Date Line.

The present BRD research program stems from the Outer Continental Shelf Environmental Assessment Program (OCEAP) managed by the National Oceanic and Atmospheric Administration and the Bureau of Land Management (BLM) during the 1970's and early 1980's. A primary goal of the OCEAP was to gather information on status and trends of marine animals and their habitats that would be useful to the U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service, and other management agencies in evaluating mineral leasing plans, industry operating procedures, and provisions for protecting fish and wildlife offshore and nearshore. The Bering Sea was one of the principal study sites during the OCEAP because of internationally important natural resources and the potential for impacts to fish and wildlife populations from planned industrial activity.

Databases on distribution and numbers of marine animals in the Bering Sea collected during the OCEAP provided the foundation for more intensive ecological research during the 1980's and 1990's. It was during this time period (mid- 1980's) that the USFWS and other agencies recognized declining trends in the populations of several key indicator species and animal groups in the Bering Sea. In 1985 the ABSC (then the Research Division of the USFWS) began collaboration with the Alaska Region of the USFWS and the Minerals Management Service (MMS) to examine causes of declines in marine waterfowl and several seabirds. The ABSC also launched long-term studies of Bering Sea marine mammals managed by the USFWS.

Four species of Bering Sea waterfowl--emperor geese, black brant, spectacled eiders, and Steller's eiders--have been the subject of ABSC research in recent years. Emperor geese nest principally on the Yukon-Kuskokwim Delta (YKD) within 30 km of the Bering Sea and winter on coastal beaches along ice-free areas of the Aleutian Islands and the Alaska Peninsula. The emperor goose population declined precipitously from 139,000 in 1964 to 42,000 in 1986, and has fluctuated between 51,000 and 71,000 since then. The current level of 57,000 is less than one-half historic population highs and well below the management objective of 150,000. The factors responsible for this quick decline and slow recovery are poorly understood. The ABSC, in collaboration with the USFWS, initiated mark-recapture studies to determine survival of adult females on nests and seasonal and annual survival of adults and juveniles during the post-nesting period. Gosling survival studies were also initiated to better understand whether poor survival of young has affected the overall population. Results from these studies and population modeling exercises demonstrate that managers must enhance survival of adult emperors to promote recovery of this species to former levels.

Another marine goose of the Bering Sea, the black brant, has experienced population declines on their main breeding grounds on the YKD. Nearly the entire world population of brant stage at Izembek Lagoon near the tip of the Alaska Peninsula during fall prior to migration to primary wintering habitats in Mexico. To understand factors controlling brant populations the ABSC collaborated with the Canadian Wildlife Service, USFWS, BLM, MMS, network of Nature Reserves (Russia), and UAF to individually mark nearly 45,000 black brant with coded leg bands on primary breeding colonies in the Bering Sea and at smaller colonies in the high arctic of Alaska and Canada. We estimated seasonal and annual survival rates of adult brant from resightings of leg-banded birds at key migration staging areas such as Izembek Lagoon and wintering areas in Mexico. Mean monthly survival rate was lowest in late spring migration and highest in winter. We concluded that subsistence harvest in spring was a primary factor limiting recovery of black brant. Concern for disturbance to brant from air-traffic associated with Outer Continental Shelf petroleum exploration in the North Aleutian Shelf prompted the MMS to contract with the ABSC to examine the response of brant to incidental and controlled aircraft overflights during fall staging at Izembek Lagoon. A multi-year research effort at Izembek Lagoon revealed that brant are especially sensitive to helicopters flown at intermediate altitudes (300-750 m). However, lateral distance between aircraft and flock was the most important parameter in predicting response of brant to overflights. Disturbance can be minimized by routing aircraft at least 1.6 km from staging brant.

The Bering Sea and adjacent estuaries provide critical pre- and post-nesting staging and winter habitats for seaducks. Two seaduck species have experienced dramatic, unexplained declines in their numbers during the last 20 to 30 years. Based upon surveys conducted on the breeding grounds, the YKD population of spectacled eiders declined from 50,000 pairs in 1971 to about 1,700 pairs in 1992. In 1993 the USFWS listed spectacled eiders as threatened under authority of the Endangered Species Act (ESA). From 1992-1996 YKD spectacled eiders have increased an average of 16% per year to about 3,000 pairs, still 94% below the historic population. Working closely with the USFWS and the Spectacled Eider Recovery Team, the ABSC initiated research on nesting birds in Alaska and Russia. We also developed implantable satellite transmitters to track birds at sea because virtually nothing was known about post-nesting distribution of the species. Even the location of wintering areas was a mystery. Genetic studies were conducted to examine relationships between different nesting populations of spectacled eiders in Alaska and Russia. These field and laboratory studies yielded some surprising and significant results important to understanding factors limiting recovery of spectacled eiders. Nesting studies on the YKD showed that spectacled eiders experienced relatively high production, but exposure of adults and young to lead from spent shot adversely affected survival. During the period from arrival through incubation, 13.0% of adult females and 6.6% of adult males had elevated blood lead levels. During the brood-rearing period, 35.8% of adult females and 12.2% of ducklings were exposed to lead. Models predicted that 50% of the successfully breeding hens were likely exposed to lead, and 25-35% of the spectacled eider breeding population on the YKD was exposed to lead. Adult females exposed to lead prior to hatching their eggs survived at a much lower rate than females not exposed. Satellite telemetry studies revealed the location of important post-nesting staging areas in Norton Sound and the Gulf of Anadyr. Satellite telemetry and subsequent aerial surveys resulted in the discovery of virtually the entire world population (363,000 birds) wintering in the Bering Sea pack-ice between St. Lawrence and St. Matthew islands. These discoveries offer, for the first time, the opportunity to examine factors that may be limiting survival of spectacled eiders during the nearly 9 months they are at sea.

In 1997 the North American population of Steller's eider was classified threatened under authority of the ESA. This species has essentially disappeared as a breeding bird on the YKD, and now nests in very small numbers on Alaska's North Slope. In the North Pacific Rim there are fewer than 150,000 Steller's eiders with virtually the entire population dependent upon the Bering Sea and adjacent estuaries along the Alaska Peninsula and Aleutian Islands during the post-nesting period. The ABSC and USFWS are evaluating survival of the population through a mark-recapture study at Nelson and Izembek lagoons where Steller's eiders molt and winter. We have leg-banded over 50,000 Steller's eiders and are developing population models based on survival estimates derived from recaptures. Our plans are to initiate cooperative projects in Russia where Steller's eiders nest to evaluate their distribution, movements, and habitats in the Bering Sea.

Common murres, thick-billed murres, and black-legged kittiwakes are among the most abundant and widely distributed seabirds in Alaska, with very large breeding colonies on the Pribilof Islands and St. Matthew Island. In contrast, red-legged kittiwakes are restricted to only 6 locations in the world--all in the Bering Sea. More than 90% of all red-legged kittiwakes breed at the Pribilof Islands on St. George Island. Studies of these and other seabirds were initiated at the Pribilofs in 1975 and have continued more or less without interruption. From this work it is known that seabirds in the southeastern Bering Sea rely heavily on juvenile walleye pollock for food, and that some seabird populations have declined during the past two decades. In particular, populations of murres and both species of kittiwakes have declined by up to 50% at colonies in the Pribilofs, although declines appear to have leveled off in recent years. These declines followed more than a decade of falling output in chick production by murres and especially kittiwakes during the 1970's and early 1980's. Productivity has improved in recent years, but populations remain low. Factors influencing breeding success are not well described, but include long- term changes in oceanographic conditions and associated variability in forage fish abundance. In particular, kittiwake and murre breeding success are intimately linked with recruitment of juvenile walleye pollock. Relationships between pollock recruitment, adult spawning stocks, and commercial fisheries remain unclear. The ABSC will continue working with the USFWS, UAF and other collaborators to investigate these relationships and to identify factors limiting seabirds in the Bering Sea.

Three species of marine mammals--sea otter, polar bears, and Pacific walrus--have been the subject of ABSC research in recent years. Catastrophic declines in Aleutian Islands sea otters, especially at Adak Island, have presented an important challenge to researchers at the ABSC and CSC. The number of sea otters counted during surveys of Adak has declined from at least 2,500 individuals in the late 1980's to less than 600 in 1997. Current research is focused on three questions concerning sea otter population declines in the Bering Sea: 1) how wide-spread is the decline? 2) what is the cause, and are their links to other marine ecosystem changes? and 3) what are some of the ecological consequences? Each of these questions is answerable because of our knowledge of the system and the existence of an excellent historical database for sea otters and the coastal ecosystems in which they live. The geographical extent and magnitude of the decline can be assessed by repeating surveys conducted over the past 30-40 years. The cause of the decline is a more problematic question, but resolvable. Evidence from our recent research at Adak Island has shown that the declines are not due to food-limitation, disease, dispersal, or reproductive failure. There is some evidence suggesting that the declines are linked with changes in the adjacent oceanic ecosystem. Similar declines in a variety of marine birds and mammals in the Bering Sea suggest that what seems to be happening with sea otters is the consequence of a large-scale ecosystem collapse. We intend to evaluate this hypothesis by obtaining measures of sea otter demography and body condition, and by searching for concordant patterns in the timing and spatial scale of declines among species. Finally, ecosystem effects will be assessed by repeating work from a variety of habitat surveys and ecological studies conducted over the past several decades from Attu Island in the west to Unimak Island in the east. One of the more intriguing hypotheses is that the sea otter declines are being driven by killer whale predation. We speculate orcas are transforming the coastal kelp forest from a 3- to a 4-trophic level system, and that the recent entry of orcas into the coastal system is being driven by declines in their preferred or previous prey (pinnipeds). These changes ultimately are the consequence of ecosystem regime shifts in the open sea caused by fisheries or perhaps climate change. Alternative hypotheses to explain population dynamics of sea otters in the Bering Sea are linked to disease and contaminants.

Polar bears are apical predators in the pelagic fish and seal food web in sea ice habitats and prey primarily on ringed seals. The Chukchi Sea population occurs in western Alaska and recent ABSC research has been focused on defining the range of the population and on the development of suitable aerial survey methodologies to provide an estimate of size for this wide-ranging population. Over 200 adult females have been fitted with satellite telemetry collars during the past 10 years in western Alaska and eastern Russia, and their subsequent movement patterns indicate that the Chukchi population is shared internationally between the U.S. and Russia. The northern Bering Sea is seasonally used by polar bears during the winter months when the sea is ice-covered. This use is concentrated in the vicinity of St. Lawrence Island and along the Russian coastal areas of the Gulf of Anadyr, where recurring polyñas provide sea ice habitats favorable for ringed seals. Maternity denning has not been documented in the Bering Sea, and the majority of maternity denning for this population occurs on Wrangel and Herald Islands in the northwestern Chukchi Sea of Russia. A suitable aerial survey protocol has been developed and tested, however, due to the economic crisis in Russia and the subsequent collapse of the logistical infrastructure within the Russian arctic, the survey protocol has not been implemented. Seasonal interrelationships between polar bears and sea ice habitats have been investigated using remotely sensed data on sea ice coverage. Bear use of habitats with 75-100% ice cover in the northern Bering Sea is more common than in areas with lesser ice cover.

Pacific walrus are apical predators in the benthic invertebrate food web of marine environments of the Bering and Chukchi seas. The entire Pacific walrus population occurs along the southern edge of the sea ice in the Bering Sea during winter months. Walrus are concentrated in two general areas during this period; southern Bristol Bay off western Alaska and the Gulf of Anadyr. Adult females and their young, and immature animals migrate north into the Chukchi Sea during early summer when the sea ice recedes. They remain in contact with the receding ice throughout the summer and return to the Bering Sea in the fall when sea ice reforms. Adult males remain in the northern Bering Sea during the ice-free period and frequent land-based haulouts in Alaska and Russia. Efforts to periodically census the population have been only marginally successful, as the variation in the estimates is high and calculated confidence limits are wide, always including zero. ABSC research on Pacific walrus has concentrated on summer haulouts of adult males in the Bristol Bay region. Approximately 50 walrus have been fitted with satellite transmitters at 4 major haulout sites; Cape Sineavan, Round Island, Cape Peirce, and Cape Newenham. Movements of instrumented animals indicate exchange of animals between all haulouts during the summer months, with a general haulout use pattern of southern haulouts during early summer (Cape Sineavan and Round Island) and the more northern haulouts during late summer (Cape Peirce and Cape Newenham). During early fall, adult males move north to the St. Lawrence Island area and re-establish contact with the female segment of the population. Use of the summer haulouts by individual walrus is highly variable within haulouts and between haulouts. It is believed that this variation is due to differences in the quality and extent of benthic feeding sites associated with the various haulouts. The current research is designed to locate benthic feeding sites associated with specific haulouts, to characterize each site, and to examine the hypothesis that usage patterns of the various haulouts by walrus is related to the ecological characteristics of the benthic feeding sites.

Sea ice is the substrate used by polar bears for hunting seals and by Pacific walrus as a haulout platform for resting between feeding bouts. It occurs in the Bering Sea during winter months and its extent and characteristics are highly variable between years. Remotely sensed Nimbus SMMR and SMM/I data have been used to define the extent and general coverage of sea ice in the arctic. However, the resolution of these data is a 25 x 25 km cell size. AVHRR data have a higher resolution (1 km2 cells), but the satellite sensor uses visible light bands and requires cloud-free conditions and solar illumination (daylight), conditions that often do not occur in the arctic. Current ABSC research on sea ice remote sensing is collaborative with Russian scientists and is using simultaneously collected Russian satellite passive microwave and active radar data to define ice types and coverage at a resolution of 3 km cells.

These data will then be used to examine the interrelationships between polar bears and walrus and their sea ice habitats.

In conclusion, the BRD in partnership with other Department of the Interior agencies, state and Native organizations, universities, and foreign governments is actively engaged in researching causes for documented changes in migratory birds and marine mammals dependent on the Bering Sea. We encourage other interested groups to join us in resolving resource problems in this internationally important ecosystem.

## MMS Past and Ongoing Research: Bering Sea

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### Introduction

Oil and gas exploration and development in the United States portion of the Bering Sea is managed by the U.S. Minerals Management Service (MMS) and the State of Alaska (State). The MMS manages oil and gas activities on the Federal outer continental shelf (OCS). The OCS comprises those lands located generally 3 miles offshore of the coast and seaward. The State of Alaska administers these activities on State submerged lands located from the coast to the State/Federal boundary.

### MMS-Sponsored Environmental Information

The OCS Lands Act as Amended (OCSLAA) (43 U.S.C. 1331-1356 [1994]) provides statutory authorization for the expenditure of funds to provide information needed for the prediction, assessment, and management of effects on the human, marine, and coastal environments of the OCS and nearshore areas that may be affected by OCS oil and gas activities. These funds are administered by the MMS Environmental Studies Program (ESP) with the intent to achieve objectives consistent with the OCSLAA:

- Provide information on the status of the environment upon which the prediction of impacts on the human, marine, and coastal environment may be based,
- Ensure that information already available or being collected is in a form that can be used in the decision-making process, and
- Provide a basis for future monitoring of OCS operations.

*Pre-lease.* In consideration of the ambitious U.S. leasing schedules for the Bering Sea in the 1980's, a formidable amount of multidisciplinary information was needed to complete EIS's on the Bering Sea natural and human environment and to support lease-sale and post-lease decisions. During and somewhat prior to that period, MMS alone spent more than $100 million on environmental studies applicable to Bering Sea pre-lease environmental assessment and post-lease monitoring- decision processes. These studies fell in major categories defined by MMS as pollutant transport (i.e., ocean circulation studies and oil-spill-trajectory modeling), oil-spill fate and effects (i.e., weathering and other biogeochemical interactions), ecosystems, endangered species, living resources, social and economic, and environmental geology. As an example, MMS attributed 171 of the environmental and 55 of the social/economic studies that it sponsored as applicable to leasing decisions in the St. George Basin Planning Area, situated between Unimak Pass and the Pribilof Islands.

The process of synthesis is critically important considering the numerical scope and disciplinary diversity of the above research effort. This vital component of integrating and summarizing numerous study reports was accomplished by a series of 1. Synthesis, 2. Information Transfer, 3. Information Update and 4. Meetings, as well as production of hard-cover volumes such as Hood and Calder (1981). Thus, the potentially ephemeral and/or specialized literature of individual reports was made more useful, accessible, and available to a wider public. The most recent synthesis reports for specific Bering Sea planning areas are Jarvela (1984) for the Navarin Basin, Hameedi (1982) for the St. George Basin, Thorsteinson (1984) and Jarvela and Thorsteinson (1989) for the North Aleutian Basin, and Truett (1985) for the Norton Basin. Reports from MMS Information Transfer Meetings such as USDOI, MMS, Alaska OCS Region (1990a) also reviewed studies that were ongoing in the Bering Sea. Additional synthesis efforts for key topics of concern such as the bowhead whale (Burns et al. 1993), effects of noise on Bering Sea pinnipeds (Johnson et al. 1989), the Yukon Delta (Thorsteinson et al. 1989), forage fish (USDOI, MMS, Alaska

OCS Region 1987), and effects of OCS mining (USDOI, MMS, Alaska OCS Region 1989, 1990b) are also available.

Dissemination of information goes hand in hand with the synthesis process, and MMS-sponsored researchers have been encouraged and required to publish their results. For Bering Sea physical oceanography, of 200 reports and publications known to have been published since 1981, about 75 were sponsored by MMS; and more than 35 of them integrated physical and biological research (R. Prentki, MMS, Alaska OCS Region, Pers. Comm.).

*Post-lease.* Twenty-four exploratory wells have been drilled in the Bering Sea. There were no reported discoveries of oil or gas, and all of the wells were permanently plugged and abandoned. The absence of a discovery of economically commercial quantities of hydrocarbons has generally discouraged industry interest in additional leasing and exploration in previously drilled planning areas. Industry has continued to express interest in drilling in the North Aleutian Shelf Planning Area, which is still considered a frontier area. During the development of the MMS's 5-year oil and gas leasing program for 1997-2002, industry indicated a small interest in additional leasing in the Norton Basin Planning Area. However, under the final 5-year program, no lease sales in the Bering Sea planning areas are proposed for the 1997-2002 period (USDOI, MMS 1996).

As the information regarding location and timing of exploration and development improved, the scale of desired environmental information and the related uncertainties decreased. During post-lease phases, because exploration locations and issues are more clearly defined, much more focused efforts such as monitoring studies were implemented. For example, Houghton and Blaylock (1987) and Brueggeman (1987) provided research designs for monitoring Bering Sea hydrocarbon pollution and endangered whales, respectively. The former may be of particular interest to parties currently designing studies of other potential Bering Sea contaminants. With the termination of Bering Sea post-lease activity, as well as relinquishment of leases (see Exploration History, below), the MMS environmental studies mandate for the Bering Sea was significantly lessened. Thus, the MMS environmental studies effort has been significantly reduced in the Bering Sea, with the exception of completion of certain physical oceanographic studies, social indicators monitoring, and monitoring of protected species as part of ongoing region-wide studies . Several of the ongoing studies, although now managed by entities other than MMS and cited elsewhere in this workshop, were cooperatively designed and inititated in the early- to mid-1980's under MMS sponsorship, including seabird colony monitoring and the Alaska Marine Mammal Tissue Archival Program (AMMTAP). The latter has served as model for national monitoring programs.

Although the MMS Alaska ESP's mission in the Bering Sea is much reduced, we remain interested in cooperative opportunities to obtain information useful to our decision process and useful to improved management of the valuable resources of the Alaska OCS. We also will be glad to assist interested parties in accessing information related to past and ongoing MMS studies. The MMS Alaska OCS Environmental Studies Section can be contacted at 907-271-6617 or the MMS Environmental Studies Program Information System can be accessed via Internet at <http://www.mms.gov/espis>.

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## Past and Ongoing Research Programs – State of Alaska

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### Introduction

The past and ongoing research programs relating to the Bering Sea ecosystem conducted by the State of Alaska are, generally, in conjunction with statutory fisheries management responsibilities. The Alaska Department of Fish and Game has responsibilities for subsistence, commercial, personal use, sport fisheries for salmon and herring. The State of Alaska also manages the shellfish fisheries of the Bering Sea through authority delegated by the North Pacific Fisheries Management Council. The State has a long tradition of marine mammal research, although since the Marine Mammal Protection Act there is no statutory responsibility for managing subsistence take of marine mammal in the Bering Sea region.

These stock assessments and fishery monitoring programs are necessary for sustainable fisheries management, and provide the primary information by which one can monitor change and health of the Bering Sea ecosystem.

### BS/AI Shellfish Data Collection Programs (ADF&G – CFMD)

The Alaska Department of Fish and Game (ADF&G) has a large data collection program on shellfish stocks and fisheries in the Bering Sea and Aleutian Islands (BS/AI) area. ADF&G has an assessment program in the BS/AI area that complements the annual trawl survey conducted by the National Marine Fisheries Service. An annual test fish survey on Bristol Bay red king crab generates revenue for the assessment program and provides a unique platform to conduct at-sea research. ADF&G conducts a triennial rotational survey on Norton Sound red king crabs, St. Matthew blue king crabs, and Adak golden king crabs. ADF&G developed and applies length-based population estimation models for Bristol Bay and Norton Sound red king crabs, St. Matthew and Pribilof Islands blue king crabs, and Bristol Bay Tanner crabs.

ADF&G records the landings of all shellfish (crabs, scallops, snails, etc.) harvested in the BS/AI region. For the most intense fisheries, inseason catches are monitored by MCI satellite reports and by single side band radio so that timely closures can be made when catch quotas are reached. ADF&G administers onboard observer programs for scallops (all vessels) and crabs (catcher-processor vessels and floating processors). In 1996, crab observers were deployed on the following fisheries: South Peninsula grooved Tanner crab (1,586 pots sampled), Eastern Aleutian triangle Tanner crab 1,002 pots), Bering Sea triangle Tanner crab (179 pots), Eastern Aleutian grooved Tanner crab (460 pots). Bearing Sea grooved Tanner crab (822 pots), Western Aleutian grooved Tanner crab (503 pots), Bering Sea Korean hair crab (14,001 pots), Western Aleutian Korean hair crab (136 pots), Bering Sea snow crab (1,384 pots), St. Matthew blue king crab (96 pots), Bering Sea Tanner crab (134 pots), Western Aleutian golden king crab (13,000 pots), Eastern Aleutian golden king crab (4,208 pots), Western Aleutian scarlet king crab (175 pots), and Bristol Bay red king crab (84 pots).

ADF&G conducts an active research program on BS/AI king, Tanner and snow crabs. Research program funding sources include test fish, federal, and state of Alaska general funds. Research studies are conducted at-sea, in laboratories with flowing sea water systems, and by computer simulation models. Recent research topics include: mark/recapture studies including development of a passive integrated transponder tag, growth, reproductive dynamics, gear studies to reduce bycatch of females and sublegal males in crab pots and to reduce crab bycatch in cod pots, studies on the effect of handling on crab survival, population dynamics, climate and oceanographic effects on crab recruitment, and analyses of alternative harvest strategies and stock rebuilding strategies.

BS/AI Herring Data Collection Programs (ADF&G – CFMD)

The Alaska Department of Fish and Game (ADF&G) conducts annual stock assessment programs for Pacific herring (*Clupea pallasi*), primarily to establish appropriate harvest levels for herring fisheries in the region. The assessment programs acquire information on herring spawning location, spawn timing, abundance, age, weight, length, and sex of the commercial harvests and spawning populations, and integrate this information in stock assessment models. In addition, ADF&G conducts occasional special projects to examine performance and improvements of stock assessment programs. Funding sources for Bering Sea herring projects are State of Alaska general funds and test fishing funds for special projects.

In all areas of the Bering Sea, aerial surveys are the principal stock assessment method because of the remote locations, large area over which herring spawning occurs, and relatively short spawning periods. The spring movement of herring into coastal spawning areas provides an opportunity to acquire assessment information with aircraft and small vessels, avoiding the need for expensive large vessel support which would be required to acquire assessment information at other times of the year. ADF&G stock assessment programs are primarily conducted in tandem with management support operations in order to keep costs down. Herring aerial surveys record the timing and location of herring inshore movements and spawning events. In addition, aerial surveyors estimate the total surface area of herring schools observed during daily coastal overflights. Another assessment project funded by test fish receipts converts herring school surface areas to biomass based on a sample of surface area estimates of schools subsequently captured and enumerated by purse seine vessels. A recent project investigated the feasibility of using remote sensing techniques to detect and measure herring school surface areas.

Approximately 15,000-20,000 herring are collected annually for age-weight-length enumeration in ADF&G assessment programs. Samples are taken from commercial harvests as well as ADF&G test fishing projects and are used to describe the age composition of the commercial catch and spawning population, and herring growth.

ADF&G also monitors and records commercial and subsistence harvests of herring. Commercial harvest records are based on copies of sales receipts received from processors ("fish tickets"), which are required under Alaska statutes. Fish tickets are edited for consistency and then the information is archived in a centralized fish ticket database. In addition, a separate and less formal system is used to monitor harvests during the short, intensive herring fisheries based primarily on catch reports received by radio from fish processors.

In cooperation with the University of Alaska, ADF&G periodically assists graduate students with research studies, most recently on factors affecting herring recruitment processes. ADF&G works cooperatively with NMFS and NPFMC to address bycatch of Bering Sea herring in offshore trawl fisheries. A project utilizing NMFS observer information was instrumental in defining the migration path of the major spawning concentration of herring in the eastern Bering Sea.

Western Alaska Salmon Data Collection Program (ADF&G – CFMD)

The Alaska Department of Fish and Game has a large data collection program associated with management of salmon fisheries in Western Alaska, which includes the coastal commercial and subsistence fisheries of the North Alaska Peninsula, Bristol Bay, Kuskokwim Bay, Norton Sound, and Kotzebue Sound. Extensive commercial and subsistence salmon fisheries occur in the Yukon and Kuskokwim Rivers. The data collection programs include in season monitoring the magnitude and salmon escapements throughout the area using a variety of methods including visual counts in aerial surveys, sonar counts, weir counts, tower counts, and mark recapture.

ADF&G conducts extensive, in-season, monitoring of catches in Western Alaska salmon fisheries. For the intensive targeted fisheries for Bristol Bay sockeye, Yukon River chinook and chum salmon, Kuskokwim River chum, chinook, and coho salmon the department conducts test fisheries in fishing districts to provide more timely information on salmon abundance. The catches and escapements for these intensively fished stocks are sampled for age and length, sockeye salmon smolts are enumerated for certain Bristol Bay river systems. Stock and age specific catch, and escapement is used to estimate stock-specific productivity. This information is used to evaluate fishing strategies, estimate escapement goals, and develop pre-season forecasts of run strength.

The department also conducts a variety of salmon research programs and includes: developing more accurate and cost effective escapement enumeration method such as sonar and mark recapture; conducting a wide variety of stock identification studies which are used to develop more stock specific fishing strategies and identifying origin of mix-stock fisheries. The department has an extensive genetic stock identification program for salmon, shellfish, and marine finfish. This program is used to identify discrete lineage and inventory genetic diversity, develop methods for stock identification and admixture analyses, and species identification.

<u>Marine Mammal Data Collection Program (ADF&G- DWC)</u>
The Alaska Department of Fish and Game began a marine mammal research program at statehood and has continued to conduct studies of marine mammals ever since. Marine mammal research has been done by staff members in the Division of Wildlife Conservation, often in collaboration with researchers from the University of Alaska, the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, and other organizations. Major sources of funding other than the State have included the National Oceanic and Atmospheric Administration, the Minerals Management Service, the North Pacific Fisheries Management Council, and the U.S. Marine Mammal Commission.

*Statehood through 1975.* One of the earliest marine mammal research activities involved ADF&G biologists in coastal villages working with local residents to obtain samples from harvested animals. Results from analysis of those specimens, supplemented by data from Coast Guard icebreaker and University research vessel cruises, were used to develop a basic description of the biology of ice associated seals and walruses. Population assessments were begun for selected species, particularly harbor seals that were being commercially harvested at sites on the north side of the Alaska Peninsula, and Pacific walruses that were recovering from a prior period of over-exploitation.

*1975-1983, OCSEAP Studies.* While passage of the Marine Mammal Protection Act in 1972 curtailed State marine mammal management activities, the Department maintained an active research program. The Outer Continental Shelf Environmental Assessment Program provided substantial funding to conduct pre-development studies of marine mammals in the Bering Sea and elsewhere. Major ADF&G projects included continuation of natural history studies of ice-associated seals and initiation of a study on belugas; compilation of data on marine mammal distribution in the coastal zone; and a radiotelemetry study of belugas in Bristol Bay. Natural history studies were also conducted on harbor seals and Steller sea lions in the Gulf of Alaska. Because ADF&G resumed management of walruses during part of this period, detailed monitoring and sampling of the walrus harvest were conducted. The Department also participated with the Fish and Wildlife Service in aerial surveys to estimate walrus population abundance, and initiated a program to count walruses using haulouts on Round Island.

*Marine Mammal- Fisheries Interaction Studies, 1981-1985.* During the early 1980s, Department biologists conducted a number of studies relative to the general topic of marine mammal-fishery interactions. In response to a proposal to develop a commercial clam fishery in Bristol Bay, a study was conducted to estimate the number of walruses feeding in Bristol Bay and the importance of surf clams in their diet. This involved a series of aerial surveys to look at at-sea distribution and abundance and the collection of animals to examine stomach contents. Similar work was done on seals, with particular emphasis on harbor seals in Bristol Bay. Stomach contents were collected from Steller sea lions in the western Bering Sea on a Russian research cruise.

*1990-Present*. During the late 1980s, most marine mammal work by ADF&G was in parts of Alaska other than the Bering Sea. Major programs in the Bering Sea include: 1. Biology of ringed seals in relation to Beaufort Sea oil and gas development, 2. Studies addressing recovery needs of Steller sea lions that have been listed under the Endangered Species Act; and 3. Biology of harbor seals in areas impacted by the Exxon Valdez oil spill, and in other parts of the State.

In the Bering Sea, ADF&G has been working on a cooperative study of the biology of spotted seals. Animals in both Alaska and Russia have been tracked using satellite-linked tags. A study supported by the Cooperative Institute for Arctic Research is now being done to analyze the seal data relative to the greenbelt phenomenon. In conjunction with the Alaska Beluga Whale Committee, department staff are monitoring the beluga subsistence harvest and conducting population assessments in Bristol Bay and the Norton Sound/Yukon delta region. Molecular genetics studies are being done with the NMFS Southwest Fisheries Science Center to look at stock structure of both belugas and spotted seals.

Subsistence Data Collection Programs, ADF&G –Division of Subsistence

The Division of Subsistence compiles existing data and conducts studies on all aspects of subsistence hunting and fishing in Alaska. These data are important in resolving allocation issues as well as documenting changes in species utilized and patterns of use. Databases maintained by the division include Community Profiles; Subsistence Salmon, Herring, and Harbor Seal and Sea Lion Databases; and the Subsistence Map Series and Catalog.

Other Departments

Two other departments besides Fish and Game have environmental oversight functions, the Department of Environmental Conservation (DEC) and the Department of Natural Resources (DNR).

DEC is a regulatory agency established to protect public health and the environment. It develops air and water quality standards, responds to air, water, and land pollution, maintains an agricultural and seafood product safety assurance program, and monitors specific sites throughout the state. The department also has two laboratories to test for pathogens and chemical pollutants. Its divisions include Environmental Health, Air and Water Quality, and Spill Prevention and Response.

DNR is responsible for the inventory and management of all State resources except fish and wildlife extending from uplands to submerged lands. Its goal is to protect these resources while encouraging wise development. Its divisions include Agriculture, Forestry, Geological Surveys, Land and Water Management, Mining, Oil and Gas, and Parks and Outdoor Recreation.

## The Bering Sea — Studies Past and Present by the University of Alaska

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### Preface

The scope of this summary of work done by the University of Alaska in the Bering Sea is by necessity abbreviated and incomplete. In particular, note that the references provided are merely samples, and no attempt has been made to assemble a comprehensive bibliography. Work on the Bering Sea by the University of Alaska began in the early 1960s and continues today. In this presentation, we will emphasize research relevant to ecological concerns. We have not included the considerable volume of work on coastal systems which includes sea grass studies, sea ice properties, physical oceanography and ice/atmosphere interactions.

### The Early Years

The University of Alaska began research in the Bering Sea in the 1960s. Research on the Gulf of Alaska led to an interest in the passage of water through the Aleutian passes, since the passes near the base of the chain serve as a conduit for the passage of water into the Bering Sea. The question of whether or not nutrient-enhancement through turbulent mixing could contribute to high productivity along the Aleutian Shelf was posed. This question still remains relevant, and largely unanswered, although technology now exists which would make an answer attainable.

The 1970s, however, was the period of major advancement in the University's involvement in the Bering Sea. Two factors played a role: The University of Alaska and Hokkaido University began discussions towards the "PROBES" project which included a series of workshops, and an effort was launched within the Institute of Marine Science to look at the ice-related ecosystem of the Bering Sea. Interest in the latter had been generated by results from a cruise of the R/V *Alpha Helix* (then operated by the Scripps Institution of Oceanography), escorted by the Coast Guard icebreaker, *Burton Island*. These results showed a very verdant phytoplankton production associated with the ice. Based on this one-time observation, an ice-edge productivity program was started.

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### Past Research

*Ice Edge Ecosystem Research.* In 1974, the first cruise devoted to ice edge ecosystem research was sponsored by the National Science Foundation (NSF). Due to a delay in the arrival of the R/V *Alpha Helix* and an early spring, the Bering Sea was ice-free during the cruise. Nevertheless, the large number of stations throughout the entire U.S. portion of the Bering Sea shelf and up into the Chukchi Sea provided information on the nutrients, productivity and hydrographic structure over the weeks following the ice retreat. This cruise was followed up by work done under the Outer Continental Shelf Environmental Assessment Program (OCSEAP), managed by the National Oceanic and Atmospheric Administration

(NOAA). Cruises took place throughout the years 1975, 1976 and 1977, with emphasis on the ice melt period, but with additional year-round coverage in the southeast Bering Sea shelf region. A single shelf-wide sampling of ice algae using a helicopter was also done. This work clearly demonstrated the importance of the spring ice edge bloom in the Bering Sea. Fortuitously, the research began during very heavy ice years, before the so-called regime shift of 1976. The PROBES work followed the regime shift, and the disagreements in the findings for the southeast Bering Sea can only be understood with a retrospective view of the major changes which occurred at the end of the decade.

The ice edge work continued with spring-only cruises in 1981, 1982, 1987 and 1988, supported by NSF. Overall, this work spanned the period of the major regime shift of the late 1970s, and showed that the spring bloom is advanced by at least two weeks in areas covered by sea ice, that the bloom lasts about two weeks, and that substantial portions of the products move rapidly to the bottom.

More recent work on the effects of sea ice over the southeast Bering Sea Shelf formed the basis of a doctoral dissertation (Wyllie-Echeverria, 1996). This work brought attention to the role of sea ice in producing a "cold pool" of water that lies over the bottom during the summer subsequent to a heavy ice year. This affects the distribution of juvenile pollock and probably other components of the system.

Research supported by OCSEAP and by the Alaska Sea Grant College Program included work on marine mammals as it related to sea ice, with emphasis on the distribution of marine mammals to sea ice types (Burns et al., 1981).

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Wyllie-Echeverria, T. 1996. Sea ice and fish distributions on a sub-arctic shelf. Ph.D. Thesis. University of Alaska Fairbanks.

*Benthic Studies.* The benthic communities of the Bering Sea shelf were examined during the OCSEAP period by Dr. Howard Feder and his students, and this work continued with PROBES. A number of graduate dissertations resulted from this work. Dr. Sam Stoker sampled benthic invertebrates extensively over the shelf as the basis of his doctoral dissertation at the University of Alaska.

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Stoker, S. 1981. Benthic macrofauna of the Eastern Bering/Chukchi continental shelf. In: The Eastern Bering Sea Shelf: Oceanography and Resources. D. W. Hood and J. A. Calder (eds.). National Oceanic and Atmospheric Administration, pp. 1069-1069.

Feder, H. M. and S. Jewett. 1981. Feeding interactions in the Eastern Bering Sea with emphasis on the benthos. In: The Eastern Bering Sea Shelf: Oceanography and Resources. D. W. Hood and J. A. Calder (eds.). National Oceanic and Atmospheric Administration, pp. 1229-1262.

*Marine Mammals.* A considerable amount of work was done on marine mammal physiology, with emphasis on energetics and population biology.

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Fay, F. H. 1981. Marine mammals of the Eastern Bering Sea shelf: An overview. In: The Eastern Bering Sea Shelf: Oceanography and Resources. D. W. Hood and J. A. Calder (eds.). National Oceanographic and Atmospheric Administration, pp. 807-811.

*PROBES.* PROBES was an interdisciplinary study designed to track the events in the Bering Sea shelf that lead to high production in the upper trophic levels. The stimulus was a mutual U.S.-Japan concern about the ability of the Bering Sea to support the huge annual catch, on a sustained basis, of groundfish, pelagic fish, crabs and other marine resources. Initially, the so-called “Golden Triangle” was emphasized (the area encompassed within longitudes 165° and 170° W and latitude 54° N). In common with some recent studies, pollock (*Theragra chalcogramma*) was selected as the biological tracer to check the energy transfer and determine how the combination of oceanographic factors, the circulation pattern and timing of crucial events in the production cycle, both primary and secondary, resulted in a highly efficient energy transfer among trophic levels. PROBES created the A station line, which allowed concentration of effort on chemical-biological changes that occurred over the spring bloom (Hood and Codispoti, 1984; Whitledge et al., 1986). Further, the cross-shelf advection/diffusion model of Coachman et al. (1980) gave the PROBES investigators the rationale to establish the inner, middle and outer domains for the southeastern Bering Sea shelf, and to explain why the pelagic and benthic food chains are located near the physical fronts on the shelf (Cooney and Coyle, 1982). A special edition of Continental Shelf Research is devoted to the results of PROBES, in addition to a large number of publications in the refereed literature and as contributed papers to conference proceedings.

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Cooney, R. T. and K. O. Coyle. 1982. Trophic implications of cross-shelf copepod distributions in the southeastern Bering Sea. Mar. Biol. 70:187-196.

Hood, D. W. and L. A. Codispoti. 1984. The effect of primary production on the carbon dioxide components of the Bering Sea shelf. In: J. H. McBeath (ed.). The potential effects of carbon-dioxide-induced climatic changes in Alaska. Misc. Publ. 83-1, Sch. Agric. Land Resour. Management. Univ. Alaska, pp. 33-39.

Whitledge, T. E., W. S. Reeburgh and J. J. Walsh. 1986. Seasonal inorganic nitrogen distributions and dynamics in the southeastern Bering Sea. Cont. Shelf Res. 5:109-132.

*ISHTAR.*. This project was carried out between 1983 and 1991, and involved 12 principal investigators from five U.S. institutions and four foreign institutions. The focus was the ecosystem of the northern Bering Sea and southern Chukchi Sea. It sought to understand the processes that support the apparent high production of life in the waters between about 62º and 69º N. This area is part of the Inner Shelf Domain and is expected to have a low primary production. However, the productivity of the region is fueled by a major current, the Anadyr Stream, that provides a steady supply of nutrients and biota from the deep Bering Sea far to the south (Coachman, 1993; Grebmeier et al., 1988; Sambrotto et al., 1984). These waters sustain very high production and organic matter transfer. The region contains one of the most productive benthic communities hitherto described (Highsmith and Coyle, 1990). The plume of Pacific water and the entrained organic production from the shelves makes a significant contribution to the carbon balance of the Arctic Ocean (Walsh et al., 1997). Volume 13, Nos. 5/6, 1993, of Continental Shelf Research is devoted to the results of ISHTAR.

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Highsmith, R. C. and K. O. Coyle. 1990. High productivity of northern Bering Sea benthic amphipods. Nature 344:862-864.

Sambrotto, R. T., J. J. Goering and C. P. McRoy. 1984. Large yearly production of phytoplankton in the western Bering Strait. Science 255:1147-1150.

Walsh, J. J., D. A. Dieterle, F. E. Müller-Karger, K. Aagard, A. T. Roach, T. E. Whitledge and D. Stockwell. 1997. $CO_2$ cycling in the coastal ocean. II. Seasonal organic loading of the Arctic Ocean from source waters in the Bering Sea. Cont. Shelf Res. 17 (1):1-36.

*International Collaborations.* University of Alaska scientists participated in a U.S./Russian (Soviet) program called BERPAC, which involved cruises of the vessel Academic Korolev in the Bering Sea. The goal of the work was to study the status and dynamics of arctic marine ecosystems in light of anthropogenic impacts and possible climate change. The program emphasized contaminants. The lead U.S. agency involved was the Department of the Interior's Fish and Wildlife Service, and the University of Alaska was one of a number of entities participating in the field work. Cruises were conducted in 1977, 1981, 1984, 1988 and 1993.

The University of Alaska and Hokkaido University carried out a joint program called "Bioclimatology of the Bering Sea," which included a study of the St. Lawrence Island polynya area using the Hokkaido University vessel *Oshoro Maru*. The *Oshoro Maru* has conducted annual cruises in the Bering Sea since 1953, occupying 2,480 hydrographic stations. This collaboration continues, with University of Alaska Fairbanks scientists participating regularly in the cruises.

<u>Current Research</u>

University of Alaska scientists are participating in the NOAA FOCI program and also in the SEBSCC (Southeast Bering Sea Carrying Capacity) program. These will be presented separately in the program.

Physical oceanographers, Dr. Tom Weingartner and Dr. Zygmunt Kowalik, have been studying the hydrographic regimes of the Bering Sea and the tidal regimes, respectively. Dr. Weingartner's recent work has looked at the passage of water through the Aleutian passes and circulation in the Gulf of Anadyr and northern Bering Sea. Dr. Don Schell and his colleagues are looking at the history and status of productivity in the Bering Sea based on the use of stable isotopes as proxies.

*Marine Mammal and Bird Research.* Work is also underway in the Pribilof Island area looking at the energetics and health of Stellar sea lion populations in light of their declining numbers and endangered status. This work is done primarily through the Marine Mammal Consortium based at the University of British Columbia, with Dr. Michael Castellini working on physiological parameters and Dr. Alan Springer with energetics. Dr. Springer is also looking at seabirds in the Pribilof Islands region. University of Alaska scientist, Dr. Ken Coyle, has been working with Dr. George Hunt of the University of California Irvine on the prey sources for seabirds in the southeast Bering Sea.

*BESIS (Bering Sea Impacts Study).* Regional assessments of impacts due to global climate change have become a high priority in the national and international programs on global change research. Workshops organized by the University of Alaska and funded by the International Arctic Science Committee (IASC), NSF and DOI have begun to address the regional impacts in Alaska and the Bering Sea. Climate models indicate an amplification of the global greenhouse warming in the region, and this amplification has already been observed over the last few decades. Model results were compared with observations of changes in temperature, precipitation, sea ice extent, the permafrost regime and other cryospheric parameters. While considerable uncertainties remain in the long-term (century) prediction of change, there is some agreement between model results and observed trends by season on the shorter decadal time scales. The observed warming during the last few decades is matched by corresponding observed decreases in snow cover and glacier mass balances, by thawing of the permafrost, and by reductions in sea ice extent. Major impacts due to this in the region include costly damage to roads and other infrastructure, and large-scale changes in ecosystems when permafrost thaws, changes in the productivity of marine ecosystems, economic impacts on the Bering Sea fisheries and on petroleum and other human activities in the region, as well as social impacts on northern indigenous populations. Some of these impacts have positive ramifications but most are detrimental to human interests. While uncertainties exist about the future, climate change during the past few decades over most of the land areas of the Arctic is already occurring at the rate of greenhouse warming predicted by the models for the high latitudes. This has led to the major impacts listed above, which will become even more pronounced if present trends continue.

*Arctic Research Initiative on the Bering Sea.* This joint project between NOAA and the University of Alaska Fairbanks is managed by CIFAR — the NOAA-UAF Cooperative Institute on Arctic Research. Started in FY97 and continuing in FY98, the project's focus is on the "Health of the Western Arctic/Bering Sea Ecosystem," in particular, on two major research areas, including four major sub-topics:

Natural variability of the Western Arctic/Bering Sea ecosystem

1. The Bering Sea Green Belt: processes and ecosystem production
2. Atmosphere-ice-ocean processes that influence ecosystem variability

Anthropogenic influences on the Western Arctic/Bering Sea ecosystem

3. Arctic haze, ozone and UV flux and their potential impacts
4. Contaminant inputs, fate and effects on the ecosystem

In FY97, 15 projects were funded through this initiative; in FY98 more projects are likely to be funded, with proposals due at CIFAR by 15 December 1997.

## Southeast Bering Sea Carrying Capacity Program
## Coastal Ecosystem Regional Study

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Background

The Southeast Bering Sea Carrying Capacity (SEBCC) project conducts research on the southeast Bering Sea shelf ecosystem, with an emphasis on the role of pollock. It is supported by the Coastal Ocean Program of the National Oceanic and Atmospheric Administration (NOAA), and is managed by NOAA's Pacific Marine Environmental Laboratory, NOAA's Alaska Fisheries Science Center and the University of Alaska Fairbanks. It is a five-year project, designed with a plan for mid-term evaluation and retuning.

The Bering Sea is among the most productive high-latitude seas, and supports large populations of marine fish, birds and mammals. This productivity is critically important to the U.S. economy in that fish and shellfish from the region constitute almost 10% of the world and 40% of the U.S. fisheries harvest. Pollock, salmon, halibut and crab generate over 2 billion dollars each year in fisheries revenue and provide a major source of protein. Presently, most Bering Sea fisheries are not overexploited, although there have been major changes in abundance over the last thirty years. Populations of several species, such as king crab and Greenland turbot are near historical lows. Our understanding of this system is inadequate.

The overwhelming dominance of walleye pollock in the Bering Sea suggests that this species now plays a singularly important role in the ecosystem. Our conceptual model proposes that the juvenile (age 0-age 1) pollock population represents a nodal element of the Bering Sea ecosystem, and that a large fraction of the ecosystem energy passes through this population. Juvenile pollock respond to and potentially impact primary and secondary production through grazing, and influence the availability of food to higher trophic level species, including adult pollock, seabirds and marine mammals.

Goal

The goal of Southeast Bering Sea Carrying Capacity (SEBSCC) is to increase understanding of the southeastern Bering Sea ecosystem. New information will be used to develop and test annual indices of pre-recruit (age-1) pollock abundance, which will support management of pollock stocks and help determine the food availability to other species.

Central Scientific Issues

1. How does climate variability influence the Bering Sea ecosystem?

Is there historical evidence for a biophysical regime shift on the Bering Sea shelf? How is this reflected in ecological relationships and species mix?

Are there "top down" ecosystem effects associated with climate variations as well as "bottom-up" effects?

2. What limits population growth on the Bering Sea shelf? Is there evidence of a single species carrying capacity, e.g. for pollock, or a more complex structure?

What is the ecological role of pollock on the Bering Sea shelf, i.e. how are pollock, forage fish, and apex species linked through energetics and life history?

How important is cannibalism?

3. How do oceanographic conditions on the shelf influence biological distributions?
How do the separate mixing domains, sea ice, and the cold pool influence overlap or separation between predators and prey?

4. What influences primary and secondary production regimes?
What are the sources of nutrients to the southeastern Bering Sea shelf, and what processes affect their availability?
Is the variability in sea ice extent and timing the primary factor influencing productivity?
What determines the relative allocation of organic carbon going to benthos versus that remaining in the pelagic system?
What are the lower trophic level structure and energetics on the shelf in summer and winter, especially regarding euphausiids?
What is the role of gelatinous organisms?

Structure

The program consists of four types of projects:

1. Monitoring. This includes shipboard surveys, multi-disciplinary moorings, and analysis of satellite data (2 projects).

2. Retrospective Analyses. These studies use historical databases to investigate the biological and physical consequences of the different domains and of climatic variation (4 projects).

3. Process Studies. These are nested within the broad-scale observations to investigate specific biological and physical processes (6 projects).

4. Modeling. Modeling investigations participate in the formulation and interpretation of the field studies, and provide the context for integration of the results (3 projects).

Time Line

A workshop for all Principal Investigators, Scientific Advisors and the Program Management team is planned for mid-December 1997. This will provide an opportunity to review the progress of SEBSCC in meeting its goals, and revise the announcement for the second funding cycle. The new proposal cycle will begin early in 1998.

## Alaska Sea Grant Program

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Sea Grant is a public service program, it uses the tools of research, education and technology extension to accomplish that public service. I will focus only on certain research elements of what Sea Grant has done at the University of Alaska, and particularly that research that I think is applicable to the Bering Sea. The support for research that Sea Grant has provided has been to individual investigators through calls for proposals. There have been other activities that I think have been of support for the broader research community, both at the University of Alaska, and most of you represented in this room. We have made some small contribution in advancing some new program areas.

In terms of support to individual investigators, the Sea Grant has made a long-term investment in energetics modeling. A.J. Paul has been a significant contributor to that and I think that Pat Livingston and others have used the kind of detailed energetic studies to help with the basic modeling and food trophic interactions for those species. Similarly, fishery faculty at the University of Alaska has contributed to recruitment modeling, really looking at single species modeling of herring, pollock, shrimp and rockfish. Despite our intense interest in this meeting and in Bering Sea Ecosystem studies, and despite the challenges to the North Pacific Council and others to incorporate ecosystem issues in their management, I suspect that we're going to have to rely on this traditional kind of recruitment modeling for some time before we can abandon it. Also researchers have looked at genetic and survival relationships of the salmon, habitat preference work for juvenile flatfish, physiological health of Steller sea lions, and some biotechnology approaches to PSP. Issues of toxic algal blooms are of national interest. We kill more people in this state with toxic algal blooms than the rest of the nation does. It seems not to have the attraction that *Pfisteria* has, but PSP is a major issue and we really need to make advances in that area.

In terms of support to the broader research community, our Lowell Wakefield Symposia series is the most significant contribution that Sea Grant has made. Sea Grant provides the organization. Brenda Baxter is the coordinator hired by Sea Grant. She seeks the talent from the North Pacific Fishery Management Council, from NMFS, from our university, Fish and Game, University of Washington and others. It is because of the high degree of ownership by all of the other scientists, all of the scientists in this room and the others that have formed these Lowell Wakefield Symposia is the reason they have been useful and is the reason they will continue to be useful. A proceedings is published for each and every one of the symposia that have been held. We print them at the minimum cost so that they can be circulated well. If you follow the symposia over the recent years, you can also track the interest of the community, since the community is designing this. If we look back a few years, the most recent of the single species symposia out of the Lowell Wakefield's area was on crab. But if you look from that year, 1995, and if we move forward from that time we discover that we move from a single species interest by the scientists in the region to those that go into subjects such as what is the role of forage fish. We're talking about interactions, looking at fishery stock assessment models that involve a variety of these different things, and if you'll look at the one planned for next year, you'll see that it's on ecosystem considerations. Sea Grant isn't doing this. This is helping us monitor what is interesting to the scientists in these regions who form these things. As we move forward I think we can see that the community readiness to move towards this ecosystem approach to management is very substantial.

Sea Grant has clearly been one of those that have contributed to fisheries oceanography. Both government and academia have kept fishery scientists and ocean scientists, oceanographers, separated from each other. In the 1960s universities began to integrate their dormitories. However, it wasn't until the 70s and 80s that we actually allowed these scientists to get together, co-habitat if you will, to report some of this. Sea Grant has funded some things like the modeling of salmon work in Prince William Sound which, because of its process orientation, could have substantial transferability into the Bering Sea. The modeling of pollock response to climate, Fishery Scientist Quinn getting together with Physical Oceanographer Niebauer, both capable of handling large datasets to enable us to look at pollock response in the Bering Sea. These kinds of things will and have contributed to the council's process of looking at how ocean and how ecosystems and physical change can effect that. Again, if we look at Sea Grant's support of the Lowell Wakefield series, that has also helped this area of fishery and oceanography moving forward.

The Sea Grant symposium "Is it food?" is the meeting that nobody really wanted to be held. The real name of the meeting was, "Is it food availability that is causing the decline of piscivorous seabirds, fish-eating seabirds and pinnipeds in the Aleutians and Bering Sea region?" The approach was to reach far beyond the northwest region of this continent to bring in international pinniped experts from all over. It also brought in the west coast experts on birds, fisheries, climate change. It was a very exciting meeting which was not conclusive and could not give you a management answer to what you do with a fishery in order to help management, but I think the questions there helped focus the ecosystem issues that are now on the table before all of the fisheries managers.

It was very interesting to point out that the group easily came to the conclusion that, yes, it's probably food availability that drives the success of something like pinnipeds, K-selected species, but when you then ask the next question, What does the pollock fishery have to do with that? It then showed the measure of our ignorance. There were those that argued pollock had big mouths, they're big hungry beasts, if you take more pollock out of the system it'll free up the fatty forage fish, pinnipeds will do better. The other half of the group on this side of the room said, no, pollock is fine food, any pollock in a net is not in a sea lion's mouth, we should release more pollock. That debate is going to continue and we're going to find that this ecosystem is not as simple as fishermen, marine mammals and pollock. But it did help focus the discussions. As with the others, the "Is it food?" meeting was summarized in a publication.

I now want to move on to the research, Alaska Marine Research Plan. The RMR Board, the Regional Marine and Research Board, was formed under Federal Law 103593. The Sea Grant director was given the privilege of chairing the board. There were federal people, gubernatorial appointees and academics on the Board. The Alaska Marine Research Plan that was developed has annual figures, number of people involved and what came out of it. That might also be useful even now as we try to collect some of that data. It is a detailed analysis of research, not only at the university, but also at Fish and Game, at NMFS and other places. The summaries from that federal/state/academic board contain the research priorities. Even though this was done in 1993, it is not very out of date. The real priorities identified are to distinguish between natural and human induced changes in marine ecosystems. It also was to stimulate the development of a data gathering/sharing system that will serve scientists in the region from government to academia in the private sector in dealing with these issues and provide a forum for enhancing and maintaining a broad discussion.

The priorities, which I argue still hold, were to distinguish between human and natural resources by way of investigating the physical biological factors that affect recruitment, growth and survival of key marine species. Also, to investigate the linkages between the pelagic and benthic food chains. Thirdly, to determine the human induced factors in this system and what role they are playing in terms of habitat, in terms of fishing practices, in terms of releasing hatchery fish to the systems. Another human factor to investigate was to distinguish with respect to water quality the difference between human induced changes and natural changes. Another priority was to stimulate the sharing of data and inventory these databases. Finally, the Regional Marine Research Plan's final priority item was to provide a way to maintain ongoing communication.

From my experience as Sea Grant Director, I have drawn several conclusions. I think we do have to maintain, as Jim Coe said, the mowing of the lawn. We have to continue to collect that data or we won't see some of the big signals. But we are going to have to find some new approaches. Those approaches probably will have to include a better harvesting of data in existing places. Some of those are in libraries, some of those are in the benthic record and some of those are in the otolith record. Don Schell is here, if you want to know what whales were eating 30 years ago, he says give me a piece, I'll tell you.

That kind of historical data, for a system that is changing as dramatically and as over long time frames as the Bering Sea is, even those of us that are only a little beyond mid-career are impatient to wait another hundred years so that we can get three more cycles. So if we harvest the old record I think we'll be able to do that. Also, I do think the academic community can be an invaluable source of some of these new approaches. I think that's maybe an edge where academia has an advantage over government; whereas clearly, academia could not possibly sustain the necessary force to keep the lawn mowed. Next, my experience is that if you want the best data from faculty, what you want to do is state what your research goals are. Don't try to give them assignments. I think what academia does best is ask the unique question. I think scientists are all equally qualified to give good answers, but I think the freedom of the academic community allows the academic community to ask a different kind of question and I think that fits our new approach to Bering Sea.

I argue that the conclusions of that RMR Board were not far off target five years ago. We're behind; we have not yet had the result I think to really get at the issue. We don't understand how the system works. And it's difficult for government agencies that have day to day, year to year management responsibilities to get at these long-term issues, but if we don't start, if we don't have the resolve to do it, we're really going to be behind the eight ball very shortly.

In summary I would make three recommendations. First I'd recommend that we recognize that we really don't know how the system works. If we were to convince the North Pacific Management Council to either double or halve the take of pollock in the Bering Sea, we would not know where the energy would come from to sustain a much larger population or where it would come from, or where it would go to sustain a much lower population. Would it go to pinnipeds, would it go to sharks, they're certainly increasing in great numbers? Would it go to lantern fish, would it go to another commercial species? We have no idea how the system works. I suggest we get on top of that, recognize it and don't pretend that we can make long term decisions with the lack of knowledge. Number two, I suggest that we recommend that we maximize our opportunity to learn. I think we ought to treat all of the managed actions as an experiment. By way of example, I am critical of the way that we set aside the protection of rookery areas. If we set aside the same protection for all the rookery areas, what are we going to learn? We're going to learn that the climate changes in 10 years that they were in. If we don't start thinking of these management actions as experiments, we're missing a huge opportunity to learn. And I think we've got to take that advantage. I suggest that we clarify our research goals. Not the specific actions, but the goals. What are we trying to get to, so that we can get broad participation and that we get together and see that additional competitive funding is provided. Number three, I don't think that we know that much more now than they did five years. It's time to get off the dime and keep moving forward.

## U.S. Department of State - Bering Sea Projects

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During fiscal years 1992 through 1995 we had a sum of money for funding various projects. The amounts varied between $3 to $10 million, generally for funding special projects. Some projects in this part of the world were funded through that program. The rationale for it was that during that period of time federal agencies, academic institutions, private sector organizations and state governments all needed some kind of quick response funding for oceans, environmental and scientific programs and that the federal government's response time, due to the budget cycle, was so long. The State Department needed some money in hand to jump start those kinds of special projects in the post cold war world.

I want to show you two of the most comprehensive of the products from the studies developed under the State Department's program. The first document, "The Bering Sea Ecosystem", which has been mentioned by some folks today, was produced by the National Research Council of the National Academy of Sciences, with the participation of a number of people who are here. Another document was also produced, "Ecology of the Bering Sea: A Review of Russian Literature." It is in English and was produced here at the University of Alaska under the Sea Grant College Program.

I would like to make a couple of other points. First, I was prepared to talk about the need for literature review, going back to look at past studies, not just updating your data on your diskette from last year's study. I think a lot of speakers have addressed that today and I feel good that everyone is taking a fresh look at work that has been done by others. Perhaps we could look at work done by those from other countries, not just U.S. scientists.

A second point is one that does not need to be stressed anymore, but I want to touch on because I have a couple of good examples. It is the need for multidisciplinary-interdisciplinary approaches to the problems. One example that comes to mind of a real success story in this area is an east coast story of Atlantic salmon. Taking a look at salmon population studies, the presence of Atlantic salmon off the west coast of Greenland and comparing it to sea surface temperatures off the Coast of Labrador in the North Atlantic led to the development of a very effective, very reasonably accurate predictive model for abundance of Atlantic salmon off the west coast of Greenland. That is probably a sad story because there may not be that many more North American origin Atlantic salmon off the coast of West Greenland.

Another related point, one that was made by a couple of folks also this morning, is the need to find a way to make better use of traditional knowledge.

Another point that needs to be made is the need for improvement in our predictive models. As Ron Dearborn said, we don't know how the system works. It is hard to make accurate predictions when we don't know that. One method has been effective at the national level. I recall in the late 70s, early 80s, NOAA made the corporate decision to focus on mesoscale weather phenomenon. The OAR and the Weather Service realized they just didn't know enough about those weather phenomena that affected a state or a few states, rather than the large systems that we see moving across our weather map everyday. Not overnight, but gradually, piece by piece they tackled that problem, learned more about those phenomena. I believe the three to five day weather forecasts today are more accurate than they were some years ago, perhaps because of that. Maybe that is a model we could use here. We can't solve all the problems in this ecosystem or in these ecosystems that impact the Bering Sea, but bit by bit, piece by piece we can. The plans are here, the concepts are here. Others have pointed those out. There is hope that we can achieve better understanding and develop better predictive models.

What does the State Department care about any of this? This is Alaska, this is one part of the country. What is the international hook? If we are not going to write the check then why am I here? Well, part of the reason that I am here is that there is a huge laundry list. I am most familiar with the fisheries side of international agreements, whether they are multilateral or bilateral, that deal with the resources of this region. I want to talk about the harsh political side of things for a second. In order for a treaty to be made, whether it is a fisheries treaty or a migratory bird treaty or any other treaty that you can think of, the Executive Branch and the Congress have to be behind it. Those two things do not happen unless there is a constituency: people that depend on the species or the species mix that's in question. Those constituencies are present in the Bering Sea, they are the people that live on the Yukon River, they are the people that fish out of Dutch Harbor, they are the people in the Pribilofs, they are all the people in this room, I suspect. One of the things we do not need to do, one of the problems we do not need to solve, is to generate interest in support for whatever it is we try to do. I think that is built in. When we decide on a game plan, whether it is by 5:00 o'clock tomorrow or two meetings hence, I think that the political force is here in this region to cause something to happen. I think that is a good thing.

The other aspect of having all of those international agreements, is that there are scientists in those other countries who are doing work. Another challenge is to get access to the scientific work that is being done in other countries. I am not so optimistic as one of the speakers who thought that the Russian Federation was getting its research arm organized and going back to work. My experience has been that at least a couple of meetings this fall, there were many people reading science from handwritten notes that they scratched out on an airplane coming over. My great fear is that those are not backed up by science but are backed up by politics. They say that the pollock stocks in the Navarin Basin like it so much there because there is so much food that they don't need to go anywhere else in the Bering Sea, and that their now predominant finfish species there is herring while pollock are on the decline. Maybe that's true, maybe it isn't. I am concerned, and I want to sound a note of caution about what Russia is doing and what ability they have to continue the kind of scientific research that we expect from them and that we need from them. However, there is PICES, the North Pacific Anadromous Fish Commission, the Convention for the Conservation and Management of Pollock Stocks in the Central Bering Sea, and a number of forums that many people in this room participate in. In these forums we can encourage more dissemination, more access to research done by others and perhaps can help move that research in directions that help us understand better what is going on in the Bering Sea.

I have noticed many of the charts of this region that have been presented today appear as does the one up there without any sort of geopolitical marker, such as the convention line, the maritime boundary line depicted. We need to keep in the backs of our minds that the treaty that was negotiated in the early 1990s has not been ratified by the Russian Duma. There are all kinds of people who are hoping for some instability in that area so that they can perhaps help themselves to living marine resources that might occur on our side of what we continue to recognize and assert is the maritime boundary. So we need to solve that maritime boundary problem with the Russians and we need to be aware that it is out there.

Here are some good notes. There are some new tools in our tool kits. One of these is the FAO Code of Conduct for Responsible Fisheries, which the United States is implementing. There are some new challenges for scientists: the precautionary approach, what does it mean, and how do we do it. Another agency has produced this publication and I recommend it to you. Also, the UN agreement on straddling fish stocks and highly migratory fish stocks had some additional muscle for the LOS based regimes for management of the tuna and tuna-like species and straddling stocks one could argue, like pollock. The third positive note is the FAO compliance agreement, whereby the flag states of vessels have the responsibility to keep those, know where they are and keep their vessels under control when they're fishing on the high seas. I think those are three worthwhile tools in the fisheries area that can help us do the things we need to do in the Bering Sea over time.

## Environmental Protection Agency
## Research Planning for the Bering Sea: Sharing the Vision

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The mission of the U.S. Environmental Protection Agency (EPA) is to protect human health and safeguard the natural environment (USEPA, 1997a). This is a unique and broad-based mandate among federal agencies. We do not manage natural resources, nor are we responsible for protecting specific environmental resources. Rather we are a regulatory agency required to implement national environmental laws to achieve desired results (e.g., under the Clean Water Act: protect the chemical, physical and biological integrity of the nation's waters). From its origin, EPA has led the nation in controlling pollution and other environmental risks to human health and the environment. As a result, our air, land and water are much safer and cleaner than 25 years ago. However this success has led to the realization that much more is required to protect human health and the environment than reducing point source contaminant discharges.

EPA's efforts across the nation to implement integrated ecosystem management represent a significant change in the national philosophy of environmental protection from command and control of specific dischargers to voluntary community compliance. The U.S. EPA established ecosystem protection as one of seven objectives for the Agency, and is supporting voluntary compliance through Community-Based Environmental Protection to achieve this environmental goal (USEPA 1994). The Office of Research and Development established "research to improve ecosystem risk assessment" as one of six high priority research areas (USEPA 1996a), and developed a targeted strategy for providing scientific and technical support for community-based efforts (USEPA 1996b). The Office of Water instituted a "watershed protection approach" (USEPA 1991) encouraging States to reorganize permitting and other environmental management actions on a watershed basis. Interested parties in many local communities are using consensus-building to develop environmental management plans for their valued resources.

EPA research in the Arctic reflects our mission and philosophy. Below is a brief summary of projects covering three principal areas of current research: (1) basic and applied research and development of environmental technologies, (2) local and regional community-based and performance-based approaches to environmental protection, and (3) expanded application of risk assessment to better incorporate science into decision-making about ecosystems. This summary is intended to characterize the type of work in which EPA is partnering in the Arctic and Bering Sea. Following the summary is a proposal for a new role for EPA in the Bering Sea based on the Agency's concern about the region and lessons learned from ecosystem level protection activities.

<u>Summary of Activities and Data in the Arctic</u>
Current research by the Agency in this region is more Arctic related than Bering Sea specific. However, much of the work has potential applicability in and around the Bering Sea and is therefore summarized below.

<u>Basic and Applied Research and Technology Development</u>
The Arctic is a concentration area for locally and globally-generated contaminants and pollutants. EPA is supporting research efforts to evaluate contamination types and levels in the Arctic and Bering Sea. The Agency is also interested in the potential affects on human populations and natural ecosystems. The Office of Research and Development staff contributed to the writing of a chapter on "Heavy Metals" and on characteristics of ecosystems and human populations relevant to pollution issues for the Arctic Monitoring and Assessment Program's *State of the Arctic Environment Report* (AMAP, 1997). The

report contains findings from a six-year assessment of the status and trends of Arctic ecosystem conditions. In addition, a number of current EPA research efforts include the following:

Under the Environmental Monitoring and Assessment program (EMAP), and in partnership with the National Park Service, the Agency is investigating Arctic haze and trophic nutrient cascade at Denali National Park. We are evaluating potential impacts of nutrient loads on nitrogen limited aquatic ecosystems and changing exposures to ultraviolet-B. An air quality station was established in FY 1996 and a UV-B monitoring site was established in September, 1997.

EPA's Region 10, with U.S. Fish and Wildlife Service and U.S. Geological Survey supported research near Barrow Alaska on snow contamination. The research involves using ultra trace analyses on snow samples to evaluate atmospheric inputs of heavy metals and other contaminants in Kasegaluk and Elson Lagoons at the Dease Inlet of Admiralty Bay.

EPA Region 10 supported a grant to University of Alaska-Anchorage titled "Alaska Native Use of Local Food Resources: Harvest, Contaminants, Concerns and Cultural Importance." The work is designed to develop a database on contamination of subsistence resources in Alaska including: (1) the contribution of local food sources to Alaska Native diets, (2) contaminants in local food sources and potential health effects, (3) cultural importance of these food sources, (4) Alaska Native concerns about contaminated foods. Research needs are also being identified.

EPA's National Center for Environmental Assessment and National Exposure Research Laboratory, in cooperation with the Agency's Office of International Activities is supporting an "Environmental Risk Assessment for Arctic and Subarctic Energy Development." The arctic oil and gas risk assessment is conducted under the Gore-Chernomyrdin Commission's Environmental Working Group to apply intelligence technologies to civilian sector environmental problems. Information derived from intelligence satellites and other classified sources, both in Russia and the United States, have been combined with civilian data and used to create "derived products" (i.e. unclassified, publishable maps) for Geographic Information System application.

Under the 1994 US-Russia "Arctic Pollution Prevention Agreement" work is ongoing to expand low-level liquid radioactive waste treatment in a Murmansk facility. In addition a joint project among the U.S., Norway and Russia under the Arctic Military Environmental Cooperation, we are working to develop and manufacture prototype transportable interim storage containers for spent naval nuclear fuel.

Under the Agency's Environmental Technology Initiative, EPA Region X and the Office of Research and Development, in cooperation with the Department of Energy, the Alaska Division of Energy, and Kotzebue Electric, are supporting a project titled: "Displacement of Diesel Fuel with Wind Energy in Rural Alaska Villages." The project is designed to determine the potential for minimizing human health and ecological risks associated with the use of diesel fuels.

<u>Community-Based Environmental Protection</u>

Many environmental risks are not amenable to regulation, and command and control efforts can stifle innovation in solving environmental problems. As a result, EPA is promoting cooperative efforts to protect human and environmental resources. Community-based environmental protection programs are those that help facilitate community involvement in environmental issues, promote education and awareness, and bring diverse partners to the table to come to agreement about what needs to be done. The Agency is working with several Arctic communities in this capacity.

Through a grant in FY 1998 to the Tribal Government of St. Paul, Pribilof Islands, the local community is conducting surveys of island residents to develop the community's vision for ecological, economic, human health and cultural values to guide the development of an integrated response assessment.

In FY 1996, EPA Region 10's Office of Waste and Chemical Management provided grant funds to the Louden Village Council Tribe of Galena, AK to produce a documentary on "Koyukon World View and Arctic Contamination Issues." The film depicts a community-wide strategy for solving chemical and waste management problems. The model strategy: 1) identifies chemical and waste management problems, 2) develops a collaborative method for solving these problems among agencies or governments with differing cultural perspectives and environmental priorities, 3) identifies specific actions or solutions to more effectively manage contaminants, and 4) transfers lessons learned to other Native communities. Additional efforts include demonstration projects, brochures and other sources of information.

Under the National Environmental Policy Act (NEPA) Tribal Program, EPA Region V's Office of Strategic Environmental Analysis in cooperation with the Bureau of Indian Affairs and U.S. Forest Service, provided training for Native Americans at Fort Yukon, AK on NEPA.

In FY 1997, the Agency's Office of Radiation and Indoor Air initiated a cooperative agreement with the University of Alaska-Fairbanks and the Alaska Department of Environmental Conservation to develop a case study to increase the level of awareness in the Alaska Native Community about the nature of risk from radiological contamination on Amchitka Island.

Ecosystem Level Risk and Response Assessment. Every natural system is subject to multiple sources of stress that may combine to cause adverse effects or change. The traditional approach to risk assessment was to evaluate the effects of a single stressor on a single receptor. While useful, this approach was found inadequate to address multiple stressors or for meeting the needs of communities trying to protect or manage ecosystem resources. To address this need the Agency has expanded the application of risk assessment to ecosystems through several activities:

In FY 1996 the EPA Office of Water and Risk Assessment Forum presented ecosystem level risk assessment case studies in five watersheds across the country (USEPA, 1996c). Interdisciplinary interagency teams of from 10 to 50 professionals participated in each watershed. The purpose was to apply the risk assessment process in a community context, identify how the process needed to change to accommodate ecosystem level issues, and generate lessons learned. The lessons for planning and problem formulation will be published in FY 1998

The Agency is about to publish final *Guidelines for Ecological Risk Assessment* (USEPA 1997b). The *Guidelines* expand on the *Framework for Ecological Risk Assessment* (USEPA, 1992) and incorporate lessons learned from the watershed case studies.

EPA, in conjunction with the local community and multiple federal, state, commercial and environmental partners, is initiating an integrated response assessment for the Pribilof Islands. The process is designed to transform scientific data into meaningful information about the potential for change and possible risk of human activities on ecological, human health, economic and socio-cultural values of importance on the islands. The purpose is to enable the local community and other concerned resource managers to make informed management decisions about the environment, human well-being and economic development in the Pribilofs. The work differs from other, current research prioritization efforts due to its primary focus on establishing a shared vision for management goals, integrating across multiple values and applying the rigor of ecosystem level risk assessment to allow integration of results for sustainable management.

EPA's Interest and Role in the Bering Sea

Although EPA has supported considerable work in the Bering Sea Region and is implementing its regulatory mandate, EPA has played a limited role in the area. However, evidence suggests that the Bering Sea is under stress. Contaminants are appearing in unexpected locations, increasing numbers of species are being listed as endangered or threatened, human health may be compromised from the consumption of traditional foods, and global climate change is likely to have major implications for the ecosystem. Such signs of risk are reason for concern. If EPA is to meet its mission to protect human health and safeguard the natural environment, then an area of such ecological, economic and cultural importance must become a higher priority. Given the nature of the place, and the diversity of potential stressors, EPA is offering to the Bering Sea community, lessons learned from our experience working with communities and our advancements in ecosystem level risk assessment. There are many lessons we can share. Here we focus on two: *(1) a shared vision about environmental values of concern is critical to successful research design and priority setting;* and *(2) the quality and value of science increases significantly when the scientific questions are relevant to potential risks and management concerns*.

Sharing a Vision

The most important lessons learned when changing from command and control of discharges to ecosystem level protection and voluntary community compliance is that we must: (1) partner; (2) work toward the same end; and (3) clearly define what end is desired.

Agreement on desired ends is a shared vision. For environmental and human resources they may include desired condition of ecological entities, human cultural integrity and economic stability. They can be as broad as the Clean Water Act interim objective: "to protect and restore the chemical, physical and biological integrity of the nation's waters." Although broad visions must be interpreted for a particular place like the Bering Sea, they provide the underlying philosophy for that interpretation. A shared vision is not "everyone has come to share my vision," nor is it a specific management objective (e.g., productivity of fisheries, meeting a permit limit). With a shared vision, all aspects of research, community work and management responsibilities can work in concert.

Shared Visions and Research

While different agencies have jurisdiction for managing specific resources in the Bering Sea, each of these managed resources is dependent on ecosystem functions we may not understand. Recognizing this, recent work by international, national and regional groups is dedicated to prioritizing and funding research that promotes better scientific understanding of Bering Sea resources and processes. Results of these efforts have been extremely valuable in identifying the effects of contamination of Arctic resources, climate change, alterations of animal and plant communities and impacts on Native culture.

While quality science and more knowledge are essential for increasing our understanding of the dynamics of the Bering Sea, more data alone are not sufficient for determining risk associated with these changes or understanding the consequences of management action or inaction. Quality science means more than the availability of tools, methods, models, monitoring and assessment data and techniques for assessing ecosystems. To help us identify research gaps and define research priorities for the Bering Sea we see the need for:

1. Defining scientific questions responsive to environmental concerns and desired results represented in our shared vision

2. Including questions about multiple sources and types of stress to ecosystem processes and components.

3. Establishing Bering Sea conceptual models that represent our hypotheses about relationships among stressors, ecosystem values and potential environmental outcomes

Proposal for Developing a Shared Vision

The Arctic Bering Sea region is an area of tremendous ecological, economic and cultural value that is sensitive to ever increasing anthropogenic challenges. Changes are occurring in the Bering Sea, potentially caused by a combination of local, national and international activity. Thus we see the Bering Sea and its coastlines as a critical environmental value at risk. We believe that community and performance based approaches are critical to protecting this valuable resource.

Within this framework, EPA is proposing an international conference and working group designed to bring together all interested parties to develop a shared vision for the Bering Sea. We will capitalize on lessons learned from many community and performance based efforts across the country, a process proving highly successful in pulling partners together to identify a common vision, design research, and promote cooperation in achieving environmental goals. EPA's role in these efforts has been facilitator and enabler because we do not manage human health or environmental resources, yet we are responsible for the protection of both. Thus our interest in developing a shared vision for the Bering Sea is to help us achieve our mission "to protect human health and to safeguard the natural environment" through innovation and cooperation.

A key lesson from these efforts is that success is only possible by establishing partnerships and incorporating the ideas of all interested parties. Thus, we want you as a partner, your ideas, your assistance and participation. EPA's intended role is to help design and facilitate the conference and process the results. The expected outcome is a vision we can share. It is not shared management. Rather, we want to enable scientists to design more powerful research, to prioritize our research for more effective management and ensure that every resource and risk manager, whether from a fishing village, an industry, or federal agency, as well as scientists, has the opportunity to work in concert to achieve positive environmental results.

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## U.S. Arctic Research Commission Perspectives

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The U.S. Arctic Research Commission is a group that is probably little known to a good many of you. It has seven commissioners appointed by the President of the United States; four academics, two industrialists, one Alaska Native. All the present commissioners are Clinton appointees now. The commission was created in and given as its principal assignment to develop and recommend an integrated national Arctic research policy. Because of the relationship between the Bering Sea and the Arctic Ocean, because of concerns over the Bering Sea Ecosystem at that time, the Bering Sea was included in the commission's area of responsibility. In order to implement the commission's recommendations on an integrated national Arctic research policy, the National Science Foundation was designated as the lead agency for implementing Arctic research. An interagency Arctic Research Policy Committee chaired by the director of NSF and composed of departments and agencies, including Interior and Commerce, was formed. The director of NSF is also a nonvoting member of the commission and agencies may designate observers to the commission. This sounds well integrated but it doesn't work that quite that well because the Interagency Commission always meets in Washington, D.C., and the director of NSF only gets up here about once every couple of years.

Of our seven commissioners now, five live in Alaska and one is at Woods Hole. Our chairman lives in Washington and is the major promoter of the SCICEX Program, which puts researchers on nuclear subs for under-ice cruises. We have had preliminary discussions about integrating SCICEX into a Bering Sea program, but those are still very preliminary. Our mandate is also to facilitate cooperation between the federal government and state and local government, with a particularly expressed mandate to cooperate with the Governor of Alaska and with the agencies and organizations reporting to him.

We have new legislation forming the North Pacific Research Board. Note that the word "fisheries" is not included in the title. It is a North Pacific Research Board and its purpose is to oversee the distribution and make recommendations to the Secretary of Commerce on grants for marine research in the North Pacific. It also mentions the Bering Sea and the Arctic Ocean. So the board can write as broad a mandate as necessary in utilizing these funds. Congress also sent a strong message in the formation of the research board with its members, public, nominated by the Governors of Alaska, Washington, and Oregon, very similar to the North Pacific Fisheries Council's composition. The Governor of Alaska's members are designated as Alaska Native, Oil and Gas, Environmental, Fisheries Industry, and University. The agency members such as Commerce and Interior and State, also include the U.S. Coast Guard, the Office of Naval Research, the Arctic Research Commission, Alaska Fish and Game, the North Pacific Fisheries Management Council, the Oil Spill Recovery Institute in Cordova, and the Alaska Sea Life Center. The message Congress is sending is that it wants this research base to be as broad as possible as we move into the next stage of Bering Sea Ecosystem research.

The other new element in this is the Arctic Council, which has had its first meeting. The Arctic Council grew out of the Arctic environmental protection strategy that the U.S. signed at Rovaniemi. These are international agreements, not treaties. The Arctic Council has as its major purpose to protect and come up with international means of enhancing and protecting the Arctic environment and also to involve the indigenous people of the Arctic in decisions that affect them, especially those that will lead to sustainable development. So the commission that I am on is dedicated to insuring as much as possible that U.S. delegations to the five working groups of the council and to the senior Arctic officials that ministerial meetings are with the best scientific position possible at the moment. It is difficult to say at this time how much real influence the council and its working group will have. But at the last ministerial meeting in Norway when the Arctic Marine Assessment Program put its document on the shelf, it got a good deal of attention around the rest of the world.  The document contains a good deal of the contaminant discussion and the general environmental problem discussions that have been going on here today.

Our first commissioners established the Bering Sea as a high priority and in our report we continued that.  We only come out every two years with a report.  In the report we recommended a concentrated multi-agency program of intensive study of the Arctic Ocean and the Bering Sea.  The Polar Research Board document on the Bering Sea came at a most opportune time.  The report stated that the management in the oceans is still typified by a focus of maximizing yields of economic profits from individual resources without an understanding of the ecosystem processes required to sustain those resources.  There are many reasons, chief of which are a gross undersampling of the marine environment and consequent poverty of information and its biological diversity.

Recently, I have returned to the Bering Sea where I was heavily involved, especially in Far Eastern Soviet fisheries and in preparing Alaska and the Law of the Sea.  In my document on the international fisheries regimes of the North Pacific, I stated that man threatened the foundation stocks of the Bering Sea Ecosystems and that a continual drain of nutrients would take its toll and reduce the total productivity of the system.  We were looking to get the Magnuson Act in and turn around some of the things that led me to that particular perception, but nothing has happened in the last years that would cause me to change the basic conclusions I made.  The commission last year had a meeting in Anchorage on the Bering Sea and one in Dutch Harbor.  We heard from many people about their fears, especially regarding the effects of over-fishing of pollock stocks in the western Bering on the pollock stocks of the eastern Bering.  The points that have been discussed over and over today on pollock were made clearly in those meetings.  If we are truly going to regard pollock as a basis of the ecosystem, we had better get a handle on it.  Steve Cowper, our former governor who is now Director of the Northern Forum, has intensive contacts in the Russian Rar East with the local governments and the regional governments.  He has been one of the loudest in stating that we have to get moving on treating the Bering Sea as a total ecosystem.  That is something that I am in total agreement with.  The Sound Ecosystem Assessment funded by EVOS Trustees' money in Prince William Sound is an ecosystem assessment that has a heavy involvement of local people, especially of the fishery communities and of the villages in Prince William Sound.  That is a model that I recommend for looking at as we proceed forward in establishing the necessary framework for doing a true Bering Sea Ecosystem assessment.

In getting ready for that, when the Alaska Native Claims Settlement Act was passed, it created a federal/state land use planning commission to implement the act.  The first thing we did was to bring together a planning group from all the federal and state agencies.  In three years, that group pulled together all known information on the lands and resources in Alaska, and that formed the basis for the commission.  We sent the planning group back to their agencies and then proceeded to develop the background with Congress for the Alaska National Interest Lands Act.  Without that kind of basis it would have been much more difficult.  But because all the agencies were involved in developing the information, and even though coordination was difficult at times, it still moved forward from a common database.  We put this database out in a series of regional atlases that are still the only documents of that kind in Alaska now, years after the last one was published.  I would highly recommend that such a group be pulled together that really can establish the state of the art as it is known in the Bering at this time.

The North Pacific Research Board is the first group that is a formal state/federal group that has been formed in some time.  We had a Land Use Council that replaced the one I referred to previously.  This council was made up of the agency heads and chaired by the Governor of Alaska and the Secretary of Interior's designee.  It did not work because they never tackled the tough questions.  They stayed away from subsistence; they stayed away from ANWR.  After their year authorization ran out, nobody tried to save them because they were not doing anything.  I hope the North Pacific Research Board can be got off to a good start and tackle the tough problems up front.

Reference has been made to what is needed for a statement of policy guidance in this area. I would just refer to the President's statement on Arctic policy. His objectives, which include the Bering Sea, are protecting the Arctic environment and conserving its biological resources, assuring that natural resource management and economic development in the region are environmentally sustainable, strengthening institutions for cooperation among the Arctic nations, and involving the Arctic's indigenous people in decisions that effect them. Those first four are also the Arctic Council's objectives. There are two that are just ours: enhancing scientific monitoring and research on local, regional and global environmental issues and meeting post cold war national security and defense needs. If we are going to keep the focus that has been established by the Congress through the North Pacific Research Board and by the President in his statements on Arctic policy, we are going to have to get down to work. The area of sustainable development is the key. We will be hearing more tomorrow from Cochran with the Alaska Native Science Commission, which has been formed for coordinating differences in what sustainable development means to everyone, and also to coordinate traditional knowledge.

At the Arctic Council there are three permanent participants from non-governmental organizations, none of which deal very much with the Bering. They are the Sami Council, the Russian Arctic Indigenous Peoples of the North and the Inuit Circumpolar Conference. There are four other permanent participant seats available on the council under the agreement, one of which is the group that is being proposed as the Aleut/Koryak Group, which will bring together the villages of the Bering Sea in a manner similar to what Larry Merculieff was talking about earlier today. I don't know whether it will be exactly Larry's model, but the proposal will be brought before the Arctic Council as rapidly as possible.

The other thing I would like to address briefly is logistics. The commission recently received a report that we commissioned on research logistics from the Arctic Research Consortium, a group of U.S. universities with Arctic interests with headquarters at UAF. The logistics are pretty weak. The university still makes do with the *Alpha Helix*, as a lot of you do. If we are going to do a big job out there, we are going to need a lot more ship time than has been available in the past. We have tried this before, but I understand NOAA is going back for some new fisheries research vessels. I hope they are because if we are going to go forward they will be badly needed. I think we should consider some permanent terrestrial research stations on the Bering Rim and on the islands. Larry brought this up also. Our little station at Tulik Lake on the North Slope has served as a focus for tundra researchers. The labs at Barrow, formerly the Naval Arctic Research Lab, are now operated by the North Slope Borough and the Ukpeagvik Inupiat Corporation and they are still a principal center for research in the high Arctic. Those terrestrial stations do provide a focus for people to gather and for enabling them to stay together in the field for a longer period. These are things that I would like to put before you at this time.

This is an unparalleled opportunity to make a great leap in marine research, if we utilize to the fullest all of our resources. As I've said over and over, we have a strong mandate from the Congress and the Administration. The State of Alaska has historic priorities in Bristol Bay, False Pass and other areas and should be encouraged to enlarge its role in ecosystem research. It seems to me that the richer our state has become, the less we spend on R&D. That is something that is going to be up to the citizens of this state to turn around. It is a state that has a billion in its various accounts, half billion in the Permanent Fund and a half billion in the other accounts. It has some duty to contribute some in research and development of its own welfare. Coordination will be the key to success. It doesn't come free, coordination and liaison, you have to budget for it, somebody has to do it. The reason we sold the congress on creating the funds for marine research in the environmental research and restoration fund and North Pacific Research Board, was because the EXXON *Valdez* Trustees had created their research fund and are hopefully going to add substantially more to it. There are limits to where that fund can be used under the terms of the agreement. It seemed that having another fund, which did not have the limits put on it by the EXXON *Valdez* money, would enable us to take the next step in expanding the type of research that has been done with the EXXON *Valdez* money in the Gulf. Now that we have the tools, for the sake of the Bering Sea Ecosystem, let's make it work.

**Past and Ongoing Bering Sea Research Activities of the International Pacific Halibut Commission**

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Introduction

The Pacific halibut (*Hippoglossus stenolepis*) is distributed along the continental shelf of the North Pacific from Santa Barbara, California to Nome, Alaska. The center of adult halibut abundance is the central Gulf of Alaska, but the Bering Sea serves as a major nursery area contains about 20% of the adult biomass. The commercial halibut fishery is in its 107th year with recent biomass levels at record high levels. While halibut are the target of a directed fishery and are managed separately, they nevertheless figure prominently in the management of the Bering Sea groundfish complex and are an important component of the demersal ecosystem.

The International Pacific Halibut Commission (IPHC) was established in 1923 under a convention signed by Canada and the United States. The convention authorized the IPHC to conduct scientific investigation of the halibut resource and recommend regulatory measures for the halibut fishery of the northern Pacific Ocean including the Bering Sea.

IPHC Bering Sea Research

Nearly all of the research done by the IPHC staff is directed toward one of three continuing objectives of the Commission:

- Improving the annual stock assessment and quota recommendations;
- Developing information on current management issues;
- Adding to knowledge of the biology and life history of halibut.

In each of these areas our routine work program applies the best information and methods available, while our research program aims to improve the information and analytical methodology.

The IPHC conducts annual setline surveys of the resource and develops special projects to answer critical research questions.

*Standardized setline survey.* The purpose of the systematic setline survey is to collect fishery-independent data on halibut that is used in conjunction with fishery dependent data in the annual stock assessment. The data that are routinely collected include: catch-per-unit-effort (used as an index of abundance), sex-specific length at age, age composition, biomass distribution, and recruitment. Standardized setline surveys have been used since 1961. Generally, different areas are surveyed each year, but in 1997 the IPHC embarked on a five-year plan to survey all areas of known halibut distribution. A few statistics demonstrate the sampling effort expended in 1997:

15 commercial vessels were chartered for periods of 2 weeks to 2 months
2000 miles of gear were set at 1130 stations
1100 sampling-person days
82,000 halibut caught and sampled

*Research surveys.* The International Halibut Commission has been conducting research aboard chartered commercial fishing vessels since 1925. The primary purpose of most charters has been to collect information pertaining to stock assessment and migration of Pacific Halibut. Since 1925, the IPHC has completed approximately 271 separate charters; 99 using trawl gear, and 172 using setline gear. Charter duration has varied between 1 week to 4 months consisting of 1 to 9 separate trips. In addition, the

Commission has placed observers aboard numerous commercial and government vessels gathering information on the size, age, and sex composition of halibut.

There have been three primary survey designs used by the IPHC; spot surveys, grid surveys, and random stratified surveys. All charters before 1961and periodically through 1994, were spot surveys. In this type of operation, the captain of the vessel chooses the specific fishing spot within a large area specified by the IPHC. The grid surveys first used in 1961 were made up of a network of longitudinal and latitudinal transects specifying predetermined station locations. The random-stratified surveys use predetermined station locations stratified on commercial and non-commercial grounds. This design has been used only for setline vessels off Oregon, Washington, and Vancouver Island since 1995.

Although the primary purpose of the IPHC surveys has been stock assessment and tagging, there have also been numerous other projects completed either as special charters or in addition to stock assessment work. Examples of the types of research studies performed between 1925 and 1997:

Setline:
Migration (tagging)
Local area depletion experiments
Hooking mortality
Male-Female fish length/otolith weight collections
Oil spill impact
Hooking behavior (Underwater video)

Trawl:
Larval halibut collection
Juvenile fish surveys
Bycatch mortality
Trawl/Setline gear comparison

<u>Halibut-Environmental Research Projects</u>
The IPHC staff has documented interdecadal variability in growth, recruitment, and production of the Pacific halibut stocks, which have led to changes in estimates of abundance and harvest rates. Long term (20-30) environmental conditions may affect halibut productivity to a similar degree as fishing activities. The IPHC is beginning to incorporate environmental science with halibut biology to evaluate inter-relationships. We are currently undertaking three environmental research projects: Fishery-Oceanography, Early Life History, and Stable Isotopes.

*Halibut Fishery Oceanography.* We are assembling available physical and biological data that may relate to changes in halibut production and biology (IPHC 1997). Research to date shows decadal scale regime shifts in oceanographic and meteorological conditions related to fish production. The long time series of halibut catch, age, and growth data provide a unique opportunity to test regime shift hypotheses for Pacific halibut with our data.

*Early Life History.* It has been noted that that maternal effects such as number of eggs produced, egg size, egg and larval viability, and spawning time could have broad management implications. A link between larger female size and increased larval/juvenile fitness implies that a commercial fishery selective for large females would reduce fitness of progeny. Long-term environmental changes appear related to halibut production. We are investigating how the environment operates on female fitness/progeny fitness and relates to larval/juvenile survival.

*Stable Isotopes.* The use of oxygen isotopes in biological calcareous materials, such as the aragonite of fish otoliths, as a thermometer for tracking historical temperatures over decades and centuries has been in place since the 1940s. By analyzing oxygen and other isotope ratios (e.g., C, Sr/Ca, Mg), we hope to retrospectively identify the environment experienced by juvenile halibut. This research may help us to clarify the migration pathways of halibut that recruit to different areas along the continental shelf.

Identification of a migration pathway requires a unique signal in the environment, thus this project is critically dependent on the fisheries oceanography project.

Future Directions
- Continue environmental focus on halibut life history
- Migration of juvenile halibut from Bering Sea
- Incorporate ecosystem variability in models of halibut population dynamics
- Incorporate knowledge of ecosystem effects into advice that reflects the precautionary management principle

Opportunities for Collaboration
The IPHC has embarked on an ambitious five year sampling program. A systematic survey over the entire continental shelf, similar to that conducted in 1997, will be conducted each year through 2001. As such, this represents one of the most comprehensive sampling regimes available for ecosystem-oriented research. We welcome inquiries as to the possibility of collaborative sampling and/or research. For example, it would be quite possible for us to take additional environmental or biological samples. Also, we have routinely taken other agency biologists aboard our many setline and research cruises. During the past decade, we have taken biologists from WDFW, ODFW, NMFS, the Makah and Quileute tribes, and the Coast Guard. We also place IPHC biologists aboard NMFS and UW cruises. This coming year we may participate in a collaborative study on seabird bycatch mortality. We are discussing with the National Marine Fisheries Service and the Fish and Wildlife Service a pilot program aboard IPHC setline survey vessels to determine effectiveness of seabird scaring devices required by regulation for fishermen using longline gear for groundfish in the Fishery Conservation Zone off Alaska.

We are also planning on conducting collaborative research on building models of oceanographic transport using our newly developed ocean bottom properties database. We are beginning multi-species investigations based on catch and biological data from our own and other agency surveys.
Inquiries about collaboration should be directed to the IPHC at the following address:

Dr. Bruce Leaman, Director
International Pacific Halibut Commission
P. O. Box 95009
Seattle, WA 98125-2009
Phone: (206) 634-1838

## INVENTORY OF DATA AND INFORMATION BASES

### Overview of Inventory of Data and Information Bases Presentations

The workshop organizing committee, in pursuit of the goal to identify important data gaps, included this section of the program to identify the location of the knowledge that currently exists and how it might be accessed and retrieved. With this knowledge in hand, scientists might find the information they needed already existed. True gaps could then be identified. This section also inadvertently captured a cross section in time of the transition between old and new ways of storing, accessing and retrieving information. The notes that follow reference material found in the submitted papers and also in the oral presentations made by these speakers.

The data sources for traditional knowledge, as presented by Patricia Longley-Cochran, appear to be individual Native elders. Her comment that "When an elder dies, a library burns," emphasized that much of this information is transmitted by oral tradition. Though many Western scientists acknowledge that their research can profit from traditional knowledge, accessing the information they need in this manner is very daunting. The Alaska Department of Fish and Game does maintain a traditional knowledge database, "Whiskers", (mentioned by Craig Mishler during the panel discussion, not by this presenter). Ms. Longley-Cochran noted that the Alaska Native Science Commission is in the process of compiling information from previously existing sources. If funding is available, meetings will be scheduled to identify community members who hold the knowledge of the land, what is happening within the land, the issues they know and what information is already available.

For those of us who began our careers before the advent of computers and the Internet, the presentations by Alan Springer and Chuck Fowler exemplified the efforts individual scientists normally made to gather the information on subjects of interest to them. Springer identified many U.S., Russian and Japanese efforts to gather data on Bering Sea phytoplankton, zooplankton and other lower trophic level information including the projects, type of data, supporting organizations and individual researchers holding the data. Charles Fowler provided a table of data types compiled for the marine mammals of the Bering Sea (and thereby also identified some data gaps). He did not provide source material, but noted that the data existed in hundreds, if not thousands, of locations. Both scientists' materials appear to have been gleaned through long years of individual efforts.

The primary purpose of a number of data gathering projects appeared to be to make that data accessible to the scientists, managers and stakeholders with a use for it. Sid Stillwaugh presented the information gathering services of NOAA's National Oceanographic Data Center, Coast Watch, SeaWiFS, the National Weather Service Forecast Office, the National Ice Center, the National Snow and Ice Data Center, the National Climatic Data Center, and the National Data Buoy Center. He provided the types of oceanographic and weather data each provided with names, phone numbers, email addresses and web sites for contacts.

Stein, Krahn (presenter) and Tilbury addressed chemical contaminant databases relevant to the Bering Sea Ecosystem. They addressed the Arctic Monitoring and Assessment Program (AMAP) which examines chemical contaminants in higher trophic level animals, the USGS's Alaska Marine Mammals Tissue Archival Project (AMMTAP), NOAA's Marine Mammal Health and Stranding Response Program (MMHSRP) and NOAA's National Status and Trends "mussel watch" project. AMMTAP not only stores data, but also samples. Data types, geographic coverage, time frames, formats, contact information, current uses and significant gaps were addressed.

Scott Hatch identified four seabird databases, the Beringian Seabird Colony Catalog, the Pelagic Seabird Atlas of the North Pacific, the Pacific Seabird Monitoring Database, and the Beringian Seabird

Bibliographic Database. He also provided complete information on what is contained in each, from whom and how it is accessed.

The presentations by Mark Shasby and Bernie Megrey demonstrated where the Information Age is headed and how a multi-agency, multi-field range of Bering Sea ecosystem data is already being compiled and made accessible to anyone with a PC and a modem. Shasby described the mission of the Federal Geographic Data Committee, created by presidential mandate and encompassing 15 federal agencies, to link federal and other participating organizations' databases under the National Spatial Data Infrastructure. There are currently 50 federal and state servers linked via UNIX or Windows NT and Z34.5 search and retrieve protocol. These standards and protocols have been adopted by the Arctic Data Directory under the Arctic Council, composed of Arctic nations. Shasby is in charge of one node, the Alaska Geospatial Data Clearinghouse, composed of federal, state, local and tribal governments and non-governmental groups. He suggests creating a similar queriable clearinghouse for the Bering Sea which could not only access databases on any of the NSDI nodes, but could also create chat rooms on the Bering Sea, for example.

Bernie Megrey demonstrated the potential of the NSDI with NOAA's Bering Sea Ecosystem Biophysical Metadatabases. Currently this metadatabase provides access to 13 databases primarily created by various NOAA Bering Sea projects. These include midwater and bottom trawl surveys, primary productivity, ichthyoplankton, groundfish and observer data, food habits, and predator-prey relationships. There are also databases from Soviet trawl surveys and Japanese long line surveys. Megrey has contacted and received additional databases to be included from Russia, Japan, Korea and China. He has a form, distributed at the Bering Sea Ecosystem Workshop, which ultimately could allow inclusion of most of the databases mentioned by other participants. By using the NSDI system, those databases would reside on the computers of their originators, but could be accessed through the Bering Sea Ecosystem Biophysical Metadatabase node of NSDI. How Shasby's concept of a Bering Sea Clearinghouse would integrate with this current NOAA project remains to be seen.

This section of the workshop demonstrated the range of databases available on Bering Sea resources and provided information on how to access many of them. It also provided a window to the future. If Bering Sea information can be accessed on whatever subject is required no matter where the information actually resides, ecosystem-based coordinated research and ultimately management will be far easier.

**An Inventory of Major National Oceanographic Data Center (NODC)/NOAA Physical Data and Other Data Resources for the Bering Sea Region.**

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Ph: (206) 526-6263, Fax: (206) 526-6485, Email: sstillwaugh@nodc.noaa.gov.

The National Oceanographic Data Center (NODC) is the U.S. repository and distribution facility for global ocean data. NODC ensures that oceanographic data collected at great cost are preserved and maintained in a permanent archive where they are available for use by scientists, engineers, resource managers, planners and others. NODC provides customers with access to databases of physical, chemical and biological ocean data as well as numerous individual data sets and data products.

The following presentation is an inventory of NODC physical oceanographic data holdings available for the Bering Sea basin. The station or record counts of the parameters presented are not project specific but represent an approximation of all data on file (all years) and available to users on request.

The geographic boundaries arbitrarily chosen for the basin wide inventory include:
Latitude - 53° North to 66° North and Longitude - 160° West to 165° East.

<u>NODC Data Base Inventory</u>

| Parameter | Total No.of stations or records |
|---|---|
| 1) Bottle Cast | 8,957 stations |
| 2) High resolution STD/CTD | 9,311 stations |
| 3) Mechanical Bathythermograph | 9,981 stations |
| 4) Expendable Bathythermograph | 11,547 stations |
| 5) Current Meter (components) | 1,400,035 records |
| 6) Drifting Buoys, Surface | 100,178 records |
| * (components include east-west (u) and north-south (v) vector components) | |

Data Base time frame: 1900 to the present
Availability: All NODC holdings are public information and available free of charge to NOAA, or at nominal cost of recovery to others. Data exchange is also a consideration.
How Accessed: Some NODC data sets are available on-line, however, the majority of NODCs holdings are accessed via direct contact with data center staff. (Specify project, cruise, time frame, geographic area of interest, etc.)
Media: mag. tapes, magnetic cartridges, diskettes, CD ROM, electronic file transfer (ftp)
Contacts: 1) NODC Liaison Office, Seattle. Ph: (206) 526-6263, Fax: (206) 526-6485
Email: sstillwaugh@nodc.noaa.gov
2) National Oceanographic Data Center. Ph: (301) 713-3277, Fax: (301) 713-3302, Email: services@nodc.noaa.gov, Web site: <http://www.nodc.noaa.gov>.

<u>Satellite Imagery and Related Data</u>

1. NOAA CoastWatch - products derived from AVHRR satellite data, primary product for the region is sea surface temperatures (SST).

   Contact: Near real time or recent data and information: Mr. Gary Hufford

NOAA/NWS, Alaska region, Anchorage. Ph: (907)271-3886, Fax: (907)271-3711, Email: Gary.Hufford@noaa.gov.

*for retrospective CoastWatch data, contact NOAAs National Oceanographic Data Center (CoastWatch Active Access System), user access Mrs. Mary Hollinger, Ph: (301)713-3277, x153, Fax: (301)713-3302, Email: mhollinger@nodc.noaa.gov.

2. SeaWiFS and SeaWiFS SeaStar - global ocean color, etc
   Contact: Gene Carl Feldman, Ph: (301)286-9428, Email: gene@seawifs.gsfc.nasa.gov
   Web Site: http://seawifs.gsfc.nasa.gov/SEAWIFS.html.

3. Other NOAA Weather Satellite Coverage Imagery and digital data - (GOES, polar orbiters). Contact : NOAA's National Climatic Data Centers= Satellite Active Archive (SAA). Ph: (704) 271-4800, Fax: (704) 271-4876. Web Site: http://www.saa.noaa.gov.

**Sea Ice and Marine Meteorology**

NODC does not maintain databases for sea ice forecasts or data. Listed are three sources for one or more of this type of data.

1. National Weather Service Forecast Office, Alaska Region - graphic analyses of sea ice, as well as five-day forecasts, year round. Contact: Mr. Russell Page, Regional Ice Forecaster, Phone: (907) 266-5113. E-mail: Russell.Page@noaa.gov, Web site: <http://www.alaska.net/~nwsar/>.

2. National Ice Center, NOAA/NAVY - worldwide operational sea ice analyses and forecasts. Contact: E-mail: liaison@natice.noaa.gov, ray@natice.noaa.gov. Web site: <http://www.natice.noaa.gov>.

3. National Snow and Ice Data Center - archive for digital snow and ice data, worldwide
Contact: User Services, NSIDC, Boulder, CO. Ph: (303) 492-6199, Fax: (303) 492-2468
E-mail: nsidc@kryos.colorado.edu. Web site: <http://www-nsidc.colorado.edu>.

Marine Meteorology

Two NOAA sources for both shore station data and NOAA buoy data for the region, are presented:

1. NOAA, National Climatic Data Center - NCDC is the worldwide archive for climatology data. Examples of 4 shore stations, NWS sites for the region are presented here.

| Station | Approx. Period of Record |
|---|---|
| 1) Nome, AK | 40-50 yrs. |
| 2) St. Paul Is., AK | 24-40 yrs. |
| 3) Unalakleet, AK | 20-40 yrs. |
| 4) Cold Bay, AK | 40-50 yrs. |

(Basic weather parameters available might include air temps, rainfall, snowfall, wind, station pressure, etc). Contact: NCDC User Services, Asheville, NC. Ph: (704) 271-4800, Fax: (704) 271-4876, E-mail: services@ncdc.noaa.gov. Web site: <http://www.ncdc.noaa.gov>. Availability: Data are available on mag. tape, magnetic cartridges, CD ROM, diskettes, publications. No cost to NOAA , nominal charge for data recovery to others.

2. NOAA, National Data Buoy Center (NDBC). In addition, marine weather and sea state data are available, both historical and real time via NOAA meteorological buoys previously or currently in service in Bering Sea locations. Buoy station locations, buoy I.D=s past and present are most easily viewed using the NDBC web browser. Many buoy data sets, both historical and real time data are available directly off the NDBC web site free of charge.
   Contact: National Data Buoy Center (NDBC) Ph: (601) 688-1720, Fax: (601) 688-3153, E-mail: dgilhousen@ndbc.noaa.govWeb site: <http://seaboard.ndbc.noaa.gov>.
   Availability: free web site access, CD ROM data sets at cost recovery prices.

## Bering Sea Ecosystem: Relevant Chemical Contaminant Databases

John E. Stein, Margaret M. Krahn*, and Karen L. Tilbury, Environmental Conservation Division, Northwest Fisheries Science Center, National Marine Fisheries Service, 2725 Montlake Blvd. E., Seattle, WA 98112, Ph: (206) 860-3330; Fax: (206) 860-3335, Email: John.E.Stein@noaa.gov.

### Background

Investigations of chemical contaminants in biotic and abiotic compartments of the Arctic ecosystems have increased recently. A major impetus to this increase in chemical surveillance in the Arctic were findings indicating that there is global atmospheric transport of organic contaminants from lower to northern latitudes, followed by removal of contaminants from the atmosphere through processes (e.g., cold climate, precipitation) specific to the Arctic region. In addition, concerns over potential ocean disposal of spent nuclear reactor components raised concerns of radionuclide contamination of Arctic environments. Transport via rivers and oceans make these organic and trace element contaminants available to plants and animals in food chains where selective uptake and transfer of contaminants (e.g., PCBs, DDTs, certain trace elements) can result in biomagnification in animals at the top of a food chain (e.g., marine mammals), increasing the risk for toxic effects. Moreover, Native populations, who rely for subsistence on species that are high in a food web, can potentially receive exposure to appreciable concentrations of certain chemical contaminants.

The relative lack of comprehensive chemical data was also an important factor for increased study of the fate and effects of contaminants in Arctic ecosystems, including the Bering Sea. The need for more comprehensive information was recognized internationally by a consortium of Arctic nations, which led to the formation of the international Arctic Monitoring and Assessment Program (AMAP). The first phase of AMAP was recently completed and a second phase will be initiated in the near future. The data collected to date on chemical contaminants in the Arctic are primarily for higher trophic level species (e.g., marine mammals, eagles), seabirds and subsistence species. There are fewer data on lower trophic level biotic compartments (e.g., fish, invertebrates) and abiotic compartments (e.g., sediment, water) in marine areas. The contaminants of primary concern are persistent organic pollutants, such as chlorinated pesticides (e.g., DDT, chlordane, toxaphene); polychlorinated biphenyls (PCBs); polycyclic aromatic hydrocarbons; toxic trace elements ("heavy metals"), such as mercury, cadmium, lead; and radionuclides, such as radioactive isotopes of strontium, cesium, and iodine, which can come from multiple sources. Pesticides that are currently widely used (e.g., endosulfan) are also of some concern.

Current programs developing contaminant data for the Bering Sea ecosystem are the Alaska Marine Mammal Tissue Archival Project (AMMTAP) supported by the US Geological Survey's (USGS) Biological Resources Division, the National Marine Fisheries Service's Marine Mammal Health and Stranding Response Program (MMHSRP), and NOAA's National Status and Trends "mussel watch" project. The AMMTAP is conducted through the MMHSRP. The primary objective of the AMMTAP is to archive marine mammal tissues under state-of-the-art conditions to establish a sample base for future retrospective studies. The MMHSRP includes real time biomonitoring of contaminant exposure in Arctic marine mammals. For example, the MMHSRP is providing technical support to a project funded through the NOAA Arctic Research Initiative to investigate whether observed biological effects in northern fur seals in the Pribiloffs are associated with persistent organic pollutant exposure. The National Status and Trends project focuses on US near coastal sites and includes a few sites in the Bering Sea ecosystem. There is also some information on levels of the above contaminants in surficial sediments and fish. These latter data are from the NOAA's previous National Benthic Surveillance Project and are available on the Internet. The accessibility of the data from these projects is presented below.

There are a limited number of readily accessible databases on chemical contaminants for the Bering Sea, however, there is an increased effort to further develop such databases. For example, the University of

Alaska Anchorage is in the process of developing a database on chemical contaminant levels in subsistence resources, which will include data for the Bering Sea region. In addition, the Arctic Environmental Data Directory (AEDD), maintained by the USGS in Anchorage (AMAP data manager for North American data), is planning to add data sets that relate to Arctic contamination into its database. Moreover, data generated by the MMHSRP will be made available through a national marine mammal database, which will include a range of biological as well as contaminant data. In addition, there are data in peer-reviewed publications on species of interest, such as Steller sea lions, northern fur seals, gray and bowhead whales. In comparison to the temperate latitudes, the scope and breadth of data on chemical contaminants in Arctic systems, such as the Bering Sea, are limited; however, for the Bering Sea there are some high quality data available and there are ongoing programs of relatively limited scope that will continue to collect and make the data more accessible. Furthermore, the NOAA effort to develop the Bering Sea Ecosystem Biophysical Metadatabase will provide a additional mechanism for identifying the sources of information on a wide range of data on the Bering Sea; this project is seeking to include contaminant data.

Database Information

The major databases identified on chemical contaminants in the Bering Sea ecosystem are:

I. University of Alaska at Anchorage (Institute of Social and Economic Research) Data Base

content/parameters - contaminants in subsistence foods, health effects of contaminants on animals and people, Native community concerns and recommendations, cultural benefits of subsistence foods, nutritional value of subsistence foods, and grants and programs to address contaminant concerns.

geographic coverage – Alaska

time frame - unknown (database not complete)

format - searchable database

contact and accessibility - Mary Killorin (University of Alaska Anchorage); Internet

current use - to access existing information, set research goals, set monitoring and clean-up priorities, and animals and people, Native community concerns and recommendations, cultural benefits of subsistence foods, nutritional value of subsistence foods, and grants and programs to address contaminant concerns.

significant gaps - unknown

II. NMFS Marine Mammal Health and Stranding Response Program Data Base (including data from USGS supported by AMMTAP)

content/parameters - contaminant data, as well as, life history parameters, pathology, and serology for marine mammals

geographic coverage - US coastal waters including Alaska

time frame - pre-1990 as available; 1990 to present

format – electronic

contact and accessibility - Teri Rowles, NMFS, Office of Protected Resources, Silver Spring, MD; available in the future on the Internet

significant gaps - full life history data on limited numbers of sampled animals, number of species sampled from Bering Sea ecosystem and other regions, and samples/data on prey species

III. Arctic Environmental Data Directory (AEDD) maintained by USGS
content/parameters – currently contains descriptions of data on global change studies, environmental interactions, earth sciences, social sciences, and policy and management
geographic coverage – Arctic (as defined by AMAP)
time frame – current
format – electronic
contact and accessibility - Bruce Molnia, USGS, Reston, VA; Internet
significant gaps - contaminants; however, intend to add contaminant data on measurements of radionuclides, persistent organic pollutants and trace elements (heavy metals)

IV. NOAA/NATIONAL STATUS AND TRENDS DATA BASE
content/parameters - organic contaminants and trace metals in bivalves, fish and sediment (no bivalves from Bering Sea)
geographic coverage - US coastal waters including the Bering Sea
time frame - 1984 - present (1984 - 1996 for Bering Sea)
format - searchable database
contact and accessibility - Tom O'Conner, National Ocean Service, ORCA, Silver Spring, MD; Internet
significant gaps - limited number of sites

V. Other (e.g., data sets)
data sets held by individual researchers in electronic or hard-copy format and only accessible by individual requests, for example:

Ylitalo, G.M., Buzitis, J., Krahn, M.M., Chan, S-L., Stein, J.E., Antonelis, G.A., and Spraker, T.R. 1995. Analyses of northern fur seal (Callorhinus ursinus) blubber and milk samples for selected chlorobiphenyls (CBs) and DDTs by HPLC/PDA. Poster presentation at PNWSETAC Annual Meeting, Seattle, WA, May 12-13, 1995.

publications in scientific journals - electronic or hard copy available by request from authors. The following are examples and not intended to be comprehensive.

Krahn, M.M., Tilbury, K.L., Becker, P.R., and Stein, J.E. (1997). Organochlorine contaminants in blubber of four seal species: integrating biomonitoring and specimen banking. Chemosphere. 34(9/10):2109-2121.

Lee, J.S., Tanabe, S., Umino, H., Tatsukawa, R., Loughlin, T.R., and Calkins, D.C. (1996). Persistent organochlorines in Steller sea lion (Eumetopias jubatus) from the Gulf of Alaska and the Bering Sea, 1976-1981. Marine Pollution Bulletin. 32(7):535-544.

Mossner, S. and Ballschmiter, K. (1997). Marine mammals as global pollution indicators for organochlorines. Chemosphere. 34(5-7):1285-1296.

Varanasi, U., Stein, J.E., Tilbury, K.L., Meador, J.P., Wigren, C.A., Clark, R.C., and Chan, S-L. (1994). Chemical contaminants in gray whales (Eschrichtius robustus) stranded along the west coast of North America. Sci. Total Environ. 145: 29-53

## Lower Trophic Levels

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### Data Acquisition

Phytoplankton and zooplankton studies in the Bering Sea were undertaken in 1932-1933 by the State Hydrological Institute and TINRO of Russia and continued in 1950-1958 by the Institute of Oceanology and in 1954-1961 by the Kamchatka section of TINRO. The comparability of these early data to modern data is unknown. TINRO continued plankton research in the western Bering Sea in the 1980s and published results in reports and a series of papers that are archived at TINRO-Vladivostok . About half of the material collected during those cruises is stored at DVO RAN and the rest was discarded. Plankton data continue to be acquired from the western Bering Sea by TINRO.

Japan began collecting more-or-less systematic time-series data on phytoplankton and zooplankton biomass in the N. Pacific, including the Bering Sea, in the early 1950s that continues today. Summary data have been reported recently.

Studies of primary productivity over a broad area of the eastern and northern Bering Sea in summer and winter were first undertaken by IMS during several cruises in 1965-1971 (P. McRoy and J. Goering). Beginning in the mid-1970s, two major programs, OCSEAP and PROBES, acquired a large amount of data on both phytoplankton and zooplankton from the southeastern shelf. These were followed by a series of studies of production at the ice edge (ICE) and on the northern shelf by ISHTAR in the 1980s. Plankton studies on the North Aleutian Shelf were funded by OCSEAP in the 1980s. Additional plankton data were obtained by K. Coyle (IMS) in the 1980s and 1990s from the northern shelf, the southeastern shelf near the Pribilof Is., the western Aleutians, and Bristol Bay. BERPAC also contributed data on plankton on the northern shelf and from set locations in other areas of the Bering Sea in the 1980s and 1990s.

Three studies have acquired plankton data from the southeastern shelf in the 1990s, Bering Sea FOCI, SEBSCC, and CIFAR. Intensive plankton studies in the vicinity of the Pribilof Is. were undertaken by PPSIO in 1994-1996. This work has been very important in describing mesoscale processes. Stable isotope techniques have been used to analyze zooplankton for the purpose of tracing trophic pathways and to obtain proxy data on primary production for the past 40 years in the Bering/Chukchi seas (D. Schell, IMS). Plankton data from the western Bering Sea continue to be acquired by TINRO and VNIRO.

### General Models

#### *Spatial*

A general model of production regimes on the eastern shelf was proposed by PROBES. It identified a series of three physical structural fronts that partition the shelf into inner, middle, and outer shelf hydrographic and biological domains. ISHTAR identified advective processes responsible for the prodigious production regime on the northern shelf. A combination of these and other observations was used to describe recently a separate habitat at the shelf edge, the Green Belt.

#### *Temporal*

The seasonality of the production regime in most of the Bering Sea is well known and is characterized by the spring bloom. The precise timing of the bloom varies between years and is influenced by physical conditions, including seasonal sea ice. An important exception is found on the northern shelf and apparently along the shelf edge, where primary production is intense for a prolonged period of summer after the termination of the spring bloom.

Long-term temporal models for the Bering Sea are few and we are uncertain about how well they characterize change. Isotope proxy data have been interpreted to mean that primary productivity has declined in the past 30 years and support a similar conclusion about secondary productivity based on Japanese net tow data. In contrast, no such decline is apparent in the Japanese phytoplankton biomass data, but biomass is likely an imprecise measure of production. A pronounced decline in transport through Bering Strait in the past three decades might represent a physical mechanism that would explain the apparent decline in production based on isotope data.

Needs

Better understanding of:

- spatial distribution of primary and secondary production
- causes and magnitude of interannual and interdecadal variability in production - has primary or secondary production declined?
- variability in the timing of production, e.g., the spring bloom, ice-edge bloom, and its effect on higher trophic levels
- importance of mesoscale processes to primary and secondary production and biomass yield at higher trophic levels
- effect of floral community structure on zooplankton community and production

Data Sets

*Phytoplankton*

Russia — Bering Sea: 1930s-present. Chlorophyll, primary production, taxa, VNIRO, TINRO.

Japan (*Oshoro-Maru, Hokusei-Maru*) — Bering Sea: 1954-present. Chlorophyll, Secchi depth, nutrients, taxa, FFHU.

Bering Sea: 1965-1971. Nutrients, chlorophyll, primary production, taxa, IMS: P. McRoy, J. Goering.

OCSEAP — SE shelf: 1975-1979. N. Aleutian shelf: 1982-1984. Nutrients, chlorophyll, primary production, taxa, NODC.

PROBES — SE shelf: 1976-1982. ‘Oceanographic data set’ includes nutrients, chlorophyll, primary productivity, $CO_2$ IMS database, P. McRoy, NODC, taxa, IMS: J. Goering.

ISHTAR — N shelf: 1983, 1985-1989. Nutrients, chlorophyll, primary productivity, taxa, IMS database, P. McRoy, NODC.

ICE — E shelf: 1970s-1990s. Nutrients, chlorophyll, primary productivity, taxa, IMS: V. Alexander, J. Niebauer.

BERPAC — Bering Sea: 1984, 1988. Nutrients, chlorophyll, primary productivity, taxa, IMS database: P. McRoy, 1988, BERPAK reports and authors: 1984, 1988.

PIES — Pribilof Islands, SE shelf: 1994-1996. Nutrients, chlorophyll, primary production, taxa. PPSIO: M. Flint.

FOCI — SE shelf: 1990s**.** Chlorophyll, PMEL: N. Coklett

SEBSCC — SE shelf: 1995-present**.** Nutrients, chlorophyll, primary production. IMS: J. Goering

CIFAR — SE shelf: 1996-present. Nutrients, chlorophyll, primary production, taxa. IMS: P. McRoy.

SeaWiFS — Bering Sea: 1997 –present. Chlorophyll, IMS: Low resolution (4 km) supplied to and available from NASAGoddard. High resolution (1 km) - D. Eslinger

ISOTOPES — Bering Sea: 1940s-present. Proxy data from whale baleen. IMS: D. Schell.

Data Sets

*Zooplankton*

Japan (*Oshoro-Maru, Hokusei-Maru*) — Bering Sea: 1954-present. Mesozooplankton: net samples. FFHU.
Russia — Bering Sea: 1950s-present. Mesozooplankton: net sample. VNIRO, TINRO.
OCSEAP — SE shelf: 1975-1979. N. Aleutian shelf: 1982-1984. Mesozooplankton: net samples. NODC.
PROBES — SE shelf: 1976-1982. Mesozooplankton: net samples. IMS: T. Cooney, S. Smith, University of Miami.
ISHTAR — N shelf: 1983, 1985-1989. Mesozooplankton: net samples. IMS data base, P. McRoy.
BERPAC — Bering Sea: 1984, 1988. Mesozooplankton: net samples. IMS data base: P. McRoy, 1988. BERPAC reports and authors: 1984, 1988.
PIES — Pribilof Islands, SE shelf: 1994-1996. Heterotrophic picoplankton-mesoplankton: numbers, biomass, growth, production, physiological condition, taxa. PPSIO: M. Flint.
FOCI — SE shelf: 1990s. Mesozooplankton: net samples, hydroacoustic data. PMEL: J. Napp. IMS: A.J. Paul.
SEBSCC — SE shelf: 1995-present. Mesozooplankton: net samples, hydroacoustic data. NMFS: J. Napp.
ISOTOPES — Bering Sea: 1980s, 1990s. Mesozooplankton: isotope data. IMS: D. Schell.
Miscellaneous — Bering Sea shelf, western Aleutians: various years in 1980s, 1990s. Mesozooplankton: net samples, hydroacoustic data. IMS: K. Coyle.

Abbreviations/Acronyms

BERPAC — Joint U.S.-U.S.S.R. Bering Sea Expeditions
Roscigno, P.F. (ed.). 1990. Results of the second joint U.S.-U.S.S.R. Bering Sea Expedition, summer 1984. U.S. Fish and Wildl. Serv. Biol. Rep. 90(13). 317 pp.
CIFAR — Cooperative Institute for Arctic Research
DVO RAN — Russian Academy of Sciences of the Far East, Vladivostok
FFHU — Faculty of Fisheries, Hokkaido University, Japan
FOCI — Fisheries Oceanography Coordinated Investigations
ICE — Ice Edge Studies, IMS
IMS — Institute of Marine Science, University of Alaska Fairbanks
ISHTAR — Inner Shelf Transfer and Recycling
NMFS — NOAA/National Marine Fisheries Sevice, Seattle
NODC — NOAA/National Oceanographic Data Center
OCSEAP — Outer Continental Shelf Environmental Assessment Program
PIES — Pribilof Islands Ecosystem Studies
PMEL — NOAA/Pacific Marine Environmental Laboratory, Seattle
PPSIO — P.P. Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow
PROBES — Processes and Resources of the Bering Sea Shelf
SeaWiFS — Sea-viewing Wide-Field-of-View Sensor
SEBSCC — Southeast Bering Sea Carrying Capacity
TINRO — Pacific Scientific Research Institute of Marine Fisheries and Oceanography
VNIRO — All-union Scientific Research Institute of Marine Fisheries and Oceanography

## Large Benthos and Fish

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The National Marine Fisheries Science Center, Alaska Fisheries Science Center (AFSC) studies 40 species of fish and crab that inhabit the NE Pacific and the Bering Sea. The AFSC conducts scientific biological surveys annually to assess size and value of commercial fisheries resources. Other surveys are conducted for special projects and scientific studies. Often surveys are executed in cooperation with foreign nations.

Data and information products from these survey activities, which go back to the early 1970's, are archived into various computer files and databases. An inventory of these data and information bases follow on separate pages presented in a fixed format.

Name: Bering Sea Chlorophyll, Nutrients and Zooplankton Database
- Type: NMFS/AFSC Database
- Content: Observations on chlorophyll, nutrients, and zooplankton populations collected during Bering Sea FOCI and SEBSCC field operations
- Parameters: Chlorophyll, nutrients, & zooplankton measurements
- Spatial Domain: Continental slope and shelf of the southeastern Bering Sea - 58N, 174W, 164E, 53S
- Time Domain: Feb 1992 – present
- Electronic Format: PC Database
- Contact: Dr. Jeffry M. Napp, NOAA/NMFS/AFSC, 7600 Sand Point Way NE Seattle, WA 98115. Ph: 206-526-4148, Fax: 206-526-6723, Email: jnapp@afsc.noaa.gov
- Accessibility: Permission of contact
- Uses: Understand biological mechanisms influencing the productivity at lower trophic levels and energy available to higher trophic levels
- Gaps: NA

Name: RACEBASE – Bering Sea Bottom Trawl Survey
- Type: NMFS/AFSC Database
- Content: Bottom trawl position and catch data
- Parameters: Catch biomass, species composition and biological characteristics of the catch; physical measurements. Includes over 17,000 trawls
- Spatial Domain: Continental slope and shelf of the southeastern Bering Sea - 72N, 180W, 158E, 51S
- Time Domain: 1959 – present
- Electronic Format: ORACLE Database
- Contact: Dr. Gary Stauffer
- Accessibility: Check with contact
- Uses: Stock assessment; understand changes in abundance of commercially important fishes
- Gaps: NA and

Name: RACEBASE - Aleutian Islands Bottom Trawl Survey
Type: NMFS/AFSC Database
Content: Bottom trawl position and catch data
Parameters: Catch biomass, species composition and biological characteristics of the catch; physical measurements. Standardized surveys completed in 1980, 83, 86, 91, 94 and 97
Spatial Domain: Aleutian Island chain in the southeastern Bering Sea - 55N, 170W, 165E, 51S
Time Domain: 1980 – present
Electronic Format: ORACLE Database
Contact: Dr. Gary Stauffer, NOAA/NMFS/AFSC, 7600 Sand Point Way NE, Seattle, WA 98115, 206-526-4170 (Office) 206-526-6723 (FAX), email: gary.stauffer@noaa.gov.
Accessibility: Check with contact
Uses: Stock assessment; understand changes in abundance of commercially important fishes
Gaps: NA

Name: RACEBASE - Bering Sea Acoustic/Midwater Trawl Survey
Type: NMFS/AFSC Database
Content: Acoustic and midwater trawl, XBT, CTD, and MBT data
Parameters: Position, date/time, bottom depth, acoustic return, catch biomass, species composition, length, weight, age, & maturity; bottom depth, SST, and salinity
Spatial Domain: Slope, shelf, & basin of eastern/western Bering Sea
Time Domain: 1977 – present
Electronic Format: Data cartridge, magnetic tape, CR-ROM, INGRESS and ORACLE Database
Contact: Neal Williamson, NOAA/NMFS/AFSC, 7600 Sand Point Way NE, Seattle, WA 98115. 206-526-6417 (Office) 206-526-6723 (Fax) email: neal.williamson@noaa.gov.
Accessibility: Check with contact
Uses: Stock assessment; understand changes in abundance of commercially important fishes
Gaps: Surveys missing in 1980, 81, 83, 86, 87 90

Name: FOCI - Discrete Sample Database
Type: NMFS/AFSC Metadatabase
Content: Metadata description of position, summary information on ichthyoplankton, other biological samples, and physical measurements taken during field operations
Parameters: Station location and sample information
Spatial Domain: Continental slope and shelf of the southeastern Bering Sea - 59.1N, 176.1W, 147.9E, 50.7S
Time Domain: 1993 – present (spring - early fall)
Electronic Format: PC Database
Contact: Dr. Art Kendall
Accessibility: Must be approved by contact
Uses: Record cruise activity, calculate at-sea maps, track sample collection, shipping and processing, link to other program databases
Gaps: some annual data gaps

Name: FOCI - Ichthyoplankton Database

Type: NMFS/AFSC Database

Content: Information on fish eggs and larvae and juvenile fishes

Parameters: Station location egg identification, pollock egg stage, larval and juvenile identification and lengths

Spatial Domain: Continental slope and shelf of the southeastern Bering Sea - 59.1N, 176.1W, 147.9E, 50.7S

Time Domain: 1972, 1977-96 various seasonal coverage depending on year

Electronic Format: PC Database

Contact: Dr. Art Kendall, NOAA/NMFS/AFSC, 7600 Sand Point Way NE, Seattle, WA 98115. Ph: 206-526-4108, Fax: 206-526-6723, Email: art.kendall@noaa.gov

Accessibility: Must be approved by contact

Uses: To understand changes in abundance and factors that influence year class variations in important fish and shellfish

Gaps: NA

Name: North Pacific (NORPAC) Foreign Groundfish and Observer Database

Type: NMFS/AFSC Database

Content: Commercial catch and biological parameters of groundfish species collected by observers aboard foreign commercial fishing vessels.

Parameters: Location, catch biomass, species composition, age, length, weight, sex, and species

Spatial Domain: Continental slope and shelf of the southeastern Bering Sea

Time Domain: 1973-90

Electronic Format: ORACLE Database

Contact: Martin Loefflad

Accessibility: Privacy Act constraints prohibit general access. Data sharing agreements can be arranged

Uses: Management of Bering Sea fishery resources.

Gaps: NA

Name: North Pacific (NORPAC) Domestic Groundfish and Observer Database

Type: NMFS/AFSC Database

Content: Commercial catch and biological parameters of groundfish species collected by observers aboard domestic (US) commercial fishing vessels

Parameters: Location, catch biomass, species composition, and biological measurements (age, length, weight, sex, species)

Spatial Domain: Continental slope and shelf of the southeastern Bering Sea

Time Domain: 1986-present

Electronic Format: ORACLE Database

Contact: Martin Loefflad, NOAA/NMFS/AFSC, 7600 Sand Point Way NE, Seattle, WA 98115. Ph:206-526-4195, Fax: 206-526-4066, email: martin.loefflad@noaa.gov

Accessibility: Privacy Act constraints prohibit general access. Data sharing agreements can be arranged

Uses: Management of Bering Sea fishery resources.

Gaps: NA

Name: Bering Sea Food Habits Database

Type: NMFS/AFSC Database

Content: Information on stomach contents of selected commercial Bering Sea species

Parameters: Location, biological information on sample (age, length, weight, sex, species), descriptions of stomach and intestine contents, and length of prey items

Spatial Domain: Continental slope and shelf of the southeastern Bering Sea 64N, 180W, 158E, 54S

Time Domain: 1994-present

Electronic Format: ORACLE Database

Contact: Douglas S. Smith

Accessibility: Must be approved by contact

Uses: Establish predator/prey and food habits baseline

Gaps: NA

Name: Bering Sea Predator-Prey Database

Type: NMFS/AFSC Database

Content: Information on stomach contents of selected commercial Bering Sea species from Japanese studies

Parameters: Location, biological information on sample (age, length, weight, sex, species), descriptions of stomach and intestine contents, and length of prey items

Spatial Domain: Continental slope and shelf of the southeastern Bering Sea 64N, 180W, 158E, 54S

Time Domain: 1970-85

Electronic Format: ORACLE Database

Contact: Douglas S. Smith, NOAA/NMFS/AFSC, 7600 Sand Point Way NE, Seattle, WA 98115. 206-526-4225 (Office) 206-526-6723 (Fax). doug.smith@noaa.gov.

Accessibility: Must be approved by contact

Uses: Determine feeding habits of selected commercial fish species of the Bering Sea

Gaps: NA

Name: Soviet Trawl Survey and Exploratory Fishing Database

Type: NMFS/AFSC Data Files

Content: Trawl survey information on commercial fish species from the Bering Sea

Parameters: Location, CPUE by species, biological information (length and weight, sex, species), and species composition

Spatial Domain: Continental slope and shelf of the southeastern Bering Sea 62N, 180W, 140E, 52S

Time Domain: 1959-77

Electronic Format: Digital File

Contact: Dr. Vidar G. Wespestad, NOAA/NMFS/AFSC, 7600 Sand Point Way NE, Seattle, WA 98115. 206-526-4249 (Office) 206-526-6723, Email: vidar.wespestad@noaa.gov

Accessibility: Not available until edited and placed into an AFSC maintained database

Uses: To extend survey abundance time series back to pre-fishery period; management; stock assessment

Gaps: NA

Name: Japan-US Cooperative Longline Survey of the Aleutian Region and Bering Sea

Type: NMFS/AFSC Database
Content: Longline survey information on commercial fish species from the Bering Sea
Parameters: Catch by species and size composition
Spatial Domain: Continental slope and shelf of the southeastern Bering Sea 60N, 172.3W, 133.0E, 54.3S
Time Domain: 1979-94
Electronic Format: PC Database
Contact: Harold Zenger, NOAA/NMFS/AFSC, 7600 Sand Point Way NE, Seattle, WA 98115. Ph: 206-526-4158, Fax: 206-526-6723, Email: harold.zenger@noaa.gov
Accessibility: Data partially available. Check with contact
Uses: Stock assessment of pacific cod and sablefish populations; monitor changes in abundance and size composition
Gaps: NA

Name: Pribilof Island Ecosystem Data

Type: NMFS/AFSC Data Files
Content: Fisheries and plankton sampling around the Pribilof Islands
Parameters: Bottom, midwater, Methot and anchovy trawl data, tucker, bongo, and MOCNESS tow data. Underwater video from ROV
Spatial Domain: Continental slope and shelf of the southeastern Bering Sea 58N, 172W, 169E, 56S
Time Domain: 1994-97, September
Electronic Format: PC Database
Contact: Dr. Ric Brodeur, NOAA/NMFS/AFSC, 7600 Sand Point Way NE, Seattle, WA 98115. 206-526-4318 (Office) 206-526-6723 (Fax), Email: rbrouder@afsc.noaa.gov
Accessibility: Data accessible. Check with contact
Uses: To examine distribution and ecology of juvenile walleye pollock in relation to hydrographic fronts
Gaps: NA

Inventory of Data and Information Bases: Large Benthos and Fish

- NMFS, Alaska Fisheries Science Center (AFSC) studies 40 species of fish and crab that inhabit the NE Pacific and the Bering Sea.
- AFSC conducts scientific biological surveys annually to assess size and value of commercial fisheries resources.
- Other surveys are conducted for special projects and scientific studies. Often surveys are executed in cooperation with foreign nations.
- Data and information products from these survey activities, which go back to the early 1970’s, are archived into various computer files and databases.

***Large Benthos and Fish, Summary***

| Database Name | Time Domain | Electronic Format |
|---|---|---|
| RACEBASE - Bering Sea Acoustic/Midwater Survey | 1977-present | ORACLE & INGRESS Database |
| RACEBASE - Aleutian Islands Bottom Trawl Survey | 1980-present | ORACLE Database |
| RACEBASE - Bering Sea Bottom Trawl Survey | 1959-present | ORACLE Database |
| Bering Sea Chlorophyll, Nutrients and Zooplankton Database | 1992-present | PC Database |
| FOCI - Discrete Sample Database | 1993-present | PC Database |
| FOCI - Ichthyoplankton Database | 1977-1996 | PC Database |
| North Pacific (NORPAC) Foreign Groundfish and Observer Database | 1973-1990 | ORACLE Database |
| North Pacific (NORPAC) Domestic Groundfish and Observer Database | 1986-present | ORACLE Database |
| Bering Sea Food Habits Database | 1994-present | ORACLE Database |
| Bering Sea Predator-Prey Database | 1970-1985 | ORACLE Database |
| Soviet Trawl Survey and Exploratory Fishing Database | 1959-1977 | Digital File |
| Japan-US Cooperative Longline Survey of the Aleutian Region and Bering Sea | 1979-1994 | PC Database |
| Pribilof Island Ecosystem Data | 1994-1997 | PC Database |

## Marine Mammal Data - Bering Sea Ecosystem

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A number of previous workshops and meetings have been called to address questions regarding research, data availability, and identity of institutional involvement and interaction in research in the Bering Sea Ecosystem (e.g., see Melteff and Rosenberg, 1984; Ito 1984). The following is a presentation of information related to such questions in regard to the marine mammals of this region. The work of Loughlin and Jones (1984) should be consulted for an earlier treatment of these and related issues as well as a more detailed treatment of the quality of data regarding marine mammals. The picture today is not dramatically different.

A variety of transitions in value-related perceptions have led to dramatic changes in the sources, qualities, and intensities of data collection in regard to marine mammals in the Bering Sea since the late 1700s. Marine mammals, such as the sea otter and fur seal were of considerable commercial importance well before the development of commercial fisheries comparable to those seen in this area today. Commercial whaling in the Bering Sea began with Bowhead whaling in the mid-1800s. Currently, marine mammals serve more as indicator species for the ecosystem of the Bering Sea. For example, declining populations serve to raise questions regarding the health of this ecosystem. Implementation of legislation such as the Marine Mammal Protection Act and the Endangered Species Act is the basis for funding significant parts of current research activities.

Data regarding the commercial harvest of marine mammals, especially northern fur seals, extends back to the late 1700s. Increasing reliability, accuracy and sheer volume characterize data collected for marine mammals over the history of pertinent scientific studies. Related to these changes is the impressive innovation and sophistication brought to the field of marine mammal research by technological advances such as satellite tracking devices.

The commercial harvesting of fur seals is now carried out only on a limited basis in the western Pacific. In their time, commercial harvests of whales and seals afforded scientists a variety of research opportunities. Initial studies concentrated on distribution, population dynamics, diets/prey consumption, physiology, and morphometrics, with limited attention to parasites and diseases. Similar sampling continues today, based on samples obtained in subsistence harvests.

It was not until the mid-1900s that scientific studies based on samples from specimens taken independent of harvesting regimes was given much emphasis. The transition from the harvest-based sampling to more general scientific sampling brought with it greater emphasis on studies of behavior, genetics, stock structure, concentrations of pesticides (plus their derivatives) and heavy metals, specific causes of mortality, status, age specific mortality and reproduction, and more detailed data on all aspects of biological/ecological studies initiated in conjunction with commercial harvests.

The volume and quality of data varies from species to species, dependent in large part on funding and correlated until recently with the commercial value of the species involved. In more recent times, the focus of research has been increasingly related to perceived problems, such as the decline in the population of the Steller sea lion, following on the heels of a decline in Northern Fur Seals. Gaps in knowledge tend to involve the non-commercial species and those for which no problems have been noted. Such gaps continue to frustrate progress in studies at the ecosystem level.

There are at least 26 species of marine mammals that occur in the Bering Sea ecosystem either as seasonal visitors or permanent residents. A number of these species have been subjects of scientific studies and are represented by useful data; others are species about which little is known. This pattern is shown in Table 1.

The data sets most directly related to ecosystem-level consideration for marine mammals include those regarding food habits and feeding ecology. Data regarding the numbers and identity of species occurring in the diets of marine mammals count as part of such information and are used to identify the predator-prey relationships that exist in the Bering Sea ecosystem. The species composition of diets (determined from stomach contents, and scat analysis) make up additional sets of data useful in determining estimated consumption rates important in determining estimated transfer rate of biomass, energy, and nutrients among species (especially as competitors) and between trophic levels.

Data, regarding food habits, are complementary to data regarding diseases, parasites and predators. The identity of only a few of the disease and parasite species effecting marine mammals have been established, and those that have been established are pertinent to only a small portion of the marine mammal species in the Bering Sea. Essentially nothing is known of the rates of pathogenic mortality caused among each of the respective marine mammal species by the individual species of diseases and parasites. Similarly, very little is known about the rates at which individual predator species contribute to the causes of death among marine mammals. As a result, little is known concerning the roles of such species (e.g., as natural forms of population regulation among their host/prey species), and their respective trophic levels, in the overall dynamics of the Bering Sea ecosystem. Such dynamics are potentially very important.

Censuses, surveys and field observations are not the only source of information resulting from studies involving marine mammals. Over the years, specimen collection has resulted in the accumulation of teeth, other body parts and stomach contents available for further research. This is exemplified by teeth collected from harvested, three-year-old, male northern fur seals. The microscopic examination of these teeth in the early 1990s has provided information regarding feeding behavior dating back to the late 1940s (Baker, 1991). The potential for information regarding reproductive histories, genetic aspects of stock structure, temporal changes in trophic level, and oceanographic conditions (based on existing technologies) has yet to be realized.

A similar set of samples with the potential for yielding useful information is contained in the tissue bank maintained by the Alaska Marine Mammal Tissue Archival Project, a cooperative effort of the Mineral Management Service, the National Oceanic and Atmospheric Administration and the National Institute of Standards and Technology. Tissues for this collection have been obtained from various organs of seven marine mammal species of the Bering Sea since 1987. The express purpose of this collection is the preservation of options for future analyses regarding levels of a variety of contaminating substances (e.g., pesticide and heavy metal concentrations).

Ecosystem-level studies based, in part, on marine mammal data, have appeared among scientific studies only in the last two or three decades. Initial considerations of such issues focused on identifying links between consumer species and resource species of fish that are of commercial interest. In only a few cases has work progressed to the point of being able to produce data sets of significant relevance to management that pertains to ecosystems. These are exemplified by data on estimated consumption rates by marine mammal species on resource species, especially commercially valuable fish. There are at least two sets of similar data at the ecosystem level (Perez and McAlister, 1993; Sobolevsky and Mathisen, 1996). These consist of estimated consumption rates by individual species of marine mammals. They serve as empirical examples of sustainable rates of consumption from the Bering Sea ecosystem and are the basis of an approach to management currently under development for application at the ecosystem level.

Data for marine mammals of the Bering Sea have been collected and are maintained by a variety of agencies, through international and national cooperative efforts. Those involved include: The Alaska Department of Fish and Game (ADF&G), U.S. Fish and Wildlife Service, International Whaling Commission, Indigenous People's Council for Marine Mammals, Alaska Inuvialuit Beluga Whale Committee, North Slope Borough, Mineral Management Service, the National Oceanic and Atmospheric Administration (including the National Marine Fisheries Service and its National Marine Mammal Laboratory -NMML- in Seattle), the National Institute of Standards and Technology, University of Alaska, University of Washington, Colorado State University, University of Maine, Smithsonian Institution, and a variety of agencies in Russia, Canada, and Japan. The bulk of the data sets are maintained by ADF&G, NMML, the IWC and cooperating international government agencies.

As seen in Table 1, there are numerous gaps in information regarding marine mammals of the Bering Sea. Initially, it is obvious that there are significant gaps concerning the conventional forms of interactions among species (trophic, competitive, consumer/resource, etc.) that are important in ecosystems. Beyond this, however there are even bigger gaps in knowledge. Extensive time frames must be considered in management at the ecosystem level. Such consideration helps focus on gaps in knowledge regarding such things as evolutionary interactions - the collective evolutionary effects of across species in their influence on the others within the system. Here we experience what amounts to the complete lack of a scientific field of study, especially in terms of practical importance in the application of such information.

Proceeding to the realms of management, there are gaps of several kinds. We currently lack the capacity to

1. deal with missing information, especially things that we can never know, or that are too difficult or expensive to develop,
2. deal with complexity, stochasticity, nonlinearity, and various scales of space and time,
3. place priorities on the elements of existing information,
4. define the relative importance of gaps in information (this includes an inability to clearly establish the importance of missing information relative to existing information) and,
5. achieve (even define, or identify) sustainability in harvests, either from single species resources or from an ecosystem.

In summary, the complexion and quantity of both the available data and the research conducted to acquire information about marine mammals in an ecosystem context has been undergoing continuous change. The volume of data continues to grow with increasing sophistication of research tools. Marine mammal research in the Bering Sea involves a great deal of interactive cooperative efforts of a large number of countries, institutions and agencies. Many gaps exist in our data and at least some of the gaps in knowledge are identifiable. Many of these gaps may be critical to a successful approach to management at the ecosystem level. Beyond the gaps in scientific knowledge are gaps in our capacity to manage with the information that we have in a way that accounts for both existing data and its limits.

Selected References

Baker, J.D. 1991. Trends in female northern fur seal, *Callorhinus ursinus* feeding cycles indicated by nursing lines in juvenile male teeth. MS Thesis, University of Washington, Seattle.

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## Status of Seabird Databases for Alaska and the North Pacific

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### Introduction

Seabirds are a well-studied group, not just in the Bering Sea, but in the northeastern Pacific generally and indeed throughout most ocean regions of the world. The reasons for this are clear—seabirds are conspicuous, aesthetically attractive and highly valued by the public, and relatively easy to study on land because of their colonial breeding habits. The impetus for studying seabirds is two fold. On one hand, wildlife managers and the public are concerned about the welfare of particular species and populations that may be affected by human use of coastal lands and marine resources. But equally important—and aside from any value placed on this particular group of animals—is the role that seabirds can serve as indicators of change in the marine environment.

Along the Pacific coast of North America, seabird research and monitoring has consumed substantial amounts of public funding since the early 1970's. The effort stems from various legislative and executive mandates and has been largely uncoordinated among the many entities involved, including state, provincial, and federal agencies, some private organizations, university faculty, and students. In Alaska, the combined investment in seabird research and monitoring by the U.S. Fish and Wildlife Service, Minerals Management Service, USGS Biological Resources Division, and the National Park Service amounts to at least 20 Full Time Equivalent's (FTE) and direct costs exceeding $3 million annually. However, the lack of ready access to the information generated through these efforts, by resource managers and researchers alike, is a continuing problem. Much of the information is never published in the open literature, or publication lags far behind the gathering of data. Comprehensive data management and distribution systems are needed to expeditiously put this information into the hands of those who use it.

### Seabird Databases

To capture and disseminate the core information generated in seabird research and monitoring programs, a suite of four distinct but related databases is indicated. First, a seabird colony catalog, of which several examples exist for the Pacific coast of North America (Sowls et al. 1978, Speich and Wahl 1989), is essential for documenting known seabird colonies in a given region, together with the best available information on species composition and population sizes. It represents the state of knowledge of the distribution and abundance of breeding seabirds. Estimates are of whole colony sizes and inevitably are crude in many instances. Second, a pelagic seabird database, typically with an associated atlas (e.g., Gould et al. 1982, Morgan et al. 1991), includes all at-sea censuses of seabirds, whether from ships, airplanes, land-based seawatches, or small boats working the shoreline. Such a database serves the same general purposes as the colony catalog, except it pertains to the over-water distribution and abundance of seabirds, including the nonbreeding season. Both the colony catalog and pelagic seabird database are essentially descriptive in nature. By contrast, a seabird monitoring database works specifically with observations on seabird population parameters that are replicated over time (Hatch et al. 1994). Generally, only a few of the colonies in a given region are represented, and data usually refer to sample plots rather than whole colonies. Finally, in facilitating access to published and unpublished ("gray") literature, a comprehensive bibliographic database—fully indexed by subject, taxonomic, and geographic keywords—is a valuable tool.

In recent years, substantial progress relative to Pacific seabirds has been achieved on all four fronts. None of these efforts is confined to Alaska or the Bering Sea. They range in scope from the whole of Beringia (Alaska and the Russian Far East) to arctic, temperate, and sub-tropical zones of the Pacific region above 20$^{o}$ north latitude. The Beringian Seabird Colony Catalog provides access to all available information on locations, species compositions, and sizes of seabird colonies in Alaska and the Russian Far East. The Beringian Seabird Bibliographic Database, updating and automating an earlier contribution by Handel et al. (1981), provides access to published and unpublished literature on seabirds of the same region. *A Pelagic Seabird Atlas of the North Pacific* is under development that updates and expands on earlier efforts completed for the California coast (ECI 1993, Piatt and Ford 1994). *The Pacific Seabird Monitoring Database*, an unprecedented effort to collate information on trends in seabird numbers, productivity, survival, and other parameters over the North Pacific, is emerging under the auspices of the Pacific Seabird Group.

Figures 1-3 provide examples of graphical output from each of the three field-oriented databases. The appended summary contains further information on the status, content, and accessibilty of all four databases.

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Appendix

Summary of Seabird Databases Relevant to the Bering Sea

A. Beringian Seabird Colony Catalog

Type: Two file structures (GIS and Relational), linked together

Content: Breeding populations of all seabird species; locations and sizes of breeding colonies (approximately 1,600 in Alaska, 500 in Russia)

Parameters: 39 parameters, 47 species. Each record is one observation on a species at a colony. Parameters include colony name, latitude and longitude, species name, numbers, observers, census methods, data quality, and bibliographic reference.

Geographical Scope: Alaska (entire coast) and Russian Far East (coast from Vladivostok to the Arctic)

Time Frame: 1914 to present; updated annually if data available

Electronic Format: Atlas GIS and Paradox for DOS (packaged programs customized for database)

Who has Control: Division of Migratory Bird Management, U.S. Fish and Wildlife Service, Region 7, Anchorage

Accessibility: All data and products available on request, usually within 2 days.

How it is Accessed: Request submitted to Database Manager. Database managed by Vivian M. Mendenhall and Shawn W. Stephensen, U.S. Fish and Wildlife Service, 1011 E. Tudor Rd., Anchorage, AK 99503; phone 907-786-3517; fax 907-786-3641; email vivian_mendenhall@mail.fws.gov

Current Issues: (1) Colony censuses should be updated approximately every 10 years—many are now older, and priorities for recensus are being analyzed; (2) Full-time database manager is essential—position at present is not permanent; (3) DOS-based programs in need of major rewrite for Windows

Significant Gaps: (a) Nonexistent data—few gaps in Alaska; precise location not known for some Russian colonies; (b) Existing data not in database—no known gaps

Comments: The Beringian Seabird Colony Catalog contains data on all known seabird colonies in Alaska and the Russian Far East. Data have been collected in Alaska since the 1970's, including new surveys and searches of the literature. The Russian data were assembled in 1994-1996 by Alexander and Luba Kondratyev of the Institute of Biological Problems of the North in Magadan. Data include the best estimate of each population (flagged as such) and all historical estimates. Data are suitable for estimates of regional populations (with some exceptions for hard-to-census species), but in most case are not suitable for monitoring of population trends. Maps and reports are now available on request for any species and area in Beringia, or for the entire region. Products are available at present only from the database managers, but publication of a printed atlas and an electronic version are planned.

B. Pelagic Seabird Atlas of the North Pacific

Type: In its full implementation, this system will consist of three relational database files describing (a) sightings, (b) effort, and (c) cell attributes.

Content: Present accounting does not permit a precise estimate of the size of this database, although it is thought to contain at least 40,000 shipboard transect records (10-minute strip census counts) dating from the Alaskan OCSEAP period alone. Work conducted more recently constitutes 10,000 or more additional transects. A large data set also exists on marine bird distribution from aerial surveys conducted during the OCSEAP, and in recent years the Fish and Wildlife Service has put considerable effort into small-boat shoreline surveys for marine birds, particularly in Prince William Sound.

Parameters: Cruise, date, time, observer, latitude-longitude, conditions, species, numbers, and various environmental data.

Geographical Scope: Extensive effort in all areas of the Alaskan continental shelf, plus selected cruises in the North Pacific between Hawaii, Japan, the Pacific west coast, and Alaska.

Time Frame: Includes data collected between 1976 and 1997.

Electronic Format: Text files and DBF files suitable for export to programs for mapping (e.g., Arc-Info, Arcview, CAMRIS) or data analysis (e.g, SAS or SPSS).

Who has Control: USGS-BRD, Alaska Biological Science Center, Anchorage

Accessibility: Limited at present. Some precursors to the comprehensive database under construction are available through NOAA's National Oceanographic Data Center (OCSEAP data) and/or Ecological Consulting, Inc., 2735 NE Weidler St., Portland, OR 97232 (contact R. Glenn Ford).

How it is Accessed: For advice on content, suitability for purpose, accessibility, and plans for the database, direct general inquiries to John Piatt (USGS-BRD), phone (until April 1988) 425-488-6180, email john_piatt@usgs.gov.

Current Issues: Developers currently are re-compiling and proofing original data, developing a standard database format, and integrating recent databases from agency and private sources. Statistical issues still need resolution to provide "best blend" estimates of abundance incorporating all available information (shipboard transects, aerial and shoreline surveys).

Significant Gaps: (a) Nonexistent data—winter months in Alaska (October-March), while not entirely without sampling effort, have not been studied as thoroughly as the summer period (May-August), (b) Existing data not in database—Some investigators with important contributions for the Bering Sea have not consented or provided data for inclusion in a consolidated database.

Comments: The Pelagic Seabird Atlas is a work in progress. Initial (early 1980's) work with the OCSEAP database involved data entry, error-checking, and limited analysis capabilities developed for use on a minicomputer (specifically, a Data General MV8000 housed in the Alaska Regional Office of the U.S. Fish and Wildlife Service). Several years ago, the Pacific Regional Office of the Minerals Management Service contracted a Portland firm, Ecological Consulting, Inc., to develop a PC-based data management and graphics package to handle ship and aerial marine bird survey data for the California coast. In the course of that project, ECI obtained, for comparative purposes, copies of NODC data tapes containing shipboard data from the OCSEAP program. ECI edited and reformatted the data for compatibility with the GIS system they developed called CAMRIS (Computer Aided Mapping and Resource Inventory System). The Alaska Biological Science Center (ABSC) has installed this regenerated database and associated CAMRIS software on a PC and is able to produce from the existing system a variety of graphical products pertinent to resource planning in Alaska. Currently, the main drawbacks of the system are that is does not include all of the available data, it does not provide as much flexibility in managing or analyzing the data as one would like, and it is not particularly user-friendly. The goal is a comprehensive, easy-to-use, PC-based data management and graphical presentation system for all types of existing and future at-sea surveys of marine birds and mammals in the North Pacific. Attainment of that goal involves three steps: (1) addition of available data to the PC-based system, (2) development of an efficient data entry system for PCs, including error-checking features and data management software that allows maximum flexibility for filtering and selecting records, and (3) preparation of appropriate products in hard copy, including a user's guide and database documentation.

C. Pacific Seabird Monitoring Database

Type: Relational database tables with interface to mapping software.

Content: Currently more than 9,600 observations, comprising about 1,700 time series, on population parameters of 72 species.

Parameters: Six main parameter groups (population, productivity, components of productivity, survival, reproductive chronology, and food habits), each with various derivatives, and an "other" category incorporating any study-specific observations submitted by contributors. Associated data includes colony location, year, dates, sampling design, measures of dispersion, contacts, sponsors and observers, documentation, comments, and a data release code.

Geographical Scope: North Pacific above $20^{o}$ N latitude, including Alaska, British Columbia, Washington, Oregon, California, Hawaii, Mexico, Japan, Korea, and Russia.

Time Frame: 1911 (earliest observations) to present.

Electronic Format: The database uses a run-time version of Microsoft Access for data entry, editing, querying, reporting, and exporting, and includes GIS databases for use with ArcView 2.1 to support graphical queries, mapping, and spatial analysis.

Who has Control: Pacific Seabird Group, Stinson Beach, CA

Accessibility: No data yet available for general release, but anticipated in 1998; planned future distribution via CD-ROM and/or the Internet.

How it is Accessed: For further information and updates regarding availability contact Scott Hatch or Charla Sterne, USGS-BRD, Alaska Biological Science Center, 1011 E. Tudor Rd., Anchorage, AK 99503. Phone 907-786-3529 (email scott_hatch@usgs.gov) or 907-786-3580 (email charla_sterne@usgs.gov).

Current Issues: Contributors have the option to specify a data release code for each item of information (observation) in the database. Authorized use of the database is contingent on agreement to abide by ethical guidelines established for such use.

Significant Gaps: (a) Nonexistent data—Alaska and California are the best-studied of the political units represented in the database. No known data of a suitable nature available for China; few data available from Korea or Japan. (b) Existing data not in database—data entry for all regions still in progress; preliminary data inventory for Mexico underway, initial data input for the Russian Far East contracted in 1997.

Comments: The idea that seabirds can serve as indicators of changing marine environments is gaining acceptance worldwide. This database is being developed under the auspices of the Pacific Seabird Group, whose members represent all Pacific nations and seabird interest groups, both public and private. Besides the scientific applications of the Pacific Seabird Monitoring Database—detection and geographic analysis of trends, hypothesis-testing using correlation and concordance techniques, the assessment of means and variability in seabird life table statistics, to mention a few—the database can serve as an important tool for managing and optimizing the field program. Managers will have a complete inventory of past and ongoing effort—which species are being monitored, which parameters, where, and by whom. Updated on an annual basis, that information will support a continuing assessment of program effectiveness—i.e., a means to "monitor the monitoring program" for Pacific seabirds.

D. Beringian Seabird Bibliographic Database

Type: Bibliographic database.

Content: More than 2,800 citations of published and unpublished literature concerning seabirds of Alaska and the Russian Far East.

Parameters: Seabird species (75), subject keywords (62), and geographic areas (12).

Geographical Scope: Alaska and Russian Far East (Beringia).

Time Frame: Comprehensive.

Electronic Format: Interactive, computerized PC database using Pro-Cite version 2.01.

Who has Control: Division of Migratory Bird Management, U.S. Fish and Wildlife Service, Anchorage

Accessibility: Hard copy and diskette.

How it is Accessed: Direct requests to Kent Wohl, USFWS, Migratory Bird Management, 1011 E. Tudor, Anchorage, AK 99503; phone 907-786-3503, email: kent_wohl@mail.fws.gov.

Comments: Following are two examples of citation searches by keyword using the Beringian Seabird Bibliographic Database.

| | | | |
|---|---|---|---|
| Keyword Search: | Seabirds | | |
| Refined Keyword Search: | Distribution | | |
| Refined Keyword Search: | Okhotsk | Number of Matches: | 36 |

Citation

Golubova, E. Yu. and Pleshchenko, S.V. 1993. Seabird numbers and distribution on Umara Island, Sea of Okhotsk. (In Russian). Morskie ptitsy Beringii. (Beringian Seabird Bull.) 1:25-26.

| | | | |
|---|---|---|---|
| Keyword Search: | Seabirds | | |
| Refined Keyword Search: | Distribution | | |
| Refined Keyword Search: | Bering | Number of Matches: | 301 |

Citation

Ainley, D.G. and Sanger, G.A. 1979. Trophic relations of seabirds in the northeastern Pacific Ocean and Bering Sea. Pages 95-122 *In* Bartonek, J.C. and Nettleship, D.N. (eds.), Conservation of marine birds of northern North America: papers from the international symposium held at the Seattle Hyatt House, Seattle, WA, 13-15 May 1975. Wildl. Res. Rep. No. 11. U.S. Fish and Wildl. Serv., Washington, DC.

## Traditional Knowledge Systems in the Arctic

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An Eskimo hunter once saw a polar bear far off across flat ice, where he couldn't stalk it without being seen. But he knew an old technique of mimicking a seal. He lay down in plain sight, conspicuous in his dark parka and pants, then lifted and dropped his head like a seal, scratched the ice, and imitated flippers with his hands. The bear mistook his pursuer for prey. Each time the hunter lifted his head the animal kept still; whenever the hunter "slept" the bear crept closer. When it came near enough, a gunshot pierced the snowy silence. That night, polar bear meat was shared among the villagers.

A traditional hunter plumbs the depths of his intellect - his capacity to manipulate complex knowledge. But he also delves into his animal nature, drawing from intuitions of sense and body and heart; feeling the wind's touch, listening for the tick of moving ice, peering from crannies, hiding himself as if he were the hunted. He moves in a world of eyes, where everything watches - the bear, the seal, the wind, the moon and stars, the drifting ice, the silent waters below. He is beholden to powers long forgotten or ignored in western society.

What is Traditional Knowledge?

An understanding of traditional knowledge and how it differs from non-indigenous knowledge is an important basis for determining how to use it. Knowing what it contains, and how it is acquired and held, are fundamental to being able to make good use of the knowledge and to encourage all parties to be aware of the added value its use will bring.

The words of the Director General of UNESCO (Mayor, 1994) defines traditional knowledge as:
"The indigenous people of the world possess an immense knowledge of their environments, based on centuries of living close to nature. Living in and from the richness and variety of complex ecosystems, they have an understanding of the properties of plants and animals, the functioning of ecosystems and the techniques for using and managing them that is particular and often detailed. In rural communities in developing countries, locally occurring species are relied on for many - sometimes all - foods, medicines, fuel, building materials and other products. Equally, people's knowledge and perceptions of the environment, and their relationships with it, are often important elements of cultural identity."

Most indigenous people have traditional songs, stories, legends, dreams, methods and practices as means of transmitting specific elements of traditional knowledge. Sometimes it is preserved in artifacts handed from father to son, or mother to daughter. In indigenous knowledge systems, there is usually no real separation between secular and sacred knowledge and practice - they are one and the same. In virtually all of these systems, knowledge is transmitted directly from individual to individual.

The following characteristics of indigenous knowledge were defined in a workshop on environmental assessment I attended in Inuvik, Canada in November 1995. These are the words of the Inuit people answering the question:

*What do we mean by traditional knowledge?*

- "It is practical common sense based on teachings and experience passed on from generation to generation.
- It is knowing the country; it covers knowledge of the environment (snow, ice, weather, resources), and the relationship between things.
- It is holistic - it cannot be compartmentalized and cannot be separated from the people who hold it. It is rooted in the spiritual health, culture and language of the people. It is a way of life.

- Traditional knowledge is an authority system. It sets out the rules governing the use of resources - respect; an obligation to share. It is dynamic, cumulative and stable. It is truth.
- Traditional knowledge is a way of life - wisdom is using traditional knowledge in good ways. It is using the heart and the head together. It comes from the spirit in order to survive.
- It gives credibility to the people."

*Comparisons between Indigenous and "Scientific" Knowledge.* The temptation to compare scientific and traditional knowledge comes from collecting traditional knowledge without the contextual elements. For example, Native people have a far richer and more subtle understanding of the characteristics of ice and snow than do non-indigenous people. In fact, some Native classification is available only by virtue of its relationship to human activities and feelings. In South America, some Indian tribes have a classification system for trees that identifies many species that science does not, and appears to miss obvious species that science recognizes. Once again the classifications systems have a different set of assumptions, so are not directly comparable. The species that appear to have been missed by aboriginals, turn up as recognizable in other contexts for Native people. The "extras" from a scientific perspective are identified by Native people either because science missed them, or because ecological variants have equal importance to genetic species from a traditional standpoint. These comparisons sometimes incorrectly lead science practitioners to trivialize traditional understanding.

Whereas scientific practice generally excludes the humanistic perspective, traditional understanding assumes a holistic view including language, culture, practice, spirituality, mythology, customs, and even the social organization of the local communities. Indigenous people rarely have formal written records of their knowledge.

For many indigenous people today, the communication of traditional knowledge is hampered by competition from European-derived cultures that capture the imagination of the young. They are bombarded by technology that teaches then non-indigenous ways, and limits the capacity of elders to pass on traditional knowledge to the young. As the elders die, the full richness of tradition is diminished, because some of it has not been passed on and so is lost. It is important therefore to find ways of preserving this knowledge. One of the most effective ways is to embody it in the decisions about projects that affect the communities. Around the world, there is a sense of urgency to "collect" traditional knowledge because as the elders die, there is a danger that the knowledge will die with them because young people are not always following traditional ways.

Traditional knowledge has value and validity. It provided the basis of much modern medicine; centuries of herbalist knowledge accumulated in the early writings of travelers, clerics, and natural historians.

Too often, traditional knowledge is incorrectly made parallel only to "science." Science is but a small part of non-indigenous knowledge. Similarly, to suggest that indigenous traditional knowledge is only the equivalent of science is to diminish incorrectly the strength and breadth of indigenous traditional knowledge. Thus, the suggestion that traditional knowledge should be characterized as "traditional science" diminishes its breadth and value.

While it is not appropriate to compare scientific and traditional knowledge as equivalents, the use of traditional knowledge in science means that the two knowledge bases will be in contact with each other as practitioners attempt to weave the two together. To assist in understanding the similarities and differences in the characteristics of the two, lets look at these tables. Table 1 examines the styles of knowledge, and Table 2 the characteristics of the two in their use and application.

Table 1 - Comparisons between Traditional and Scientific Knowledge Styles

| **INDIGENOUS KNOWLEDGE** | **SCIENTIFIC KNOWLEDGE** |
|---|---|
| Assumed to be the truth | Assumed to be a best approximation |
| Sacred and secular together | Secular only |
| Teaching through story-telling | Didactic |
| Learning by doing and experiencing | Learning by formal education |
| Oral or visual | Written |
| Integrated:<br>based on a whole system | Analytical:<br>based on subsets of the whole |
| Intuitive | Model or hypothesis-based |
| Holistic | Reductionist |
| Subjective | Objective |
| Experiential | Positivist |

Table 2 **-** Comparisons between Traditional and Scientific Knowledge *in Use*

| **INDIGENOUS KNOWLEDGE** | **SCIENTIFIC KNOWLEDGE** |
|---|---|
| Lengthy acquisition | Rapid Acquisition |
| Long-term wisdom | Short-term prediction |
| Powerful prediction in local areas | Powerful predictability in natural principles |
| Weak in predictive principles in distant areas | Weak in local areas of knowledge |
| Models based on cycles | Linear modeling as first approximation |
| Explanations based on examples, anecdotes, parables | Explanations based on hypothesis, theories and laws |
| Classification<br>◆ a mix of ecological and use<br>◆ non-hierarchical differentiation<br>◆ includes everything natural and supernatural | Classification<br>◆ based on phylogenetic relationships<br>◆ hierarchical differentiation<br>◆ excludes the supernatural |

Women and Traditional Knowledge

Traditional knowledge that is held by women needs special consideration for a number of reasons. Native women, as the primary harvesters of medicinal plants, seed stocks and small game, are keepers of the knowledge about significant spheres of biodiversity in their own right, and as such are the only ones able to identify the environmental indicators of ecological health in those spheres.

Perhaps even more central in importance is the fact that women share with men the responsibility for stewardship of values in their societies. They feel a keen responsibility to future generations for action undertaken today that affect the world in which we all live, for their descendants. It is women, in the main, who transmit to the next generation these values as part of their stewardship role. Their multi-generational perspective needs to be taken into account, especially when we recognize from experience that so many projects have foundered, and led to destructive consequences for nature, because insufficient consideration was given to the later phases.

It is in everyone's interest to involve women in planning, for increasingly women view plans that do not consider their knowledge and values as violence against their ability to ensure the safety and future of their children - their ability to sustain life itself.

The Structure of Local Systems of Native Knowledge

Many Natives hold" tried and true" knowledge handed down to them from previous generations through oral tradition. This "traditional knowledge" is the cornerstone of Native cultural identity and survival as a people. Some aspects of traditional knowledge are common and shared throughout the Arctic. Other aspects are more localized, and specific to certain communities, families and even individuals.

However, Native knowledge is not just traditional. Natives also possess knowledge that does not have its origin in traditional lifestyles, spirituality, philosophy, social relations, customs, cultural values, etc. In other words, Natives have obtained an extensive body of non-traditional knowledge through direct exposure (e.g., cultural interaction and formal schooling in numeracy and literacy) and indirect exposure (e.g., T.V. and other media) to non-Native values, attitudes, ways of thinking, philosophies, institutions, etc. Together, these two sources of knowledge, traditional and non-traditional, articulate to produce a frame of understanding and validation that give meaning to the world around them.

In fact, it can be argued that all Native knowledge, traditional or otherwise, is contemporary for it is given meaning from a frame of reference that is continually being updated and revised. Viewing Native knowledge as "traditional" and static invites denial of the relevance and efficacy of the application of Native knowledge to contemporary issues and problems. In other words, Natives sometimes feel that the use of traditional knowledge to denote all that they know imposes a way of life on them that is shackled to the past and does not allow them to change.

### Ecological and Non-ecological Knowledge

Many Natives possess ecological knowledge that is traditional in nature. They depend extensively on this knowledge for maintaining their relationship with animals and providing food for their families. But they have also gained extensive ecological knowledge from their own experiences with the land and other sources (e.g., formal schooling and contact with biologists). In fact, their experiences often validate, inform and give new meaning and value to traditional knowledge. Thus, Native ecological knowledge is composed of both traditional knowledge and experiential knowledge (i.e., knowledge gained through personal experience).

### Native Systems of Local Knowledge

Local knowledge systems are based on the shared experiences, customs, values, traditions, lifestyles, social interactions, ideological orientations and spiritual beliefs specific to Native communities. These are forever evolving as new knowledge is obtained or generated.

But Native knowledge is more than the sum of its parts. These parts articulate or merge to form unique, dynamic and evolving systems of local knowledge. The richness and complexity of local knowledge systems drive principally from the fact that they incorporate, and are often the resolution of, two very different world views. A researcher cannot separate out any one aspect of component of Native knowledge (e.g., traditional ecological knowledge) to the exclusion of any other without misinterpreting it as Natives see and understand it. This is why Natives want control over how their knowledge is collected, interpreted and used.

### Maintaining Ownership and Control of Traditional Knowledge

Natives own the intellectual property rights to their traditional knowledge, even if much of it has yet to be written down. No one has the right to document or use traditional knowledge without permission. And, when their knowledge is recorded by outsiders, Natives have the right to insist that it not be taken out of context or misrepresented. When traditional knowledge is cited by others, Natives also have the right to insist that the source of this knowledge be properly acknowledged. In other words, Natives have the rights to own and control access to their traditional knowledge.

Natives possess both collective and individual traditional knowledge. Most traditional knowledge is shared among community members. But some traditional knowledge may be specific to an individual.

For example, some elders and resource users will, because of different life experiences, be the only source of certain types of traditional knowledge.

It remains up to the individual to decide whether s/he wishes to share her/his knowledge with outside parties. However, we recognize that there is an urgent need to assume and maintain control over how local and traditional knowledge is collected, interpreted and used by non-local interests. Thus, we are in the process of formally taking responsibility for, and control of, any traditional knowledge studies to be carried out in Native communities. This is not to suggest that biologists and other researchers are not welcomed to participate in traditional knowledge research. Rather, by having this type of research controlled locally, it will ensure that:

1. Community needs and interests will be served first; and
2. The real contributions of local and traditional knowledge to co-management will have the potential to be realized.

Traditional knowledge incorporates knowledge of ecosystem relationships and a code of ethics governing appropriate use of the environment. This code includes rules and conventions promoting desirable ecosystem relations, human-animal interactions and even social relationships, since the latter continue to be established and reaffirmed through hunting and other activities on the land. Traditional knowledge articulates with non-traditional knowledge to form a rich and distinctive understanding of life and the world.

Many Natives view the extraction of their traditional knowledge from its broader cultural context as a form of theft and, understandably, have been reluctant to share the depth and breadth of what they know with outside interests. They also fear that, because many wildlife managers and decision-makers do not understand their culture, customs or values, their traditional knowledge will somehow be used against them (e.g., setting quotas and other hunting regulations). At best, piece-meal extraction of traditional knowledge from its larger cultural context invites misrepresentation and misinterpretation. At worst, it represents a form of misappropriation and cultural exploitation.

<u>Approaches to Accessing Traditional Knowledge</u>

*Alaska Federation of Natives Board Policy Guidelines for Research*

- Advise Native people who are to be affected by the study of the purpose, goals and timeframe of the research, the data gathering techniques, the positive and negative implications and impacts of the research.
- Obtain informed consent of the appropriate governing body.
- Fund the support of a Native Research Committee appointed by the local community to assess and monitor the research project and ensure compliance with the expressed wishes of Native people.
- Protect the sacred knowledge and cultural/intellectual property of Native people.
- Hire and train Native people to assist in the study.
- Use Native languages whenever English is the second language.
- Include Native viewpoints in the final study.
- Acknowledge the contributions of Native resource people.
- Inform the Native Research Committee in a summary and in non-technical language of the major findings of the study.
- Provide copies of the study to the local people.

Traditional Knowledge Issues

In addition to the Guidelines, these issues must be considered when acquiring, using or disseminating traditional knowledge:

- Involve communities from scoping of research design; identify the stakeholders and involve from the ground up.
- Ensure that community concerns are heard and incorporate those concerns into the study products.
- Determine what reporting will go back to the community and what form it will take; establish a community reporting schedule and keep it.
- Processes are key to coming up with solutions. Make your project process-oriented rather than goal-oriented.
- Involve local harvesters as well as elders. Landscapes change, so contemporary harvesters may know more about local conditions, while elders provide comparative information and other data.
- Integrate youth. The connection between youth and elders is an integral part of traditional societies and will yield many dividends.
- Be gender sensitive. Women's traditional activities and knowledge is different from that of men.
- Make data orientation, gathering, analysis and applications locally-centered.
- Make information useable and useful at a local level, then integrate into a larger data set.
- Develop and maintain release forms for individuals and organizations.
- Tie in as many geographical, species interaction, temporal and socio-cultural variables as practical.
- Explicitly recognize the value of traditional knowledge, whether individual or community based.
- Keep the entire gamut of socio-political ties in mind in developing contacts. Tribes, clans, municipalities, corporations, non-profits, state and federal agencies, and specialists.
- Develop Memoranda of Understanding for clarity and trust purposes.
- Develop methods and timelines for taking draft information back to communities for review and feedback, which would be integrated into products/reports for local, regional and wider use.
- Look at models for protocols/guidelines developed by other agencies/organizations and borrow as appropriate.

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**The Bering Sea Ecosystem Initiative – Requirement for a Web-based Data Clearinghouse**

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Introduction

An ecosystem-based assessment of the Bering Sea Region implies the integration of a tremendous amount of data from a wide range of disciplines. A key factor to the success of this effort will be the ability to bring together all of the relevant environmental information from a broad range of federal, state, university, and non-government stakeholders.

The case for the development of multi agency, multi organizational data clearinghouses on the Internet to facilitate creation, management, discovery, and access to large environmental and geographic data sets is now well established. These tele-communication networks of decentralized data servers exist for everything from global to regional scale projects as well as for highly localized organizational units. What they all share is a commitment to minimize duplication of effort in the collection of expensive data and information and a commitment to maximize access to the data for resource managers, stakeholders, scientists, policy makers, and the general public.

What is a Clearinghouse?

There are different ways of defining what we mean when we discuss the concept of a web-based clearinghouse. From a simplistic, institutional perspective a clearinghouse consists of the people and infrastructure which facilitate the discovery of who has what information. Clearinghouses allow individual agencies, organizations, or collections of interested parties, brought together by a geographically or issues defined theme, to band together and promote their data collection and data management activities. Clearinghouses also serve to promote the communication of ideas, issues, meetings, and even discussion groups that are relevant to the goals and objectives of the collective group.

From a more technical view, a clearinghouse is a decentralized telecommunication system of servers located on the Internet which contain field-level descriptions of available data. This descriptive information, known as metadata, are collected in a standard format to facilitate query and consistent presentation across multiple participating sites. A fundamental goal of a Clearinghouse is to provide access to data through metadata. The Clearinghouse functions as a detailed catalog server with support for links to data and browse graphics. Clearinghouse sites may even provide hypertext links within their metadata entries that enable users to directly download the data in one or more formats. Where files are too large to download directly, sites can provide an order form for requesting the information in some other format.

Why Promote a Clearinghouse?

For Federal Agencies, the establishment of Data Clearinghouses is one of the principle goals of the Federal Geographic Data Committee in its vision of the development of the National Spatial Data Infrastructure (NSDI). The FGDC is comprised of 15 Federal Agencies that work in cooperation with organizations from state, local and tribal governments, the academic community, and the private sector. Federal participation in the NSDI Clearinghouse is directed by Executive Order 12906, signed into law in 1994. The NSDI is defined as the technologies, policies, and people necessary to promote the sharing of geospatial data throughout all levels of government, the private and non-profit sectors, and the academic community. The intent of the NSDI is to provide for a consistent, reliable means to share data among all users nationwide which will result in significant savings for data collection, enhanced use of the data, and better decision making. By promoting the availability, quality, and requirements for data through a searchable on-line system a Clearinghouse greatly assists in coordination of data collection and research activities as well as serving as the primary dissemination mechanism.

Although initially intended for federal agencies, participation in the NSDI Clearinghouse has included federal, state, university, and private corporations in the United States and around the world. The role of the FGDC in the Clearinghouse has been to develop prototype software, define a set of metadata standards, provide references for implementation, facilitate discussions, develop training materials, and maintain a registry of servers that conform to the FGDC standards. These standards have been almost universally adopted and therefore provide institutions a strong incentive for participation. It makes their data more accessible, but just as importantly, allows them to participate in collective data base development efforts. The clearinghouse rules that apply for spatial data also apply to non-spatial data users as well. The bottom line is that the Clearinghouse concept provides to everyone that participates the opportunity to leverage their budgets with those of the other organizations that have also bought into the shared data concept.

Requirements for Being a Clearinghouse Provider and User

Institutional requirements are, as stated earlier, a commitment to sharing in the collection, management, and distribution of information as part of a larger network of organizations.

Technical requirements are that server implementors must have access to multi-user computers (UNIX or Windows-NT) upon which server software, interfaces, and metadata collections are stored. The NSDI (FGDC) Clearinghouse activity utilizes a search and retrieve protocol known as ANSI Z39.50 to provide interoperability among all of the different servers. The Z39.50 protocol includes client and server software that establish a connection, pass a formatted query, return query results, and present identified documents to the client in one of several formats.

The server site must also adhere to specific sets of attributes, operators, and rules of implementation, including the FGDC defined profile for metadata. As a side note, the Z39.50 protocol was initially developed by the library community to discover bibliographic records using a standard set of attributes.

On the user side, any computer with readily available web technology (Internet browser) is able to discover and access data within the Clearinghouse network. Upon accessing the clearinghouse the client is presented with a number of choices in terms of tools for performing their search. Clearinghouses typically have very user friendly front doors that assist the user by providing background information on the site as well as rules on how to begin the process of searching for available information.

Examples of Clearinghouse Sites

The NSDI Geospatial Data Clearinghouse can be thought of as Athe clearinghouse of clearinghouses@ for the U.S. The FGDC metadata standards and software protocols serve to bind all of the participating sites into a collection of data holdings that can make it virtually transparent to the users exactly where the data resides. Once a search is initiated, the servers of all of the participating sites can be accessed.

There are currently over 50 servers, primarily in North America, registered with the NSDI Clearinghouse. This accounts for all participating Federal Agencies, a number of state clearinghouses, as well as numerous regional clearinghouses organized around ecosystem and sustainable development initiatives. These state and regional clearinghouses are in most cases themselves a decentralized network of servers linked together for the common purposes of data collection and data access. The entire collection of servers and sites represents a highly distributed, yet well organized set of participating nodes. The NSDI concept is gaining rapid acceptance as an international goal with discussion currently going on regarding the establishment of a Global Spatial Data Infrastructure.

One international project, relevant to Alaska and the Bering Sea, that has capitalized on the NSDI success is the Arctic Environmental Data Directory, or AEDD. The AEDD was formed in 1988 through the U.S. Interagency Arctic Research and Policy Committee and the Interagency Working Group on Data

Management for Global Change to guide the development of an environmental data directory for the arctic. The goals of the AEDD have been to identify and describe key Arctic data sets from government agencies and academia. These descriptions of arctic data sets include global change studies, environmental interactions, earth sciences, social sciences, and policy and management. The AEDD, maintained by the U.S. Geological Survey, is the U.S. representative node to a network of data clearinghouse nodes, known as the Arctic Data Directory (ADD), maintained by the eight other arctic countries as well as 6 member organizations which have major research programs in the arctic and antarctic regions. This past October the ADD membership adopted the FGDC metadata standards and software protocols as the standard for the international arctic clearinghouse.

In the State of Alaska, Federal, state, local government agencies and non-government organizations have organized themselves as the Alaska Geographic Data Committee (AGDC), a recognized node of the FGDC. The AGDC has established its own Alaska Geospatial Data Clearinghouse, linking together the Alaska data holders into a recognized local entry point into the FGDC's NSDI. Within the AGDC Clearinghouse, in addition to the data holdings of the participating members, there currently reside two multi agency regional clearinghouse type data sets collected in support of regional studies. The data collection most relevant to the Bering Sea Initiative is that assembled for Prince William Sound Ecosystem initiative by the USGS in cooperation with a large number of stakeholders from the Exxon Valdez Oil Spill. The Prince William Sound data collection is grouped with the Copper River and Glacier Bay collections to form an organized regional clearinghouse that contains over 300 data sets with searchable metadata that are in many cases, downloadable.

A few examples of other Clearinghouses worth noting that have been established in support of multi nation, multi state, and multi organizational initiatives include: (1) the Greater Yellowstone Ecosystem Area Data Clearinghouse whose goal is to provide access to digital data for use by Greater Yellowstone managers, stakeholders, scientists, and the public; (2) the Caribbean Environment Programme which involves the 33 states and territories with a common goal of protection of the marine and coastal environment through the promotion of balanced and sustainable economic development; and (3) the Mojave Desert Ecosystem Initiative Clearinghouse which integrates a broad range of geospatial and environmental data in support of ecosystem assessment involving a wide range of stakeholders.

In addition to these examples of clearinghouses developed in support of international and regional initiatives, there are examples clearinghouses relevant to the Bering Sea that deal with information gathered more in support of missions or data themes that transcend geographic boundaries. There are a series of NSDI participant clearinghouse nodes belonging to the National Oceanic and Atmospheric Administration (NOAA) that include their National Marine Fisheries Service node and National Climate Data Center node as examples. The Biological Resources Division of USGS has initiated an National Biological Information Infrastructure (NBII) clearinghouse which is designed to help locate, evaluate, and access biological data and information from a distributed network of servers of cooperating sources.

<u>Summary</u>

In the evolution of an activity as large as the Bering Sea Ecosystem Initiative, there is going to be definite requirement for communication and coordination of data gathering and data management activities. By establishing a Clearinghouse the collective data holdings as well as future requirements for all participants can be indexed and managed. The Clearinghouse provides a tool for not only identifying where we've been and what we've got, but can also serve to identify the data gaps in terms of where we need to go in the future. Clearinghouses have been successfully established in support of similar initiatives from global to regional and to local scales.

The success of the Bering Sea Clearinghouse can be greatly enhanced by a commitment of all participants from the beginning to the vision of an open, distributed network of servers, brought together by adherence to a set of standards and protocols for describing and serving the information. The lesson to be learned from the others is that laying the foundation at the front end for this vision will greatly enhance its success at meeting the needs of all of those who will be dependent upon it later on.

**The Bering Sea Ecosystem Biophysical Metadatabase:**
**A Word Wide Web-based Tool for**
**Discovering, Collecting, Integrating, and Disseminating**
**Biological and Physical Information Related to the Bering Sea Ecosystem**

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## Background

The Bering Sea has been the subject of intense study. Data are available from at least the last century, and in the last two decades the Bering Sea has received close scrutiny by such major research programs as the Outer Continental Shelf Environmental Assessment Program (OCSEAP) and Processes and Resources of the Bering Sea Shelf (PROBES). More recently the Bering Sea's economic and biological significance has provided impetus for the proliferation of a number of developing and active, regional (PICES/GLOBEC CCCC, Bering Sea Impacts Study, Bering Sea Ecosystem Project), national (Bering Sea FOCI, Southeast Bering Sea Carrying Capacity, Bering Sea Ecosystem Study), and international (PICES/GLOBEC, Japanese and Russian programs) research efforts aimed at understanding dynamics of the Bering Sea ecosystem.

Data from the Bering Sea ecosystem have been collected by a broad range of national, federal, state, university and non-governmental research programs and organizations originating mainly from North America. There has also been substantial research activity on the western side of the Bering Sea by countries such as Russia, Korea, and Japan. Despite the large amount of time and effort spent studying this important ecosystem, there is no easy way to know what kind of data have been collected, which institutions have what research data holdings, who to contact to get data, and how to acquire data. The root of this problem stems mainly from the fact that the data reside in the custody of various investigators or their institutions and not in a central repository or centralized location that catalogs and references the information.

The Bering Sea provides about 40% of the entire U.S. seafood harvest. Our ability to manage these resources, and those of other U.S. fisheries, depends critically on knowledge of how ecosystems function. Scientists that undertake inter and multi-disciplinary investigations, such as those required of ecosystem level research, must have access to information and data sets that are more complex than those needed by studies that focus on one or two disciplinary areas of study. Data sets suitable for ecosystem research must include information on all important biological and physical components of the ecosystem and relate these often disparate pieces of information by linking them to some attribute such as common space and time scales. In addition, there must be a mechanism to examine the information in an integrated holistic way.

Centralized access of the metadatabase to investigators with many different skills and interests and from many different institutions or agencies, is critical to the study of ecosystem processes. It is essential that policies and procedures for uniform data management and rapid exchange be utilized they will foster linkages between studies on different time and space scales. Also a free flow of information to all investigators is vital in planning experiments, data analyses, and modeling efforts, and in putting together the broad picture of the relationship between and among the various biological, physical, and chemical data which have been collected.

The historical data sets available for the activities described above are somewhat problematic for several reasons. Typically the scientific objectives behind their collection were not intended to address the specific issues that are the focus of current research programs. Most of the historical data on the eastern Bering Sea is not widely available to academic or government scientists, and few of the data sets have been cross-indexed and examined in a multi-disciplinary, hypothesis-testing mode. Some of the data sets arising from these early studies are well known because of the many publications resulting from them. Others have not been summarized in the open literature and are not generally known by the scientific community. They exist in various degrees of processing and public availability. Much of the available data, such as those on animal distributions and abundance and regional hydrography, are in forms that are difficult to use. Other data sets are incomplete and/or are in forms that are not easily obtained or analyzed. Data from the western Bering Sea, collected by Russia, Japan and Korea, are basically inaccessible to North American scientists, especially historic data.

What is needed, and what the U.S. National Oceanic and Atmospheric Administration (NOAA) Environmental Services Data Information Management Program (ESDIM) funded beginning in 1996, was a three year, $218,000 project to assemble a biophysical metadatabase on the Bering Sea ecosystem. The goal of this project is to facilitate research, education, and general knowledge of the Bering Sea by locating and assembling an inventory of the biological and physical data that have been collected on the Bering Sea ecosystem. The project has identified many different types of physical and biological data that have been collected. For example, single-point and gridded time series, repetitive observations from earth orbiting satellites, ocean surveys of physical and biological oceanographic significance, specimen collections, and historical records of animal population changes have been assembled.

The Bering Sea Ecosystem Biophysical Metadatabase project will address a serious deficiency, identified in 1996 by the National Research Council[1]. In their report on the Bering Sea ecosystem, the council concluded that a directory of data and information sources relevant to the Bering Sea, catalogued in one place, was critically needed. Furthermore, they flagged the lack of such a database as the one major impediment to studying the Bering Sea. What NOAA funded, through this project, is a single, stand-alone resource that will reference as much historical data as can be located.

The project is managed by Fisheries-Oceanography Coordinated Investigations (FOCI) through the Alaska Fisheries Science Center (AFSC) and Pacific Marine Environmental laboratory (PMEL). Dr. Bernard Megrey and Mr. Allen Macklin serve as the project=s co-leaders. The objective of this project is to facilitate and enhance the ability of researchers, managers, policy makers, students, fishermen, and the general public investigate and understand the complex ecosystem of the Bering Sea. The objective is realized through locating and assembling an inventory of the extensive biological and physical data collected on the Bering Sea ecosystem, developing these into an indexed annotated catalog (metadatabase), and making the metadatabase available through various mechanisms, including the World Wide Web (www). Existing information as well as recently gathered data are examined. The metadatabase is made available to users in on-line formats. The on-line form of the metadatabase provides instantaneous access to the collected information and is implemented from the www in a homepage format. This approach provides users a real-time direct link back to the metadatabase for querying and viewing data online.

For those who may be unfamiliar with the term, metadata are brief summaries and references that document the actual scientific data. For example, if the data were vertical profiles of ocean properties

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[1] Committee on the Bering Sea Ecosystem. 1996. The Bering Sea Ecosystem. National Research Council, National Academy Press, 324p.

obtained from CTD casts, the metadata would describe the locations and times of the casts, the inclusive depths, the variables measured, the location of the data, and the name of the person to contact to request access to the data. The data themselves are not part of the metadatabase and continue to reside with their owner. If the owner chooses, a direct link to their data can be provided. Metadata are described in a common set of terminology and definitions using the recently established Federal Geographic Data Committee (FGDC) Content Standards for Digital Geospatial Data, June 1994.

Compilation of a biophysical metadatabase of the varied and disparate historical data sets (hydrography to apex predator abundances) in the Bering Sea will offer several benefits to any project studying the Bering Sea ecosystem. The metadatabase will be useful to individuals undertaking field work or designing field sampling programs, designing process studies, validating simulation models, or collecting data for retrospective analyses. The metadatabase will facilitate past, present and future comparisons of biological processes and their coupling to the physical and biological structure and variability of the environment. Decadal data sets of biotic and abiotic variables will allow the question of climate scale variability to be addressed. Moreover, it will allow individuals to monitor changes and provide baselines for formulating and testing hypotheses that will advance understanding of the interactive processes that regulate ecosystem production. We anticipant that the products of this project will become more valuable as time passes. Finally, the metadatabase will allow individuals to perform regional comparisons, better define regional differences in forcing and response within the Bering Sea, and the extent to which long-term changes are regionally focused, or coherent, throughout the Bering Sea.

The metadatabase will, by design, be spatially referenced. Providing a tool and process to identify sources of spatial data should forge stronger ties with academic and industry partners and foster public-private partnerships. Previously unavailable or obscure data will be identified and the existence of this information will be made available to a broad spectrum of users.

Including the western Bering Sea in our definition of the Bering Sea ecosystem strengthens the international nature of the project as well as providing a strong justification for establishing formal links with GLOBEC component of the North Pacific Marine Science Organization (PICES). The goals of this project are directly related to those of PICES/GLOBEC Climate Change and Carrying Capacity (CCCC) program with respect to the effects of climate change on marine ecosystems. Because of this cross-program linkage we are making every effort to coordinate to the maximum extent possible with PICES/GLOBEC CCCC data collection, distribution, and archiving protocols as well as data management plans, and plans for inventorying relevant data holdings. For example, recently the PICES Technical Committee on Data Exchange (TCODE committee) endorsed the use of the Bering Sea Ecosystem Metadatabase as a vehicle for maintaining their inventory of time series data APICES Inventory of Long Term Series Relevant to the North Pacific≅. Extending these linkages to other agencies and institutions should be fairly straighforward.

Technical Details

Digital distribution of the metadatabase from this project are accessible through the Word Wide Web from two sources -- a dedicated Windows NT Server providing direct access to the metadatabase <http://www.pmel.noaa.gov/bering/mdb/> and through FGDC compliant metadata records supplied to one of the NOAA Data Servers affiliated with the NOAA Server Project <http://www.esdim.noaa.gov/NOAAServer/> The on-line form of the metadatabase provides instantaneous access to the collected information by providing a direct real-time link via a www homepage format back to the metadatabase for querying and viewing data online. The www distribution format allows a unique capability. If the metadata record references actual on-line data then a live hyperlink is provided to the appropriate URL allowing the researcher to immediately move from the metadata reference to the actual data set of interest.

From the Windows NT Server, metadata are stored in a Microsoft ACCESS 97 database, an Open Database Connectivity (ODBC 32-bit, Version 2.5) compliant database. The ACCESS metadatabase resides on a dual 200MHz processor server running Windows NT Workstation Version 4.0, and Microsoft=s Personal Web Server Version 4.0. A menu system helps users perform their search. Results of queries and report requests are dynamically generated at the time a query or report request is issued by the user, so that the results presented to the user reflect the current status of the metadatabase. The metadatabase is accessible from any desktop computer connected to the Internet using a browser such as Internet Explorer or Netscape. Results are presented to the user in familiar web-page (HTML) format. Live hyperlinks are provided directly within metadata descriptions so that users can move directly to the data location or email a data contact with a data request immediately after finding a data item of interest.

The Windows NT Server is also configured as an anonymous FTP site, from which metadata may be indexed by a NOAA Server on a periodic basis. Once in the NOAA Server system the information is completely accessible through standard Z39.50 protocols. The NOAA Server Project is part of the NSDI Data Clearinghouse proposed by the FGDC and is NOAA=s response to Executive Order 12906. Currently, eleven NOAA data and information servers are integrated across the Internet through the NOAA Server project. This system uses the federally-mandated standards (e.g. the FGDC Metadata Standard) to achieve a standards-compliant system, developed a distributed WAIS-based metadata search capability across the participating servers that is extensible to servers throughout NOAA, and includes four mirror sites for the NOAA Server search engine which have been established to provide fault tolerance and load sharing for the system.

<u>Project Status</u>

Presently, the project is completing an outreach phase focused on identifying those researchers and institutions with data holdings that pertain to the Bering Sea ecosystem. Generally, data from the eastern Bering Sea is better known, so the project is focusing on cooperation with Asian scientists and their institutions to discover lesser-known data. Toward that end, the North Pacific Marine Science Organization (PICES) has been an important and willing partner. In 1997, the project designed and mailed via surface and electronic mail over 3,000 metadata entry forms. A poster and color tri-fold brochure were designed to help describe and promote the project. Oral presentations were made to each of the PICES committees during the sixth annual meeting in Pusan, South Korea, during October 1997. Also, a close working relationship with the PICES Technical Committee on Data Exchange (TCODE) was established. As a result of these activities, important contacts have been established and information on the whereabouts and accessibility of data have been obtained.

Besides its outreach through PICES, the project has also published its call for data in over twenty scientific newsletters worldwide, and made an appeal for data references to the subscribers of news from the North Pacific Fishery Management Council and the Fisheries-Oceanography Coordinated Investigations communities. A home page was constructed for the project. From the home page a user can find out more about the project, supply metadata records via on-line web-based forms, and view and query current metadata records from the metadatabase.

You can participate and contribute to this project by 1) identifying sources of physical and biological data on both the eastern and western parts of the Bering Sea ecosystem you are familiar with, 2) submitting a form describing your data, 3) remaining available to answer questions we may have about your meta-data, and 4) submitting updates as new data become available. We seek data and information products related to the Bering Sea ecosystem that span all biological and physical scientific disciplines, including historical as well as current information, and data on all Bering Sea ecosystem components, ranging from open ocean to intertidal areas. Types of information that are of interest include but are not limited to CTD; XBT or other water property and water chemistry information sources; ocean currents and velocities; bathymetry; all satellite images, including maps of atmospheric circulation, ocean color, ocean SST, or ocean chlorophyll concentrations; abundance and distribution of all biological organisms from all trophic levels of the ecosystem, from microbacteria and small benthic organisms to whales; sea bird data; sea ice physics; geological information; bottom composition; sources and levels of anthropogenic contamination; information on atmospheric circulation; properties of the atmosphere and ocean-atmosphere interface; and harvest of exploited marine populations.

Benefits from this project accrue both immediately and with time. Although the call for data only was published in the middle of the summer of 1997, response has been good. By fall there were already appreciable returns of forms and an obvious excitement for the project. Nearly 70 forms from five countries have provided references to data representing all facets of the ecosystem. A summary of the project can be found in Megrey and Macklin (1998).

Compiled metadata have been processed and made available through the project's home page and through the NOAA DataServer. The historical metadatabase should be completed by the end of 1999. Updates on project status will appear regularly on the metadatabase home page on the www at http://www.pmel.noaa.gov/bering/mdb/.

Those seeking more information or having knowledge of data that would enhance the metadatabase are urged to register through the www at URL <http://www.pmel.noaa.gov/bering/mdb/>, or contact one of the authors.

Summary

Placing the Bering Sea Ecosystem Biophysical Metadatabase on the www allows broad access to information and data on the Bering Sea ecosystem which will facilitate an integrated approach to ecosystem management and ecosystem investigations. Providing a means to identify the existence of data could remove the need to collect new data or reduce the expenses associated with collecting new data. Access to these data through the www will provide a valuable service to the partners and stakeholders described earlier.

The metadatabase can easily be modified to include information on the Bering Sea ecosystem that goes beyond physical and biological data. For example, socioeconomic or traditional knowledge could be added to expand the scope of the information contained in the metadatabase. Also information useful to cross-agency cruise planning and coordination could also be added.

Literature Cited

Megrey, B.A. and S. A. Macklin. 1998. Bering Sea Ecosystem Biophysical Metadatabase: A Research Collaborative Tool for Fisheries-Oceanography and Ecosystem Investigations. PICES Press 6(1): 37-40.

## DATA GAPS AND FUTURE RESEARCH NEEDS

One of the goals of the workshop was to identify data gaps and needs for future research. Although presenters in the data base section of the program outlined available data sources for the various data categories; it was not always evident what the major data gaps were. In order to better highlight the data gaps and research needs, the rapporteurs (Pat Livingston and Joe Sullivan) asked individuals from various agencies and institutions with expertise in particular species, species groups, or physical data to complete data gap tables (Tables 1-5) and provide their assessment of the most pressing research issues for that data type. Below are the tables and commentary provided by these individuals.

Physical Data (contributor: Jim Schumacher - NOAA/PMEL) – Table 1

Significant gaps in our knowledge/observations with regard to physical data are presented as important questions for which we presently lack sufficient data to answer.

- What happens between October and April? The lack of year-round observations is a major gap in addressing vital questions related to nutrient renewal processes.
- What are the dominant biophysical processes? Most of the water property data were collected as discrete samples, whereas time series are required to examine processes. For example, the extended mixing event in May 1997 was not manifested in the discrete sample monitoring data sets.
- How does the entire shelf function as a biophysical system? Although there are numerous temperature and to a lesser extent, salinity data sets, seldom was the coverage adequate to examine more than a subset of the shelf. For example, our knowledge of biophysical processes along the Alaskan Peninsula or in the Aleutian Islands is weak compared to that around the Pribilof Islands. The Gulf of Anadyr is another region where much fewer observations exist, particularly moored time series.

Table 1 - Physical observations of the Bering Sea/Aleutian Islands Ecosystem identified by types of data (X = some data exist, x = minimal data exist, blank = very little or no data of use).

| Data Type | Availability |
|---|---|
| Atmospheric | |
| sea level pressure | X |
| winds | X |
| solar radiation | |
| Sea Ice | |
| areal coverage | X |
| Thickness | |
| salt content | |
| Oceanic | |
| temperature | |
| XBT | X |
| CTD | X |
| moored time series | x |
| satellite image SST | x |
| salinity | |
| CTD | X |
| moored time series | x |

| Data Type | Availability |
|---|---|
| Oceanic | |
| sea level | |
| bottom pressure | x |
| tide gauge | x |
| satellite altimetry | X |
| nutrients | |
| discrete samples | X |
| moored time series | |
| chlorophyll/fluorescence | |
| discrete samples | x |
| time series | |
| satellite imagery | |
| currents | |
| Lagrangian drifters | x |
| moored current meters | X |

Lower Trophic Level Groups (contributors: Steve Jewett (Univ. AK), Alan Springer (Univ. AK), Jeff Napp, Bruce Wing (NMFS)) – Table 2

Phytoplankton and zooplankton - We require better understanding of spatial distribution of primary and secondary production and the causes and magnitudes of interannual and interdecadal variability in production. It is also important to gain more information on the variability in the timing of production and its effect on higher trophic levels and the importance of mesoscale processes to primary and secondary production and biomass yield at higher trophic levels. The recent unusual bloom of coccolithophorid phytoplankton in the summer of 1997 highlights the importance of understanding the effect of floral community structure on zooplankton community and production.

Our understanding of the general seasonal patterns of the abundance and distribution for mesozooplankton (i.e. those organisms easily caught with small plankton nets) is probably adequately covered for this geographic region as a result of many international programs that sample zooplankton. However, large data gaps exist for the distribution and abundance of microplankton (2 - 200 micron) and micronekton (> 20 mm). The former is easy to sample; the latter is very difficult due to gear avoidance. Present estimates of standing stock of micronekton (particularly the euphausiids) should be used with caution. Both micronekton and microplankton are important components of the system that transfers carbon and nitrogen from primary producers to apex predators.

The least understood or undersampled research area is vital rates, including secondary production. This is true for all components of the pelagic ecosystem from microplankton to micronekton. In particular, interannual and decadal scale variability of these vital rates and secondary production is poorly known. To accomplish this would first require a focused effort to determine the major pathways of carbon cycling during all seasons, not just spring. Once the major pathways were identified and methodologies refined, we would need a monitoring program to determine annual rates as relevant physical forcing functions (e.g. temperature, ice cover, wind energy) vary on their natural time scales.

Benthos - Most of the information available on the biology/ecology of the groups comprising the benthos (particularly groups 11 through 17 of the lower trophic level data gap table) comes from the work that was done for the OCSEAP studies in the mid-1970's. Most of that information relates to distribution and abundance and very little biology or ecology was done. We know that the benthic environment is dynamic and responds to a variety of changing factors, e.g., fishing, predation, climate. Priorities for filling the data gaps for these groups would be to perform some regular assessment surveys, perhaps on the order of a 2-3 year cycle. Continuation of contaminant -related monitoring and trawl impact studies on the benthos would be very worthwhile.

Other benthos (groups 18-20: sponges, corals, tunicates) - Information on these three groups is very limited and dated. Much of our information comes from the early U.S. Fisheries Steamer "Albatross" collections or earlier. Within these groups it is exceptional to find published quanitative data on abundance or distribution later than the 1930s except for some Russian publications and McLaughlin's survey of the eastern Bering Sea (McLaughlin, 1963, SSRF-401). Taxonomically these are very difficult groups and presently there are no specialists actively working on North Pacific Ocean Porifera or Tunicate collections or their ecology and only one researcher working on corals. Highest research priority should be given to taxonomy, followed by distribution and abundance surveys. Without a firm taxonomic base we can not address the other subject areas quantitatively or in many cases qualitatively. Because these groups are primarily restricted to hard bottoms and not quantitatively sampled by trawls it may be necessary to conduct surveys by submarines and remotely operated vehicles.

Table 2 - Lower trophic level organisms of the Bering Sea/Aleutian Islands Ecosystem with corresponding types of data (X = some data exist, x = minimal data exist, blank = very little or no data of use).

Species Number*

| Data Type | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Abundance | X | X | x | x | X | X | X | X | X | X | X | X | X | X | X | x | x | x | x | x |
| Distribution | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | x | x | x | x | x |
| Status | | | | | | | | | | | x | x | x | x | x | x | x | | | |
| Reproduction | | x | x | x | x | x | x | x | x | x | X | | | | x | x | | x | | |
| Mortality/ survival | x | x | x | x | x | x | x | x | x | x | | | | | | | | | | |
| Diseases, parasites, predators | | x | X | X | X | X | X | X | X | X | X | | | x | x | x | | x | | x |
| Feeding ecology | | X | x | x | x | x | X | x | x | X | x | x | x | X | x | | x | x | x | x |
| Population structure | x | X | | | | | | | | | | | | | x | | | | | |
| Morphometrics/ growth | X | x | | x | | x | | x | X | | | | | x | | | | | | |
| Behavior | | X | x | | x | | | | x | x | | | | | | | | | | |
| Genetics | | | | | | | | | | | | | | | | | | | | |
| Contaminants | | x | X | X | X | | | | | | | | | | | | | | | |

*1. Phytoplankton, 2. Copepods, 3. Euphausiids, 4. Amphipods, 5. Chaetognaths, 6. Pteropods, 7. Cumaceans, 8. Mysid, 9. Cnidarians (part. Jellyfish), 10. Larvaceans, 11. Polychaetes , 12.Other worms, 13. Snails, 14. Echinoderms, 15. Bivalves, 16. Bryozoans, 17. Shrimp, 18. Porifera, 19. Corals, 20. Tunicates.

Invertebrates: (Contributor: Gordon Kruse with Alaska Department of Fish and Game) - Table 3

A data gap chart focusing on 10 shellfish species with commercial fisheries is shown on the next page. ADF&G manages all 10 species and collects data on them through onboard observers, dockside sampling, surveys (Norton Sound and Aleutians only), and special at-sea projects mostly in Bristol Bay in the Bering Sea. NMFS also collects very important annual survey and other biological data on the crab species in the Bering Sea. Eight species of king *(Paralithodes, Lithodes)* and Tanner crabs *(Chionoecetes)* are managed under the auspices of a federal crab fishery management plan, and weathervane scallops are managed under a federal scallop fishery management plan. These federal management plans outline the arrangement for cooperative federal-state management of these shellfish resources. Most management activities are delegated to the State of Alaska, and state fishery management plans and fishing regulations describe the detailed management strategies.

Shellfish fisheries in the Bering Sea and Aleutian Islands area are very valuable but extremely volatile. Stock histories are typified by a few strong year classes that lead to lucrative fisheries by overcapitalized fleets, followed by long periods of poor year classes, stock collapse, severely limited catches or fishery closures, and tight bycatch controls on other non-directed fisheries. This scenario has been repeated sequentially with many stocks and fisheries. The value of these fisheries and costs associated with fishery collapse prompt much-needed research to better understand stock fluctuations for improved management. Limited funds and the cost of conducting field research in the Bering Sea have limited our knowledge of these stocks.

Most research on these shellfish species has been conducted by scientists with the National Marine Fisheries Service (NMFS), Alaska Department of Fish and Game (ADF&G), University of Alaska Fairbanks, and University of Washington. Much of our knowledge about these species is derived from data collected during stock assessment surveys. NMFS conducts annual stock assessment surveys on red king, blue king, Tanner, snow, and hair crabs in the eastern Bering Sea. ADF&G conducts periodic assessments of red king crabs in Norton Sound, blue king crabs off St. Matthew Islands, and golden king crabs in the western Aleutian Islands. No surveys of scarlet king crab, grooved Tanner crab, triangle Tanner crab, and weathervane scallops are conducted in the Bering Sea and Aleutian Islands area. However, good fishery-dependent data on catch rates, size composition and other features are collected by observers aboard vessels that process catches of these species at sea.

The level of knowledge about the distribution, biology, life history, population dynamics of most scallop species in Alaska is very poor. For weathervane scallops, limited information about biology and life history is available, and information about distribution is relatively good for adults but poor for other life stages. Knowledge of weathervane scallops in the Bering Sea and Aleutian Islands is limited to observer data collected aboard commercial fishing vessels. Highest priority research needs are: (1) scallop biology and life history including spawning timing, ocean conditions favorable to early life survival, specific habitat features that determine scallop bed locations, and predators, (2) estimation of recruitment, mortality, and growth rates, (3) stock assessments, (4) population dynamics, (5) estimation of biological reference points as harvest controls, and (6) effects of dredge gear on scallop stocks, other invertebrate and fish species, and benthic habitats.

Crab research needs have been identified from a questionnaire of shellfish professionals (Murphy et al. 1994), advice from crab scientists who attended an international crab symposium (Paul 1996), and annual interagency crab research meetings (Kruse 1996). Recurrent themes for needed research include stock structure, population estimation, stock productivity, and alternative harvest strategies.

Concerning stock structure, several relationships need clarification: those between Tanner crabs in Bristol Bay and off the Pribilof Islands, and those between snow crabs in the northern Bering Sea and those on the fishing grounds to the south. Regarding population estimation, considerable uncertainty exists about trawl survey catchability, and new technologies are needed to more accurately assess these invertebrate species and their bottom habitat requirements. For stocks lacking assessments, research is needed on population estimation methods using onboard observer data.

Many aspects of stock productivity are very poorly understood for most species. Good estimates of mortality rates are lacking. Predation mortality on larval and juvenile stages is particularly poorly known, and aspects of "unobserved" fishing-induced mortality require further study. Growth is well studied for red king crabs, but better growth data are needed for nearly all other species. Lack of a tag that is retained through molting has thwarted growth studies of *Chionoecetes* species. Causes of wide swings in crab abundance remain a mystery. Effects of spawning stocks, oceanographic conditions, other species, and habitat requirements on crab recruitment processes remain uncertain.

In light of poor historical management success of fisheries on large male crabs, research is needed into other harvest strategies. Alternatives include gear improvements to reduce bycatch, more conservative harvest rates, modifications of size limits and sex restrictions perhaps to maintain a stock compositions more similar to unfished stocks, and multi-species harvest policies that consider changes in other components of the ecosystem. Experimental management may have potential to help evaluate alterNatives.

Selected References

Kruse, G.H. 1996. Crab research in Alaska: an interagency long-term plan. Pages 695-705 *in* High latitude crabs: biology, management, and economics. University of Alaska Fairbanks, Alaska Sea Grant College Program Report 96-02.

Murphy, M.C., W.E. Donaldson, and J. Zheng. 1994. Results of a questionnaire on research and management priorities for commercial crab species in Alaska. Alaska Fishery Research Bulletin 1(1): 81-96.

Paul, A.J. 1996. Summary report of the international workshop on research needs. Pages 675-677 *in* High latitude crabs: biology, management, and economics. University of Alaska Fairbanks, Alaska Sea Grant College Program Report 96-02.

Table 3 - Some invertebrates (excluding those included in companion table on lower trophic level organisms) of the Bering Sea/Aleutian Islands ecosystem with corresponding types of data (X = some data exist, x = minimal data exist, blank = very little or no data of use).

| | Species Number* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Data Type | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Abundance | X | X | x | | X | X | | | X | |
| Distribution | X | X | X | x | X | X | X | X | X | x |
| Status | X | X | X | x | X | X | x | x | X | x |
| Reproduction | | X | x | X | x | X | x | X | X | x |
| Mortality/ survival | X | x | | | x | x | | | | |
| Diseases, parasites, predators | | X | X | x | | x | X | | | |
| Feeding ecology | | x | x | | | x | x | | | |
| Population structure | X | X | X | x | X | X | X | x | X | X |
| Morphometrics/ growth | X | X | x | | x | x | x | x | | |
| Behavior | | X | x | | | x | | | | |
| Genetics | | X | x | x | | X | X | | | |
| Contaminants | | | | | | | | | x | x |

*1. Red king crab *(Paralithodes camtschaticus)*, 2. blue king crab *(P. platypus)*, 3. golden king crab *(Lithodes aequispinus)*, 4. scarlet king crab *(L. couesi)*, 5. Tanner crab *(Chionoecetes bairdi)*, 6. snow crab *(C. opilio)*, 7. grooved Tanner crab *(C. tanneri)*, 8. triangle Tanner crab *(C. angulatus)*, 9. hair crab *(Erimacrus isenbeckii)*, and 10. weathervane scallops *(Patinopecten caurinus)*.

Forage Fish (contributors: Ric Brodeur, Lowell Fritz - NMFS, Kathy Rowell - ADF&G) – Table 4

Juvenile pollock - Understanding and quantifying the mortality/survival process for juvenile pollock is the most important gap that needs to be filled. Improved estimates of juvenile pollock mortality could be obtained through better understanding of seasonal changes in predator distribution, abundance, and diet.

Pacific herring - Most data collected for the Bering Sea herring biomass occurs during the inshore spawning migration in association with coastal commercial fisheries for sac roe. Abundance indices are obtained by aerial survey observations at the time of these spring fisheries. These indices are less than absolute as they are hampered by inclement weather conditions and occluded water conditions. There are also some herring spawning concentrations that are not monitored because they are not commercially viable. The abundance estimates coupled with age, size and maturity data collected in recent years, indicate the stock condition of the monitored populations are stable.

However, attempts to determining the success of year class strength and recruitment into the population have yet to be determined. Migration patterns and overwintering areas are generally understood for the Togiak herring population but are yet to be defined for spawning populations north and south of Togiak. Rearing areas and distribution of juvenile herring are also unknown for all coastal populations. Growth studies have consistently distinguished three groups of herring as northern, central and southern. Attempts to distinguish between coastal populations via genetic analysis have yet to be successful, yet spawning behavior and age structure of many of these populations appear location specific suggesting differences yet to be delineated by stock identification analyses. The spawning migration and reproductive behavior are understood for areas in which commercial fisheries occur. Though there are questions regarding regeneration of spawning habitat and incidence of subtidal spawning activity. Minimal information has been collected regarding incidence of disease or parasites in herring of the eastern Bering Sea. Parasites have been observed but have yet to be identified or incidence quantified. Contaminants specific to Bering Sea herring have yet to be explored though questions regarding the impact of waste and discharge from the fishing industry on both the spawning habitat, herring in the stage of hatching and the migrating population has been questioned.

Other forage fish species - For capelin, smelts, sandlance, and myctophids, we require estimates of seasonal abundance, distribution and population structure. Establishing a time series of these observations would be critical so we could assess population status. This would help us not only in beginning to understand the single-species dynamics of these populations but would also help us in multispecies modeling efforts.

Table 4 - Forage fish of the Bering Sea/Aleutian Islands Ecosystem with corresponding types of data (X = some data exist, x = minimal data exist, blank = very little or no data of use).

| | Species Number* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Data Type | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| Abundance | X | X | x | x | | | | |
| Distribution | X | X | x | x | | | | |
| Status | x | X | | | | | | |
| Reproduction | X | X | x | x | x | x | x | x |
| Mortality/ survival | X | X | | | | | | |
| Diseases, parasites, predators | X | X | x | x | x | x | x | x |
| Feeding ecology | X | X | x | x | x | x | x | x |
| Population structure | x | X | | | | | | |
| Morphometrics/ growth | X | x | | | | | | |
| Behavior | X | | x | x | x | | x | x |
| Genetics | x | x | | | | | | |
| Contaminants | | x | | | | | | |

*1. Juvenile walleye pollock, 2. Pacific herring, 3. Capelin, 4. Other smelts, 5. Myctophids, 6. Bathylagids, 7. Sandlance, 8. Pacific sandfish

Doug Eggers from the Alaska Department of Fish and Game submitted the following table on available data for 5 different salmon species.

Table 5 - Pacific salmon of the Bering Sea/Aleutian Islands Ecosystem with corresponding types of data (X = some data exist, x = minimal data exist, blank = very little or no data of use).

| | Species Number* | | | | |
|---|---|---|---|---|---|
| Data Type | 1 | 2 | 3 | 4 | 5 |
| Abundance | X | X | X | X | X |
| Distribution | X | X | X | X | X |
| Status | X | X | X | X | X |
| Reproduction | X | X | X | X | X |
| Mortality/ survival | X | x | X | x | x |
| Diseases, parasites, predators | X | X | X | X | X |
| Feeding ecology | X | X | X | x | X |
| Population structure | X | X | X | X | X |
| Morphometrics/ growth | X | X | X | X | X |
| Behavior | X | X | X | X | X |
| Genetics | X | X | x | x | X |
| Contaminants | | | | | |

* 1. Chinook salmon, 2. Sockeye salmon, 3. Coho salmon, 4. Pink Salmon, 5. Chum Salmon.

Groundfish (contributors: Lowell Fritz, Jeff Fujioka, Jim Ianelli, Dan Ito, Sandra Lowe, Gary Walters, Tom Wilderbuer - NMFS, Bill Clark, Steven Hare, Bruce Leaman, Bob Trumble - Int. Pac. Halibut Comm.) - Table 6

Walleye pollock - Some of the most important data gaps for pollock are: understanding its seasonal movements and abundance and how these might change in years of varying climate, how is pollock survival linked to climate and predation, and what is the distribution and abundance of juveniles.

Pacific cod - The "Research Plan for the Assessment of Pacific cod (*Gadus macrocephalus*) in the North Pacific" (June, 1997) lists 15 areas of research need, of which four are ranked "highest" priority, seven are ranked "high" priority, and four are ranked "moderate" priority. Descriptions of the four "highest" priority areas are given below, together with a description of one of the seven "high" priority areas. All of these involve data gaps to some extent, though some focus mostly on making better use of existing data.

Migration is an area of great public interest, and is conceivably important for management. The tagging study conducted by Shimada and Kimura established that cod can migrate considerable distances and that there is substantial movement from the EBS to the GOA. However, much remains to be known, for instance the regularity, timing, and magnitude of such migrations as well as whether a counter-migration from the GOA to the EBS occurs (also migrations within subareas of the EBS, AI, and GOA). Ideally, any of the suggested studies would extend over a number of seasons and years. They would also be structured so that the results are usable in the stock assessment

Two highest priority research issues of cod relate to changes in the modelling framework used for single-species assessment. One project would be to move the present cod assessment-modelling framework into Fournier's "AD Model Builder" platform either in place of or alongside the existing Synthesis models, which may improve stability of parameter estimates. Also simpler methods (e.g., biomass dynamic models) need to be examined. Furthermore, models need to be improved treatment of harvest strategy and uncertainty. The groundfish fishery management plans set an upper limit on target harvest rates, but it is conceivable that there is a more appropriate harvest rate somewhere below this limit. The proper treatment of uncertainty in model parameters is only partially understood, as is the issue of uncertainty in model structure. One outcome of a systematic treatment of uncertainty might be to provide a rational means of allocating research funds (e.g., what are the benefits of decreasing the survey sample size by 10%, what are the benefits of increasing survey frequency?).

We also require better understanding of seasonal and interannual changes in the weight-length and length-age relationships of Pacific cod. A single, time-invariant weight-length relationship is presently used but the validity of this relationship has not been re-examined for a few years. Inter-annual changes in the weight-length schedule have proven important in assessments of some other species (e.g., Pacific halibut). Seasonal changes in the weight-length schedule could also be important.

A high priority research item is one related to multispecies interactions. Pacific cod appear to be significant predators of some crab species. However, existing multi-species virtual population analysis (MSVPA) models do not include crab species. This is an important interaction that needs to be considered in multispecies models of Bering Sea region.

Greenland turbot - For Greenland turbot, the biggest issue is stock structure.and recruitment processes. Were the strong yearclasses in the late 1970's anomalous? If so, where are the juveniles now? Have increases in the arrowtooth flounder population affected recruitment onto the shelf? Is the eastern Bering Sea shelf the main nursery area? How much movement of this species occurs? For many species of flatfish, such as yellowfin sole, rock sole, Alaska plaice, flathead sole, and arrowtooth flounder, the research questions are the same:

What are the differences in distribution (habitat) and growth for all shelf flatfish with increasing or declining abundance?

A) When one species increases in abundance?
B) When all increase simultaneously?
C) What about the population dynamics of the benthic infauna and its role?

Factors influencing juvenile mortality/survival of flatfish are not well understood. What combination of factors (environment, ecosystem species composition, buffer zones with adults) constitutes a good year class? What is the differential mortality between pre- and post-metamorphosis?

What is the juvenile distribution of flatfish species? There is a lack of information except a little for yellowfin sole.

Yellowfin sole - Although adult seasonal migration has been reported in some papers, the timing and location is poorly understood.

Rock sole - The northern and southern forms of rock sole are recognized and are being reclassified as two species. However, they are still considered as one species in the stock assessment. Histological examination of the maturity of Bering Sea rock sole is still lacking.

Alaska plaice and flathead sole - no maturity information is available for flathead sole and no histology has been done for Alaska plaice. The reproductive biology of both species are unknown. There is also concern of the management of the Bering flounder and flathead sole, which are very similar in appearance and are combined in the stock assessment.

Sablefish - There is very little information on juvenile sablefish distribution and biology, and their habitat requirements. While juvenile sablefish have been observed in nearshore areas and on the continental shelf where groundfish fisheries take place, distribution information is insufficient to speculate whether habitat alterations by nearshore development or fishing gear, or fishery bycatch mortality have any effect on sablefish. While there is also a similarly low level of information on sablefish eggs and larvae, which are found primarily in pelagic oceanic waters, there is hopefully little we are likely to do to alter this habitat, and little we need to do to protect it.

Pacific ocean perch - Better habitat information is needed for Pacific ocean perch, as well as for the other slope rockfish species. There is concern with the practice of assuming that all rockfish are distributed evenly throughout each survey stratum when extrapolating survey estimates of density. Some species of rockfish are known to live at highest densities over rough, untrawlable bottom, while others are completely absent in such habitat. We encourage more research to map the distribution of habitat types in the survey area and to quantify the species composition of the rockfish community inhabiting them. This information can then serve as a basis for a more reasonable extrapolation of densities observed in survey tows to the appropriate geographic area.

Little is known about the role of rockfish early life history in determining optimal harvest strategies. Very simplistic assumptions are made on the relationship of recruitment strength to abundance and location of adult stocks. Virtually nothing is known about the location of spawning populations, areas of larvae release, drift and mortality of the larvae, location and characteristics of rearing areas, and the transition from juvenile rearing areas to adult stages. The significance of these factors in maintaining spawning populations is unknown. Early life history studies should be done, if only at modest levels, to provide some basis for evaluating the need for more ambitious studies and to provide the necessary foundation and insight for conducting them efficiently. These studies would provide preliminary information on growth, distribution, and species composition of juvenile rockfish in the Gulf of Alaska, as well as improve expertise and solve problems in methodology, such as species identification.

Other rockfish - Over 27 species of "other rockfish" have been confirmed or tentatively identified in catches from the eastern Bering Sea and Aleutian Islands regions. Relatively little information is known for these species in terms of their distribution, biology, and population dynamics. Even basic biological information such as growth, maturity, and age data is lacking for many of these species. As a first step, efforts should be directed to gaining a better information base on the biology of these species from groundfish surveys and commercial fisheries.

Atka mackerel - The most important data gaps for Atka mackerel are abundance, distribution, and mortality. Atka mackerel is a very difficult species to survey with traditional resource assessment techniques and sampling methodology. Survey abundance estimates with very large variances, when incorporated in the stock assessment, yield model results that also have wide confidence bounds. The survey does not sample adequately all of the habitats occupied by the species; therefore, we do not know the true distribution of the species when the survey is conducted (summer) nor in other seasons. This has broad implications both for single species stock assessment and for consideration of multispecies models. Natural mortality is also a very difficult parameter to estimate, and model results can be very sensitive to the value chosen. Little is known about the mortality rate of Atka mackerel, and a constant rate across ages is assumed. Information is needed to corroborate current estimates of mortality, explore differential mortality at age, and partition mortality to account for major predators.

Squid - Estimates of abundance, distribution (seasonal) and population structure for squid would be of the highest importance, given its importance as a forage item for some marine mammals.

Pacific halibut - The most critical gaps in our knowledge about halibut biology are factors driving recruitment and migratory behavior in the first few years of life. It is clear to us now that recruitment bears little relation to stock size but seems to vary on a decadal scale. Much of our present research is focused on understanding recruitment variability. We would also like to better understand migration of halibut out of the Bering Sea. In particular, we would like to determine the extent to which the Bering Sea population is closed as opposed to a nursery ground for the Gulf population.

Table 6 - Groundfish of the Bering Sea/Aleutian Islands Ecosystem with corresponding types of data (X = some data exist, x = minimal data exist, blank = very little or no data of use).

| | Species Number * | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data Type | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| Abundance | X | X | X | x | X | X | X | X | X | X | x | X | | | | x | x | x | X |
| Distribution | X | X | X | x | X | X | X | X | X | X | x | X | x | | | x | x | x | X |
| Status | X | X | X | x | X | X | X | X | X | X | x | X | | | | x | x | | X |
| Reproduction | X | X | X | x | x | x | X | | x | X | x | X | x | x | x | x | x | x | X |
| Mortality/ survival | x | X | X | x | x | X | X | X | | X | x | x | | | | | | | x |
| Diseases, parasites, predators | X | x | X | x | X | x | x | x | | X | | X | x | x | x | x | x | x | X |
| Feeding ecology | X | X | X | x | X | X | X | X | X | X | | x | x | x | x | x | x | x | X |
| Population structure | X | X | X | | x | X | X | X | X | X | x | X | | | | | | | X |
| Morphometrics/ growth | X | X | X | x | X | X | X | X | X | X | | X | x | x | x | x | | | X |
| Behavior | x | x | x | | x | x | x | x | X | X | | x | | | | | | | |
| Genetics | x | x | x | | x | | | | | X | | X | | | | | | | |
| Contaminants | | | | X | | X | X | X | | x | | | | | | | | | |

*1. Walleye pollock, 2. Pacific cod, 3. Yellowfin sole, 4. Greenland turbot, 5. Arrowtooth flounder, 6. Rock sole, 7. Other flatfish, 8. Flathead sole, 9. Sablefish, 10. Pacific ocean perch, 11. Other rockfish, 12. Atka mackerel, 13. Squid, 14. Octopus, 15. Sharks, 16. Skates, 17. Sculpins, 18. Grenadiers, 19. Pacific halibut.

Marine birds (seabirds and seaducks) (Contributor: Vivian Mendenhall, USFWS) – Table 7

Birds are easier to study than many marine organisms, especially during the breeding season for those species that nest aboveground. Data have been collected during the OCSEAP period (mid-1970s); monitoring has continued since then and other data have been added sporadically. However, there are still major data gaps that prevent analysis of the effects of ecosystem changes or other impacts on populations. Population size and status are still unknown for most species that nest underground. Distributions at sea outside the breeding season (8-9 months of the year) are poorly known (unknown for the Aleutian Tern). Mortality rates of most species have not been studied in the North Pacific/Bering Sea; data from other areas is not always valid here. Diets of most species are now reasonably well known in summer but are partly or completely unknown in winter. Differences in nutritional quality among prey species need to be elucidated. In addition, in order to understand limiting factors on a top predator such as a marine bird. It is crucial to know the dynamics of prey populations as they affect the availability of food at key times of year. Current cooperative projects are starting to elucidate some aspects of prey availability; however, it is not possible to predict the effects of any change in fish or invertebrate stocks on prey dynamics in seabird feeding areas.

Priorities for research: 1. Factors that limit food availability and quality during the breeding season and winter; will require major interdisciplinary projects to collect and integrate information for birds and lower trophic levels. 2. Winter distributions and diets of seabirds. 3. Adult survival rates. 4. Means to census and monitor auklets and other crevice-nesting seabirds reliably.

Table 7 - Marine Birds of the Bering Sea Ecosystem with corresponding data types (X = some data exist, x = minimal data exist, blank = very little or no data of use).

Species Number*

| Data Type | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Abundance | X | X | X | | x | X | X | X | x | X | x | X | X | X | x | x | | | | | X | X | x |
| Distribution | X | x | X | x | X | X | X | x | X | X | X | X | x | X | X | x | x | x | x | X | x | X | x |
| Status | X | X | X | x | x | X | X | X | x | x | | x | x | X | x | x | | | | | x | X | x |
| Reproduction | X | X | X | X | X | X | X | X | X | X | x | X | x | X | X | x | X | x | | X | X | x | x |
| Mortality/ survival | | | x | x | x | x | X | X | x | x | x | | | | | | x | | | | | | |
| Diseases, parasites, predators | | | | | | | x | | x | x | x | x | x | x | x | x | x | x | x | x | | | x |
| Feeding ecology | x | | x | x | x | x | x | x | x | x | x | x | | x | x | x | x | x | x | x | | x | x |
| Population structure | | | x | x | x | x | x | x | x | x | | x | | x | | | x | | | | | | |
| Morphometrics/ growth | X | x | X | X | X | x | X | X | | x | | X | X | x | X | x | X | x | X | X | X | x | x |
| Behavior | X | X | X | X | X | X | X | X | X | X | X | X | X | X | X | x | X | x | X | X | X | x | x |
| Genetics | | | | | | | x | x | | | | | | x | x | x | x | x | | | x | x | |
| Contaminants | | | | | | | | | | | | | | | | | | | | | x | | x |

*1. Laysan and Blackfooted Albatross, 2. Short-tailed Albatross (endangered species), 3. Norther Fulma,r 4, Shearwaters,, 5. Storm-Petrals, 6. Cormorants, 7. Black-legged Kittiwake, 9. Glaucous Gull, 10. Other gulls 11. Jaegers, 12. Arctic Tern, 13. Aleutian Tern, 14. Murres, 15. Guillemots, 16. Marbled and Kittlitz's Murrelet, 17. Least, Crested and Parakeet Auklets, 18. Cassin's Auklet and Ancient Murrelet, 19. Whiskered Auklet, 20. Puffins and Rhinoceros Auklet, 21. Spectacled Eider (threatened species), 22. Steller's Eider (threatened species), 23. Other marine ducks.

Marine Mammals- (contributors: John Bengtson, Chuck Fowler, Tom Loughlin – NMFS, Susi Klaxdorff – FWS) – Table 8

Steller sea lions, northern fur seals, bowhead whales, Alaskan harbor seals, ringed seals, spotted seals, bearded seals, and beluga whales must be studied pursuant to the requirements of the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA), to provide information relevant to these species as they interact with U.S. commercial fisheries or are taken for subsistence by Native hunters. Information regarding population size and life history strategy is necessary to determine Potential Biological Removal levels for all species of marine mammals and to implement the recovery of stocks listed as threatened or endangered (ESA), or as depleted under the MMPA. It is important to deal with the uncertainty regarding the potential responses among all marine mammal species to climate change - such as redistribution of populations, altered stock structure, and shifts in carrying capacity.

The chronic population declines of Steller sea lions in Alaska appear related to changes in the abundance or availability of their fish prey (e.g., small schooling fishes). While this hypothesis is supported by studies of these predator's diets, there is little information in-hand which documents the availability of small (noncommercial sized) fishes. Needed information includes winter and spring foraging behavior of sea lions with corresponding distribution and abundance information for their prey. Other related research is needed regarding sea lion physiology and genetics, all in the vein of trying to determine the cause of the sea lion decline.

The Northern Fur Seal Conservation Plan specifies that research be conducted to determine the cause of a recent decline in numbers of northern fur seals and to investigate the interaction between this species and other components of the Bering Sea ecosystem. Studies to describe and compare migration patterns and foraging ecology are of primary importance. It is important to continue assessment of interaction of this species with commercial fisheries and to study the prevalence of disease in the population and the effects of disease on population trends.

Harbor seals are commonly caught incidentally in commercial and subsistence net fisheries. They are also experiencing significant population declines in many areas of Alaska. The NMFS is considering listing the Gulf of Alaska stock as depleted and harbor seals have strategic status under the 1994 Marine Mammal Protection Act. Research to assess the distribution and abundance of harbor seals in the state is necessary to properly evaluate the impact of incidental and subsistence take on seal populations.

The Bering/Chukchi/Beaufort Sea stock of bowhead whales is currently harvested by U.S. and Russian aboriginal hunters. This hunt is regulated by the International Whaling Commission through agreements reached during Commission meetings. Simlarly, beluga whales are subject to a significant subsistence harvest by Alaska Natives. Continued work on estimating population size and studies of the population dynamics of these species are important.

Four species of ice-associated seals inhabit the Bering Sea: ringed, bearded, ribbon, and spotted seals. Despite the fact that these seals are important resources for the Native people of northern and western Alaska, as well as key ecological components of arctic marine ecosystems, relatively little is known of the seals' population structure, trends in abundance, life history status, or age structure. Furthermore, the extent to which their distribution and diet overlap with commercial fishery operations is largely unknown. This lack of information is particularly surprising given that these seals probably account for the bulk of directed takes by Alaska Native subsistence hunters (rough estimates range from about 5,000 to 20,000 ice seals killed annually vs. about 3,000 and 500, respectively, for Alaska harbor seals and Steller sea lions). The distributions of these seals are highly sensitive to suitable sea ice conditions, and as such, may be particularly vulnerable to climatic change. Reductions in extent of Arctic sea ice, coincident with warming trends, have already occurred, and may indicate the onset of long-term polar warming predicted by climatic models.  Evaluating changes in ice seal abundance and distribution should be undertaken as a matter of priority, given their importance to Alaska Native subsistence harvests, the unknown extent to which these seals interact with commercial fisheries, and the uncertainties concerning the seals' potential responses to climate change.

Priorities as those reviewed above result from scientific consideration, and often consensus.  Beyond what are formally (and often legally) recognized needs and problems, however, there are other clear gaps in information and little basis for evaluating relative importance.  How important is it that we have information about the abundance of less recognized species?  Do the consumption rates of fish species by marine mammal predators represent information of use in management?  How important is it that we have information about the mortality of any marine mammal species as caused by any of the various species of predators, parasites or diseases?  Long left to the realms of theory, there are as many evolutionary interactions among the species as there are predator/prey interactions or competitive interactions.  How important are these, and how can research provide information relevant to any practical application? From an ecosystem perspective, the preceding questions deal with a variety of kinds of information that may be key to avoiding unforeseen difficulties or solving known problems.  One of the gaps in our information is that of not knowing how to answer such questions.

Table 8 - Marine Mammals of the Bering Sea Ecosystem (excluding sei whales and blue whales) with corresponding types of data (X = some data exist, x = minimal data exist, blank = very little or no data of use).

| | Species Number* | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data Type | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 |
| Abundance | X | X | x | x | x | x | X | X | x | x | x | X | x | x | x | x | x | x | X | x | x | x | X | | |
| Distribution | X | X | X | X | X | X | X | X | X | X | X | X | X | x | x | x | x | x | X | x | x | X | X | X | x |
| Status | X | X | x | x | x | x | X | X | x | x | x | X | x | x | x | x | x | x | X | x | x | X | X | x | x |
| Reproduction | X | X | X | X | X | X | X | X | x | X | X | X | X | | | | x | x | X | X | x | | X | x | X |
| Mortality/ survival | x | x | x | x | x | x | X | X | | x | x | x | x | | | | | x | x | x | | | x | | x |
| Diseases, parasites, predators | x | x | | | | | X | x | | | | | | | | | | | | | | | | x | x |
| Feeding ecology | X | X | x | x | x | x | X | x | | | x | | | | | | | x | | | | x | | X | |
| Population structure | x | x | x | x | x | x | X | X | | | | x | | | | | | | x | x | | | X | x | |
| Morphometrics/ growth | X | X | x | x | x | x | X | X | | | | x | | | | | | | | | | | x | x | x |
| Behavior | x | x | | | | | X | x | | | | x | | | | | | | x | | | | x | | x |
| Genetics | | | | | | x | x | | | | | | | | | | | | | | | | | X | X |
| Contaminants | x | x | x | x | | x | x | | | | x | | | | | | | | | | | | | x | x |

*1. Sea otters, 2. Harbor seals, 3. Spotted seals, 4. Bearded seals, 5. Ringed seals, 6. Ribbon seals, 7. Northern fur seals, 8. Steller sea lions, 9. Pacific white-sided dolphin, 10. Harbor porpoise, 11. Dall's porpoise, 12. Beluga, 13. Killer whale, 14. Baird's beaked whale, 15. Cuvier's beaked whale, 16. Stejneger's beaked whale, 17. Sperm whale, 18. Minke whale, 19. Gray whale, 20. Humpback whale, 21.Finwhale, 22. Northern right whale, 23. Bowhead whale, 24. Polar bear, 25. Pacific walrus.

Subsistence information (contributor: Craig Mishler, Alaska Dept. Fish and Game) - Table 9

There are presently about 63 communities of people in Alaska that border on the Bering Sea. Subsistence harvest data is being collected from some of these communities but baseline subsistence harest data is lacking for 25 of them. Of particular interest is obtaining information on subsistence use of ice seals (bearded, ringed, spotted, and ribbon) and waterfowl in this region. These data would be useful additions to the ADF&G Community Profile Database and the Whiskers! database of traditional ecological knowledge.

| Table 9 | Population | | Percentage Native | | Occupied Housing Units | | Average Income | | Latitude | Longitude | Region | Harvest Data |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Community | 1980 | 1990 | 1980 | 1990 | 1980 | 1990 | 1980 | 1990 | | | | |
| Adak Station | 3315 | 4633 | 0.80 | 1.20 | 666 | 1019 | 16582 | 29250 | 51 | 176 | Southwest | |
| Akutan | 169 | 589 | 39.60 | 13.58 | 17 | 31 | 5833 | 27813 | 54 | 165 | Southwest | X |
| Alakanuk | 522 | 544 | 94.10 | 95.80 | 105 | 121 | 10721 | 17708 | 62 | 164 | Western | X |
| Aleknagik | 154 | 185 | 89.60 | 83.20 | 38 | 57 | 33282 | 21875 | 59 | 158 | Southwest | X |
| Amchitka | | 25 | | 8.00 | | 0 | | | 51 | 179 | Southwest | |
| Atka | 93 | 98 | 96.80 | 92.85 | 22 | 30 | 11250 | 26250 | 52 | 174 | Southwest | X |
| Atmautluak | 219 | 258 | 94.10 | 96.89 | 47 | 53 | 6094 | 15833 | 60 | 162 | Western | |
| Brevig Mission | 138 | 198 | 100.00 | 92.40 | 32 | 53 | 9844 | 15000 | 65 | 166 | Arctic | X |
| Chefornak | 230 | 320 | 96.10 | 97.50 | 38 | 64 | 11667 | 20278 | 60 | 164 | Western | |
| Chevak | 466 | 598 | 95.50 | 92.90 | 92 | 147 | 14375 | 17222 | 61 | 165 | Western | |
| Clark's Point | 79 | 60 | 88.60 | 88.30 | 22 | 18 | 1250 | 17083 | 58 | 158 | Southwest | X |
| Dillingham | 1563 | 2017 | 57.00 | 55.80 | 467 | 691 | 27292 | 44083 | 59 | 158 | Southwest | X |
| Diomede | 139 | 178 | 97.80 | 93.80 | 30 | 41 | 3281 | 14375 | 65 | 169 | Arctic | X |
| Eek | 228 | 254 | 96.50 | 95.67 | 56 | 72 | 11250 | 21000 | 60 | 162 | Western | |
| Egegik | 75 | 122 | 76.00 | 70.50 | 32 | 48 | 26875 | 20625 | 58 | 157 | Southwest | X |
| Elim | 211 | 264 | 96.20 | 91.70 | 48 | 73 | 9583 | 16250 | 64 | 162 | Arctic | X |
| Emmonak | 567 | 642 | 91.20 | 92.10 | 127 | 161 | 6375 | 25625 | 62 | 164 | Western | X |
| False Pass | 70 | 69 | 85.70 | 76.47 | 21 | 23 | 37333 | 21667 | 54 | 163 | Southwest | X |
| Gambell | 445 | 525 | 95.50 | 96.20 | 103 | 120 | 8409 | 15938 | 63 | 171 | Arctic | X |
| Golovin | 87 | 127 | 97.70 | 92.90 | 31 | 42 | 9063 | 16146 | 64 | 162 | Arctic | X |
| Goodnews Bay | 168 | 241 | 95.80 | 95.85 | 42 | 66 | 12083 | 13523 | 59 | 161 | Western | |
| Hooper Bay | 627 | 845 | 95.40 | 95.90 | 125 | 190 | 13558 | 18125 | 61 | 166 | Western | |
| Kipnuk | 371 | 470 | 96.50 | 97.45 | 75 | 99 | 15536 | 4999 | 59 | 164 | Western | |
| Kongiganak | 239 | 294 | 96.70 | 97.28 | 48 | 60 | 10500 | 33250 | 59 | 162 | Western | |
| Kotlik | 293 | 461 | 95.60 | 96.90 | 59 | 101 | 18750 | 20417 | 63 | 163 | Western | X |
| Koyuk | 188 | 231 | 95.70 | 94.80 | 48 | 61 | 12500 | 18750 | 64 | 161 | Arctic | X |
| Kwigillingok | 354 | 278 | 96.90 | 94.96 | 66 | 62 | 15938 | 14500 | 59 | 163 | Western | |
| Levelock | 79 | 105 | 87.30 | 82.90 | 21 | 39 | 13125 | 12159 | 59 | 156 | Southwest | X |
| Manokotak | 294 | 385 | 92.90 | 95.60 | 57 | 90 | 31320 | 20500 | 59 | 158 | Southwest | X |

| | Population | | Percentage Native | | Occupied Housing Units | | Average Income | | Latitude | Longitude | Region | Harvest Data |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Community | 1980 | 1990 | 1980 | 1990 | 1980 | 1990 | 1980 | 1990 | | | | |
| Mekoryuk | 160 | 177 | 95.60 | 99.44 | 44 | 63 | 9479 | 14792 | 60 | 166 | Western | |
| Naknek | 318 | 575 | 50.60 | 41.00 | 103 | 208 | 47302 | 50907 | 58 | 156 | Southwest | X |
| Nelson Lagoon | 59 | 83 | 93.20 | 80.72 | 18 | 31 | 4750 | 44583 | 55 | 161 | Southwest | X |
| Newtok | 131 | 207 | 94.70 | 93.24 | 28 | 42 | 1250 | 14844 | 60 | 164 | Western | |
| Nightmute | 119 | 153 | 97.50 | 95.42 | 24 | 29 | 8750 | 17813 | 60 | 164 | Western | |
| Nikolski | 50 | 35 | 96.00 | 82.85 | 23 | 19 | 3958 | 13750 | 52 | 168 | Southwest | X |
| Nome | 2506 | 3500 | 58.50 | 52.10 | 761 | 1119 | 23500 | 45812 | 64 | 165 | Arctic | X |
| Pilot Point | 66 | 53 | 86.40 | 84.90 | 16 | 17 | 31056 | 38750 | 57 | 157 | Southwest | X |
| Platinum | 55 | 64 | 80.00 | 92.18 | 14 | 22 | 17500 | 23056 | 58 | 161 | Western | |
| Port Clarence | 29 | 26 | 0.00 | 0.00 | 0 | 0 | | | 65 | 166 | Arctic | |
| Port Heiden | 92 | 119 | 64.10 | 72.30 | 29 | 42 | 16250 | 35000 | 56 | 158 | Southwest | X |
| Quinhagak | 412 | 501 | 97.60 | 93.81 | 82 | 127 | 10375 | 17500 | 59 | 161 | Western | X |
| Saint George | 158 | 138 | 96.80 | 94.92 | 40 | 45 | 24583 | 25250 | 56 | 169 | Southwest | X |
| Saint Michael | 239 | 295 | 95.00 | 91.20 | 57 | 69 | 10714 | 23194 | 63 | 162 | Arctic | |
| Saint Paul | 551 | 763 | 87.70 | 66.05 | 126 | 154 | 22813 | 39922 | 57 | 170 | Southwest | X |
| Savoonga | 491 | 519 | 94.30 | 95.20 | 109 | 116 | 7813 | 11339 | 63 | 170 | Arctic | X |
| Scammon Bay | 250 | 343 | 96.40 | 96.50 | 47 | 85 | 12344 | 15179 | 61 | 165 | Western | |
| Shaktoolik | 164 | 178 | 97.00 | 94.40 | 43 | 46 | 8333 | 18438 | 64 | 161 | Arctic | X |
| Sheldon Point | 103 | 109 | 95.10 | 92.70 | 20 | 27 | 8500 | 16250 | 62 | 164 | Western | X |
| Shemya Station | 600 | 664 | 0.20 | 0.45 | 0 | 0 | | | 52 | 174 | Southwest | |
| Solomon | 4 | 6 | | 100.00 | 1 | 4 | | | 64 | 164 | Arctic | |
| South Naknek | 145 | 136 | 85.50 | 79.40 | 43 | 39 | 30344 | 23750 | 58 | 156 | Southwest | X |
| Stebbins | 331 | 400 | 95.50 | 94.80 | 69 | 86 | 13036 | 23333 | 63 | 162 | Arctic | X |
| Teller | 212 | 232 | 92.50 | 91.30 | 65 | 68 | 8182 | 18749 | 65 | 166 | Arctic | |
| Togiak | 470 | 613 | 94.30 | 87.30 | 101 | 151 | 12917 | 15000 | 58 | 160 | Southwest | *** |
| Toksook Bay | 333 | 420 | 93.70 | 95.48 | 65 | 88 | 13636 | 21875 | 60 | 165 | Western | |
| Tuntutuliak | 216 | 300 | 96.80 | 96.66 | 42 | 70 | 13333 | 14444 | 60 | 162 | Western | |
| Tununak | 298 | 316 | 95.00 | 96.20 | 68 | 78 | 9667 | 18750 | 60 | 165 | Western | X |
| Twin Hills | 70 | 66 | 95.70 | 92.40 | 17 | 25 | 12083 | 11667 | 59 | 160 | Southwest | *** |
| Ugashik | 13 | 7 | | 85.70 | 8 | 4 | | | 57 | 157 | Southwest | X |
| Unalakleet | 623 | 714 | 87.60 | 81.80 | 158 | 207 | 12083 | 34531 | 63 | 160 | Arctic | X |
| Unalaska | 1322 | 3089 | 15.10 | 8.38 | 304 | 575 | 24375 | 56215 | 53 | 166 | Southwest | X |
| Wales | 133 | 161 | 91.70 | 88.90 | 37 | 49 | 3854 | 15000 | 65 | 168 | Arctic | X |
| White Mountain | 125 | 180 | 92.80 | 87.80 | 36 | 58 | 9107 | 15893 | 64 | 163 | Arctic | X |

Contaminants (contributor: Jawed Hameedi NOAA/NOS)

The current level of scientific information on the amounts, sources, and fluxes of contaminants is inadequate to describe the extent of environmental degradation and its concomitant adverse effects on the extensive and teeming biological resources of the region. Most of the data are sporadic in time and space; some very site-specific (i.e., in the immediate vicinity of an industrial activity). Further, a general lack of a sustained effort in the United States to address the Arctic Contamination issue makes it difficult to define a perspective and priorities for environmental research, assessment and monitoring needs. A broad scientific strategy articulated at an international symposium on "Protection of Life in the Sea" some twenty years ago (1979) still seems relevant today: an integrated program for systematic monitoring of the levels, trends and adverse biological effects of contaminants; scientific studies of eutrophication, harmful algal blooms, and species succession; bioaccumulation of contaminants in food chains; and assessment of vectors of emerging diseases in the coastal environment. This could form the basic building blocks of a comprehensive program to study contaminants in the Bering Sea.

However, it is also imperative that such a program be closely linked with studies on the biology and population dynamics of valued biological resources in the Bering Sea, and with specially-targeted experimental studies. This will be a daunting task, given large fluctuations in fish and wildlife populations in response to natural environmental factors; newly emerging issues (i.e., presence of a wide variety of currently-used and environmentally less persistent contaminants; toxicity of selenium and white phosphorus to fish and wildlife; reproductive effects of estrogenic xenobiotics); and strong implications to commercial and subsistence uses of the natural resources. There is little doubt that implementation of such an integrated program can only be carried out with adequate funding and a detailed strategic planning, including time-phased activities and information products.

NOAA/NOS already supports extensive programs and activities devoted to gathering of a wide variety of data on levels of contaminants and their biological effects, synthesis and archiving of biological inventories, coastal pollution sources, coastal and estuarine drainage characterizations, shellfish closures, and recreational use of the coastal region on a nationwide basis. The newly formed National Centers for Coastal Ocean Science (NCCOS or the NOS "Science Office") can provide scientific leadership and host a series of workshops (expert working groups) culminating in a comprehensive and inter-disciplinary program to assess the impact of contaminants on the Bering Sea ecosystem. NCCOS, and particularly its proposed Center for Coastal Monitoring and Assessment, Center for Coastal Environmental Health and Biomolecular Research, and Center for Coastal Fisheries Habitat Research, and Center for Sponsored Coastal Ocean Research, have the requisite capabilities to provide scientific guidance, intramural and extramural support, and technical assistance for such an effort.

## OVERVIEW OF PAST REVIEW TEAM ACTIVITIES

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Today I would like to give you an overview of the report of the NRC panel on the Bering Sea ecosystem. The National Research Council is the working arm of the National Academy of Sciences. There are those that are in the National Academy and then there are those who do the work, and this is the group. We were appointed - essentially there was a contract between the NRC and the Department of State to form this committee. The people on the committee were a diverse group of people, some of whom work intimately with the Bering Sea ecosystem on a day to day basis, some of whom had absolutely no contact at all with the Bering Sea, although were experts in various aspects of the issues that we were considering.

We had a long statement of objectives that are in the report. However, in our view the reasons for the study can be stated in the following three statements. 1) In recent decades some Bering Sea seabirds and marine mammals have undergone significant population declines. The nature of these dynamics is really not well understood in some of the earlier years that are very critical. But nonetheless, the kinds of changes in birds and mammals are ones that people are really concerned about. 2) Also, a number of fish and shellfish populations have undergone significant changes, including some large increases over the past 30 years. The king crab dynamics, in the Gulf of Alaska as well as in the Bering Sea, marks some of the declines. Some of the significant increases in a number of species were the flatfish species in the Bering Sea in the late '70s, early '80s. All these changes were of concern. 3) And of particular importance is the fact that these changes have been attributed to either some unexplained environmental conditions or human activities ranging from fishing to pollution. So essentially, what's going on here?

So what did we do? We talked a lot and, in fact, that probably is the most important thing that we did. Any group that gets together to discuss complex issues bring a lot of baggage to the table. It took us about a year and a half or two years to get that baggage out on the table and the only way we could do it was simply to discuss various issues. It was essential to the process, too. The extent that we were successful in getting some insight, collective insight, was because we got together quite a bit.

So we did a number of things, we attempted to provide a conceptual framework for understanding marine ecosystems, what we call an ecosystem perspective. But perhaps more importantly and more significantly we attempted to provide a hypothesis that explains the recent declines in marine mammals and birds, purely speculative, purely a hypothesis. We didn't analyze a lot of data, but we did talk to a lot of people. We looked at and drew on what a number of people were thinking about the system, people that were working with it a lot more closely with than we were.

We call this the cascade hypothesis and it has to do with cascading trophic interactions in the Bering Sea which we would speculate could have been going on for three or four decades, long term processes. Where we are now is not necessarily a function of what's going on in the system now, but where we are now is a function of what's gone on for a long period of time. We only had records and information going back into the 1950s and '60s, but clearly what's going on in the system now is also a function of what's gone on over the last several centuries. As Chuck Fowler pointed out, whaling exploitation in the system has been going on for a long time. And certainly the community structure of the Bering Sea and most large marine ecosystems of the world have been changing in response to human pervasion for much longer than we have historical records.

We tried to put together a story, a scenario, if you will, which started in the '50s with significant harvests of what we call case selected or species. Species that have very low turnover rates which do not replace themselves very rapidly when they are removed from the system and which provide opportunities for other species to fill in niches. There was significant whaling that's been going on, that was going on after the Second World War in the '50s, '60, early '70s. Alan Springer has been collecting and compiling a lot of information on not only the magnitude of the whaling but the location of the whaling in the whole North Pacific Bering Sea region.

Some more detailed calculations that were done by Richard Merrick in his Ph.D. dissertation at the University of Washington. He looked at the possibility of how much zooplankton prey could have been released by some of the removals that went on in the North Pacific and the Bering Sea during this period of the '50s and '60s. He made some calculations in terms of the amount of zooplankton that could be released with removal of some of the large baleen whales, the harvest of some of the rockfish species and some other fishery harvests that went on at that time. If you look at the amount of zooplankton that could possibly had been released you can calculate the number of juvenile pollock that could possibly had been supported in response to that release of prey.

One thing that is somewhat controversial is the role that pollock play and have played over the last three or four decades in the Bering Sea. Has pollock always been as abundant as it has been over the last several decades when the very large fisheries developed? Or was pollock at a different level of abundance, significantly lower, in the '50s and '60s and has subsequently bloomed in response to perhaps some sort of a trophic cascade? We looked at the possibility that the pollock stocks of the North Pacific and Bering Sea could have grown in response to a release of potential prey for juveniles in response to the harvest of some of these species that would not have replaced themselves.

We also incorporate the role of environmental variation into this scenario and, as we all know, there has been significant climatic changes in the North Pacific and Bering Sea over the last century, in particular in the late '70s. A rather sudden and significant change in the winter, atmospheric circulation in the North Pacific seems to have affected a number of significant biological responses in the region. We would speculate that a number of piscivorous fish species responded accordingly to this change in the environment. We didn't put any kind of scenario together as to how this might have happened, but it's very clear that species like Pacific cod, Atka mackerel and a number of flat fish species had very strong year classes which occurred right after the major climatic shift in the late '70s. Their populations subsequently exploded.

Some more evidence, a very interesting paper by Piatt and Anderson looks at the change in seabird colonies in the Gulf of Alaska over the last several decades, and looked for an effect of the Exxon Valdez oil spill. They essentially came to the conclusion that there had been major changes in a number of seabird colonies but it was difficult to see the Exxon Valdez effect. They hypothesized some major shifts in forage fish abundance or availability to sea birds occurring in the late '70, early '80s, the capelin up there as an example. Subsequently there were major changes in seabird diets in response to those climatic shifts.

I'm getting away from our report but a very interesting paper, by Richard Merrick just came out in the Canadian Journal where he's looked at, based on scat samples, Steller sea lion diets. He hypothesized that it may not be so much the absolute abundance of potential prey as it is the diversity of prey that is important to successful production of some of these marine mammal populations.

We started off by trying to figure out if there was a silver bullet. We looked at the data and examined the two questions: is it the environment or is it fishing relative to the hypothesized declines in the Steller sea lions and the hypothesized abundance of adult pollock in the Bering Sea. It is tough to see any kind of relationship there and it was very difficult for us to find a silver bullet. What we did instead, was to put together a scenario which we felt was at least plausible, not necessarily saying this is the way things happened but, in fact, pointing out that ecosystem changes manifest themselves over long periods of time. In order to try and understand the mechanisms and the dynamics of these changes we really have to look at processes that are occurring at different time scales and different space scales than we're normally used to. Certainly, very different time scales in the fisheries management time scales of one year.

Now, I'm going to briefly put up some general recommendations that came out of the report for management, which was a consensus of the committee. Firstly, it does not appear that pollock have been subjected to what we called ecosystem overfishing. In other words, fishing going on now does not seem to be, in our opinion, the cause of the long-term declines in marine mammals and birds.

Secondly, it seems extremely unlikely that the Bering Sea ecosystem can sustain the fish populations, which are the current targets of human exploitation as well as the food requirements of large populations of all marine mammals, and bird populations that existed before heavy human exploitation began. I think there are some techniques for exploring these questions in a lot more detail and some of those involve using food web type of mathematical models. To look in a little bit more detail at the plausibility of some of these hypotheses the Ecopath and Ecosim models can be used to explore some of these questions. They don't necessarily give you absolute answers but they certainly give you a tremendous amount of insight.

The third one is quite important. It is probably impossible for human management to cause large and complex marine ecosystems to achieve and to maintain "desirable balance", in other words, trophic management. If the specific objectives in mind are managing an ecosystem - managing fisheries to obtain specific ecosystem objectives, they probably won't be obtained because the system will not respond that well. You simply cannot predict how these complex systems are going to respond. Finally, we all know that some of the changes that have occurred over the past 200 years are likely irreversible over human time frames, 100 years or less.

## PANEL DISCUSSION

Group Leaders: Phil Mundy and Keith Criddle

Panel Members: Jim Coe, Deborah Crouse, Chuck Fowler, Bob Francis, Scott Hatch, Carl Hild, Gordon Kruse, Pat Livingston, John Martin, Larry Merculieff, Clarence Pautzke, Don Schell, Jim Schumacher, Gary Thomas.

A panel discussion was held on the second day of the workshop to consider: gaps in knowledge, needs with regard to research and databases, and coordination of research and data collection. Questions from workshop participants were solicited on the first day of the workshop and presented to the panel as a whole during the panel discussion period. Panel members were given the opportunity to respond to all or some of the questions. There was also audience participation in asking and answering impromptu questions that arose during the panel discussion period. A summary of the main topics of discussion during the panel discussion follows.

Main Questions for the Panel

- How can we develop a consensus on how to proceed – how best to agree on how to identify problems on spatial and temporal concerns that are most important?
- How can we set reasonable priorities for research when we do not have a common vision for the state or products expected from the Bering Sea Ecosystem?
- Science needs political and social support to make progress.
- Institutional structures are not conducive to scientific progress.
- International protocols for migratory species are not adequate.
- Agency and private agendas compete.
- What is the forum appropriate to explore a common goal or limited suite of goals for the Bering Sea Ecosystem.
- What science do we need to inform management to achieve sustainability, knowledge gaps, and to define and achieve ecosystem management?
- Is the ecosystem stressed, is it healthy?
- How can we distinguish between natural and human-induced changes for ecosystems?
- What are the effects of human induced factors such as harvest damage to the environment? We do not know how it works. We do not know the consequences of management decisions. How do we maximize the opportunity to learn?
- Is the decline of sixteen higher trophic level species a warning light or an epitaph for the Bering Sea ecosystem?
- Can we understand the Bering Sea without understanding its linkages to the Gulf of Alaska and the North Pacific as a whole?
- Is the 2 million mt cap on Bering Sea harvest a unique ecological management measure?
- What is the role of closed areas in fisheries management? Currently there are areas closed for: protection of marine mammals, walrus, Steller sea lion protection zone, chum savings area, summer herring savings area, red king crab, and winter herring savings area.
- Are we ready for ecosystem management in the sense that the information is there to guide management?
- Is the information available on the effects of Bering Sea fishing on the endangered Steller sea lions adequate to stop or reduce fishing in view of a precautionary approach (FAO Code of conduct for responsible fishing)?
- Is the scale and rate of groundfish fisheries just too big to manage for overall ecosystem considerations?

• Does the panel believe that Chuck Fowler's data availability grid for marine mammals is useful and should we have such a grid for all major categories of inquiry?
• What do you think about the utility of a Bering Sea clearinghouse as proposed by Mark Shasby? Does the Bering Sea Ecosystem Biophysical Metadatabase meet the needs for data management that Mark and others have described? How can we proceed on the data management front? In compiling the Bering Sea Biophysical Metadatabase why have the social sciences been excluded?
• The White Paper says that new funds could not be used to "make up shortfalls in agency funding." Yet agencies are now failing to keep up long-term monitoring because of funding shortfalls. Such monitoring is essential in any ecosystem analysis—and often is the only data we are now collecting. How can we understand the ecosystem unless current agency databases get funded?

Discussion Summary

Some panelists tackled the question of **health of the Bering Sea**. Some clearly believe the system is stressed. Others indicated that population fluctuations are not necessarily an indicator of stress but we require much more information about the system to determine whether such changes were natural or not. Concern was expressed that the species declines were jeopardizing the viability of coastal cultures and we need to take action. It was also indicated that although there was not necessarily agreement over the meaning of the species declines in the Bering Sea, that there was definitely consensus about the need to understand the declines. A draft research plan addressing this particular issue has already been drafted as required under the 1994 amendments of the Marine Mammal Protection Act (MMPA). It was suggested the next step in addressing Bering Sea health would be to modify this research plan to include any new suggestions about the key biological, physical, and social questions to be addressed based on the present workshop discussions, and then to provide a forum for discussing research priorities.

A large number of panelists agreed that a **science plan** needed to be developed, incorporating the previous planning efforts in the Bering Sea, including the MMPA Bering Sea Ecosystem Study Plan, AMAP, etc. How to guide the development of the research plan and the priorities for funding research by forming a common vision of the Bering Sea was a concern of many of the discussants. Numerous suggestions were made on the process for bringing people together to achieve a common vision. These suggestions regarding the process to be used included, in no particular order or priority:
• Bringing the primary advocates together (environmental organizations and primary stakeholders in coastal communities) to develop a common vision. The process would also include separate "visioning" activities for scientists and for fishing industry.
• Develop teams or boards of scientists set up by the new marine board that can take all the information on a particular aspect (e.g., seabirds) and tell us what the range of what we need to look at should be and what we should be precautionary about. We need to figure out a mechanism then for answering the scientific questions.
• Obtain a publicly developed science plan for the ecosystem or subecosystem that is based on existing knowledge and intense literature review of what the best hypotheses are on how the ecosystem works. We need teams of researchers that have developed responsibility to each other with regard to data sharing, keeping the teams together, and revisiting periodically a science planning effort that has exposure to the public, which plays the role of an oversight committee.
• Develop an institutional framework modeled after the S. Florida process to obtain ecosystem-oriented policy. This system enables knowledgeable people to develop well-focused questions that are addressed in a systematic way.
• Use NOAA's existing program, which provides $300,000 to $400,000 a year to communities in the Bering Sea coastal areas, to develop a coastal plan and discuss what their involvement with the Bering Sea will be through regional plans. This regional approach to getting public input was suggested by several people.

• Some advocated getting a small number of people together to find a common vision but making sure that those people have the support of the group they are speaking for.
Recognize the difficulty of obtaining a shared vision because we are sharing the Bering Sea with people on the western side who might have a different vision.
• Development of a long-term objective or goal for the system such as "broad cultural and biodiversity and a healthy Bering Sea in the year 2200."

Many participants highlighted the key scientific issues they thought should be addressed by the science plan. These issues centered on two **main research themes**:
• How does production of the species we are interested in depend on atmospheric and oceanic processes?
• What are the impacts of human uses on the system?

**Key scientific issues** that fit into these themes were mentioned as the most pressing research or traditional knowledge gap. These included:
• Investigations on the effects of bottom trawling or dredging on bottom communities and habitats
• Research on critical habitats for completing the life cycle for many important species
• Development of better information on primary and secondary production and how it varies over time
• Understanding the role of bacteria and microplankton
• Better information on processes driving production, e.g., the green belt, frontal processes, and pelagic-benthic coupling
• More information on the biology and ecological relationships of non-commercial species such as capelin, sandlance, starfish, and jellyfish
• Directed studies on identifying uncertainties of declining species and understanding the causes of decline
• Examination of density dependent processes that affect birth and death rates
• Explicit consideration of the linkages between ecosystems
• Examination of present information on ecosystem changes with a frame of reference to "normal" circumstances in order to determine stress
• Consideration of long temporal-scales, including the evolutionary timescale, to obtain a unified field theory to guide management.

The theme of **monitoring** was visited by many of the panelists and audience as a way to address some of the issues in the scientific program. Many confirmed the need to make a long-term commitment to ecosystem monitoring. Regular monitoring of lower trophic level organisms such as phytoplankton and zooplankton and seasonal monitoring to understand the habitat and life history requirements of species were specific monitoring projects mentioned. There was interest in developing appropriate monitoring plans and infrastructure to ensure that the proper monitoring efforts occur. There was a stated need for ships, scientists, and money to support the monitoring system. AMAP and BESIS projects were mentioned as possible models to use in designing monitoring of contaminants and health of marine mammal populations. Some mentioned the erosion of support for basic research and monitoring activities of agencies and the need to continue those long-term monitoring activities. Concerns were expressed by others about agencies using funds from this program to perform the existing monitoring activities of the agencies. Support was expressed for a program that would provide a mechanism or process by which research proposals would be evaluated and reviewed to determine potential for funding projects that meet the goals of the research program.

Brief mention was made of **other aspects of the research program** such as modeling activities using long time frames to understand species declines and the need for ecosystem modeling. Ensuring a proper balance of process-studies and monitoring activities was an expressed desire for the research program. The building, maintenance, and sharing of databases, which are an important ingredient for retrospective analyses, was a topic of much discussion. A need to assemble and make the best possible integrated use of the data that exists was expressed as a way to understand Bering Sea ecosystem changes.

The role of **databases,** as a means of sharing information, was considered by many participants. A web site was determined to be a good means for assisting in information exchange and consolidation. A Bering Sea clearinghouse was mentioned as a vehicle for identifying knowledge gaps and research needs but not as a forum for deciding what research is to be done. NOAA's metadatabase effort was seen to be the tool to be used for data collection and presentation. However, a need was expressed for the database effort to include all types of information, including social sciences, traditional knowledge, and other information that is not held by agencies or academics.

**Community involvement** was another focus of discussion. It was evident that community involvement was desired throughout the whole process surrounding a research program for the Bering Sea or North Pacific. There was an expressed desire for community involvement in development/affirmation of the scientific questions to be addressed by the plan. Ongoing oversight by the public in the scientific program was also seen as an important ingredient. Several people mentioned the need for mechanisms to be put into place by state and federal agencies to involve local communities in the actual research and monitoring activities. A suggestion was made to have a workshop on traditional knowledge in order to further our understanding and use of this important form of information held by members of the coastal communities. Finally, transferring the information developed in the long term to the stakeholders living in coastal communities was deemed important. This could be done by developing relationships with communities, mechanisms where there is personal interaction between scientists and stakeholders, and forums where science could be brought back and communicated to the community.

The role of **management** in the present and in the future was mentioned a few times. Firstly, a recognition that the only part of the ecosystem we can control is ourselves, is needed. Also, we need to start looking at our management and its impacts of its individual species management actions on other species. Using management as an experimental tool for gaining knowledge about the system was suggested.

## AGENCY PERSPECTIVES

### National Oceanic and Atmospheric Administration Perspectives

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I had some remarks that had to do with the importance of this area but I do not think I need to convince this group of that. However, as I go through this discussion I think we have a lot of other convincing to do to make this a priority in our funding cycles and to start to make things happen. Although we all are getting deja vu, I will tell you there are many people out there that do not have it. They are the coastal communities that were discussed here, and the fishing communities and advisors on commissions I work with. An illustrative example of that would be the North Pacific Anadromous Fish Commission. I do not know how many workshops we have had on El Niño over the last year and a half. We had one of our scientists come in and give them a discussion of what is going on there. The North Pacific index to many of you is sort of old hat, but most of them did not know what that was. The fact that there were red lines above and blue lines below or vice versa was amazing to them.

These are the people that ultimately give these things priorities, it is not the science. It is the scientists advising them of what needs to be done and the importance of the result. This is a very real discussion, this is not abstract. Clarence Pautzke, the executive director of the North Pacific Fishery Management Council, gave me our book for next week at the council meeting, and that book is very thick. Now that is just the bureaucratese of the decisions that need to be made and the letters that influence them and so forth.

We have also been presented with the Stock Assessment and Fishery Evaluation (SAFE) documents. These are the documents prepared by the agency on the status of stocks of individual species and the species groups in the Gulf of Alaska and Bering Sea. That stack is also very thick. Those are the recommendations Dr. Low is going to present for the Bering Sea at this meeting next week upon which the council will base its recommendations on quotas to the Secretary of Commerce. These are things that are actually going to dictate removal levels from the Bering Sea. We will end up with maybe 20 species groups in the Bering Sea composed of dozens of species in each one of those groups and quotas which we then will close on. Last year we had about 180 separate management actions that closed fisheries because of bycatch or directional questions.

They will also meet and discuss the efficacy of some of the management measures relative to the marine mammals we have been discussing here today. In particular, they have adopted buffer zones for protection of sea lions that have closed areas to fishing. They adopted areas closed to trawling in the Bering Sea to protect crab habitat. A lot of those things have been done. Frankly, we're not totally sure of the actual impact of those, and we need to be. We think the actions are precautionary - we went out and did something in the absence of information. Somebody mentioned time and space. Five years ago the North Pacific Council acted to restrict the harvest of pollock in the Gulf of Alaska to quarterly segments by area instead of all at once. Some of this is happening in the Bering Sea as well. Is that enough? I don't know, but that certainly was one of the actions taken.

One of the issues brought up was the purpose of this workshop. Of course, as Deborah said yesterday, part of the genesis of this was the initial development of the White Paper on the Bering Sea. That focus was not to say the Gulf of Alaska and the Arctic Ocean or Chukchi Sea aren't also important. As a matter of fact, a couple of the things we will read to you a little later on the various potential funding and decision mechanisms that Clarence and others have brought up, focus on more than just the Bering Sea. But if you look at 70 percent of the nation's continental shelf, most of it is in the Bering Sea. If you look at the coastline, if you look at the overall productivity in terms of fish and marine mammals, this is a big deal. If you also put the Gulf of Alaska in, because I think that is appropriate, it is a big deal.

I think the good news that we got from this discussion is there is a lot of coordination going on, some people are knowledgeable of it. But I will tell you, even at this meeting, there are people who commonly in their talks popped up with, well, where do I get this information and who do I go to ask? If that's true in this room, think of what it is outside this room.

When we talked about funding for new things, I think the focus is also the funding for not eroding our base. I made the comment earlier that base funding wasn't doing the same old things. Frankly, the NOAA fleet is aging, and there is a big initiative to start replacing those vessels. You are not going to conduct an awful lot of new research or old research without that type of platform. Getting support for it is an ongoing heavy fight because those vessels are not cheap.

Doing surveys off Alaska which are directed on individual species is not bad. It does attempt to tell you how much of these species there are, it does create long term databases and knowledge of the fluctuations of those species, and is requiring a large amount of charter time as well as NOAA vessels. That is not getting better, it is getting worse. So if we got an opportunity on Dinkum-Sands or somewhere else to do new things, we don't want to just go out and buy, for example, more aerial surveys. But we would want to replace those we were doing previously.

There is an element of this factor that I hope to highlight as we go along and I hope as we start to look at what is really needed, it lends emphasis to the importance of doing this. This is a big national budget. There are a lot of things going down in terms of funding but there are areas that are so important to the people dependent on these resources that they should not be decreased. The case to be made around some of those may be better than other cases, so there may be ships. I am certainly not going to argue with the South Florida case that Bob Francis brought up as case history. It is a good case history only it had several hundreds of millions of dollars and that is probably way beyond anything we are going to get. But the idea of getting together and cooperating makes sense in how it was done.

I would now like to see if we can talk about the next steps. The White Paper you heard discussed was not approved by all agencies, not because our agency or others were not concerned about the focus and getting better research opportunities, and improved management of resources in this area. It was more because it had some decision-making processes that were either regional or national. The next step is tough and nobody was totally sure of what it would be. This was before Dinkum-Sands was passed and we did not have some of the other models in front of us that are there now.

I would like to go through some of the things I heard about priorities. I don't know how we explain to people out in the rest of the world why certain things are a priority to do. It is not an easy thing to explain the need for long-term databases. We have one scientist who has measured the length and size of chum salmon in a particular creek in Southeastern Alaska for 25 years. They happen to be the biggest chum salmon in the world. They're 25-30 pounds which is very, very unusual. That is now providing information to look at climate change and to look at the effects of varying abundance of salmon on the ocean carrying capacity. However, 15 years ago it was a pretty hard sell. There are a lot of other things here that are a hard sell. So we are going to have to do a pretty good job of packaging this stuff and making it clear to everybody why we need to do it.

We have had a lot of discussions of the next step now. Again, this workshop was devised and was one among many workshops. I'll accept that comment from a lot of people, that we need to start getting together, to coordinate and to interact between agencies and groups. We also need to look at things like Pat brought up for the past MMPA Bering Sea ecosystem workshop. We know it is there but I am not sure everybody does. We did a big ecosystem workshop drive and a research plan arrived with it, I don't know exactly where it all ended up in the great decision-making process but it was done. I think that type of interchange is why we started this out. Not that we expected this particular group or any other group to immediately jump to the conclusion of what you had to do next and what the most important thing was going to be or how much it will cost. I think those are starting to get at that next step.

Bill mentioned traditional knowledge. We heard a lot of discussion about how that is built into this system and there is still a lot of disagreement on how that would work. I will second what he said about direct observation being a very beneficial thing over a long period of time. Probably, we will need a separate workshop on that and that has been brought up. You may need separate workshops on specific species, you may need separate workshops on the development of metadatabases and how that is going to work. So there are a lot of things that need to be done.

As a result of this, we will look at what was recommended by several people and come up with a smaller focus group. It will not necessarily be composed of the same people entirely. But it will look at where we go from here, how we package it and maybe to get into a mission discussion. It will certainly be formed to better describe what we heard here, to bring it together and to make it into something legible so other people can build off of it.

The Dinkum-Sands legislation has been mentioned by several people, I won't read it all again. You have heard the membership, with 19 members appointed by various groups represented. That is an interesting piece of legislation relative to timing. It is to come from appropriated funds and as far as I know there are no funds appropriated right now. So through 1998 there is no funding for that initiative. It is going to be people getting together and figuring out what they want to do on their own hook or with agencies providing support, as near as I can tell. Probably if it is going to get any money on the board it is going to be for FY99. This means they would have to make some recommendations and agencies would have to look at that from a placeholder's standpoint very quickly, because the FY99 President's budget is going out the door.

From an actual funding standpoint, a congressional standpoint, there would have to be some recommendations by summer. That is a tall order. There will be 19 seats on the board with some seats having as many as three possible nominees. They are going to have to be picked by the Secretary of Commerce from nominations. We are going forward with it and have already initiated the letter process from the Secretary to the governors asking for nominations. When I say we initiated it, I have sent something in. That does not mean it is out the door yet anywhere. Our intent would be to bring whatever group is selected together as soon as possible to start this process of looking at the future.

In the meantime, however, we do have the question of how information gets to this group. If this group has to meet in May or thereabouts and starts to look at what we have done here, then it is not going to happen by this summer. So I think there is a need for this first focus group to discuss how we will package this. How do we offer this up? What type of process will be suggested for this group to reach decisions or have information come to it?

An ancillary one that Molly McCammon and we talked about a bit, is the restoration reserve by the Exxon Trustee Council. Deborah and I are familiar with that operation and we think it works. I think there are people outside who disagree with us in terms of what we have done, but we think interagency coordination and coordination between staff and principals has been very good. Part of that has been Ms. McCammon's putting together a strong staff to build some of that peer review and to build some of the process that feeds it up to us. We do not sit there and get individual presentations and in a meeting try and decide on it. Most of us are not able to do all of that, so some of it is pre-worked over, and then the final question is brought to the Trustee Council.

The restoration reserve will probably have a similar order of dollars available as the Dinkum-Sands, it depends on investment discussions that are ongoing. But between these two things, we are at 10 to 15 millon dollars. Obviously the Exxon Valdez area is the Gulf of Alaska. The Dinkum-Sands area is the North Pacific Ocean, including the Bering Sea and Arctic Ocean, so there's considerable overlap there in these two types of things. The way decisions are made could feed off of each other.

I do think the next step is a small synthesis group to look at what was presented here. Because this workshop wasn't just about information, it was about coordinated mechanisms that have occurred in the past and how they might feed into this process. I recently heard a NOAA talk on the scope and breadth of NOAA research and which also referred a little bit to the scope and interests of Interior. I will just tell you that there is a broad range of research that NOAA engages in. There is a perception out there that we are just fish, and that is a big part of it, but it is not all of it. We have marine mammal obligations under the MMPA and Endangered Species Act. We have coastal zone interactions, and we have habitat interactions. It is a broad area of ocean research that NOAA is involved in and I think it feeds right into this background for this exercise. So I think I will leave it at that for the moment. Thank you.

## Department of the Interior Perspectives

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Well, it's been fascinating to be here and unlike most of you, I haven't been to a Bering Sea workshop before, so I've been all ears and haven't had a sense of *deja vu* and have learned a lot. What I'm supposed to do is to address perspectives of the Interior Department on this matter. I'll have to mix perspectives of Bill Brown as well. Some of what I'll say are the departmental positions and some are reactions.

The first question for me and for the administration is: is the Bering Sea a priority? And for me, and for a number of us at Interior, I would say the answer is yes. But that's not an obvious answer. There are many regions of the United States and many ecosystems, each with many communities that are very supportive of investment in research. It's easy to get caught up in your own place and think that it warrants more attention than other places. Furthermore, most of the people in the United States live elsewhere.

However, from my point of view, the case is strong that this is special. One thing that stands out is that half of the fisheries production of the United States is here. I think that fact alone will capture the attention of some whose attention is needed.

Another thing is the connection between Russia and the United States through the Bering Sea. That is significant. And there are at least two other elements that I've noted capture national attention: and one is the overall productivity of the Bering Sea, including its birds and the marine mammals, and the other is the Native people, not just current cultures but historical activity and importance to our country. So, I guess my answer to the first question is: the Bering Sea is a priority. But you should recognize that everyone in this room is probably an advocate of doing more on the Bering Sea and still as you saw a few minutes ago, the room divided itself on whether the Bering Sea or the Gulf of Alaska is more of a priority. When you get down to national budget issues, you know, everyone has priorties.

I'd like to make a few observations on points expressed during the meeting. One is the discussion of investment in web-based information systems. I am a little unclear about whether information is being integrated on an international basis. To the extent that it can, that's desirable.

Several of the speakers have talked about what I guess has been called experimental management, which is a little like adaptive management. I think that looking at management in this area through that glass is smart. We are confronted here, as many other places, with what we are calling ecosystems with complex variables. We truly don't understand them and we are at the same time, for good reasons, using their resources. Decisions are being made and will continue to be made regulating resource use. So the smart thing to do is not to make a long term commitment to any particular management regime but do what you can recognizing the challenge to set up management experiments that you think are reasonable for protecting the resources, using an experimental design, that can be improved rapidly.

A third issue is this whole matter of making sure the science that is pursued is connected to the management decisions that need to be made. And let me draw a line, I draw a sharp line between pure science, some would say real science, and applied science. And I wouldn't try to ask any scientist who is pursuing research, as a philosophical matter - and that's what NFS is supposed to be about, basically - to be too worried about management decision making. But for agencies, like Interior, MMS and Fish and Wildlife, the National Park Service and Commerce - using taxpayers' dollars to implement programs which are really related to sustainable use and conservation - the science that's conducted really needs to be linked to the management decision-making process. I think that most of us involved in that process don't think we've done a perfect job by any means in the linkage. We frequently ask the wrong questions and we frequently don't package the information that comes back very well. Even if we package it well it's often not present when the decision is made.

The Department of the Interior has a science board that the Secretary chairs and the assistant secretaries and bureau directors are its members, so it really a science management board. One thing that we have launched is to ask each of the bureaus to come up with one issue, as a starter, which is keenly important to them, which involves management decision making that recurs and which everyone would agree should be informed by science, but which probably hasn't been informed that well. We've asked the bureaus to put together teams including their own bureau, other bureaus that are stakeholders within the Department, and including USGS, which is now the central science agency of Interior. We asked them to do a self-assessment and then to come back to the science board with our Secretary present and give their observations and steps they're going to take to improve their performance in linking those two. And to make recommendations as they need for new authority.

The first of those reports back is on Monday with the Bureau of Land Management doing a report on science and fire management. That is what they chose as a starter. It strikes me that kind of analysis would have value for the Bering Sea.

Another issue that strikes me as extremely complex but important is that the whole matter of integrating the Native people of Alaska and traditional knowledge into understanding the Bering Sea ecosystem. I think that is an undeniably good objective that we should pursue and I've been trying to help as I can. There is a special challenge as we heard about this morning. We have on one hand the desire of western scientists and the government of the United States through its Constitution to develop scientific information that is freely accessible, which is not owned. And, in fact, information paid for with tax dollars cannot be copyrighted. And then we've heard that there's a desire to have control over that information. If you live in Washington, D.C. or New York you live in the sea of tabloids. The basic rule is you can say almost anything so long as the other person can say almost anything back.

Many years ago I spent two years living on an island in the tropical Pacific, studying seabirds. I learned much in that two year time frame from being next to these birds and watching them all the time - much more than I would have learned as a scientist had I just gone out and measured beaks and looked for eggs, once every couple of days. And so I guess I am, at an intuitive level, convinced that traditional knowledge is enormously important. Many generations' experience close to these creatures and the environment is of great scientific value.

Those are some thoughts on concepts. Now, the Interior Department. Well, it's pretty clear to me that the Interior Department as distinguished from its laudable bureaus has abdicated for the past 15 years or so its responsibility to have to exercise leadership in respect to the oceans. We have MMS and we have USGS and we have Fish and Wildlife, the Park Service with its national seashores and so forth, moving ahead, but they've had little support from the Department itself. Now we intend to try to change that. The Secretary is very interested in being a full partner with colleagues in NOAA and helping to make sure that our management of the oceans is sound. We've gone through a process just now of trying to redefine in a simple way the objectives of the Department in respect to the oceans, related to the Department's fundamental missions.

That's evolving. We have defined seven objectives right now. They include the conservation and sustainable use of biodiversity in the coasts and continental shelf and in terrestrial and fresh water ecosystems to the extent that those organisms depend on the ocean. Another objective is the sound management of oil and gas development, which is a traditional MMS activity. We have trustee responsibilities for Native Americans, including Alaska Natives who are dependent on the coasts and the oceans and that is a fundamental objective of the Department.

We own or have oversight jurisdiction of many islands around the world, some up here, some in the tropics. One thing we've launched recently is an environmental review of coral reefs in the small islands, many uninhabited, that are owned by the Interior Department. So another objective is comprehensive environmental management of small islands.

Through USGS we have volcano and earthquake monitoring systems that extends throughout the oceans. I guess we experienced, at least a little bit of it with this morning's earthquake. And USGS together with NOAA has a major coastal-erosion monitoring program. On top of that, or underneath all of it really, to support all the objectives, we have in the USGS an agency of 10,000 people and a billion dollars expenditures annually which is dedicated to science.

Those are the objectives and then, of course, comes the conundrum of all this: there's no new money. Where's the money? The budgets are shrinking, every department has been asked to eat three percent. These are good people and good programs and it is very easy to get excited about a new initiative until you look the person in the face who's going to have to have less because of it and try to understand what the consequences of doing more in one place are for those that have to do less.

I was in the government for a few years before I left 20 years ago and just came back recently. To me the most dramatic change has been that now we are in an act of constant cannibalism. There's the conundrum.

So the question is, okay, what can you do? Well, it strikes me that the Marine Research Board that's been created is an opportunity, certainly for the Bering Sea. It covers a broader area, but there has been a lot of discussion about the Bering Sea being at least one of the key focuses of what it does. My expectation is that there will be an appropriation next year to fund its work, but there's no guarantee of that. To follow up a little bit on Steve Pennoyer's remark, we are operating under budget caps that are related to deficit reduction - fundamental caps. The likely position of the administration, required by OMB and the enforcement of these caps, is not to have additional money allocated through appropriation to that marine board without reduction in some other area. There really is a no sum gain because the basic budget process is defined by the budget agreement and deficit reduction. The only reason I think there probably will be an increase is because that is where the congressional delegation from Alaska will be, and that's their call, obviously.

There are two other larger but probably less promising opportunities in the short term. One is that the bill introduced in the House and Senate this year: the Ocean Act of 1997. I keep saying '77, I guess that reflects my connection to years. The senate bill was introduced by Senator Hollings with support from the Alaskans and others. Senator Stevens came to the introduction announcement of the bill and was very supportive. The house bill was introduced by Sam Farr and others in the House.

The Hollings Bill was passed on the day before the Congress recessed last month. It would fundamentally do two things. It would create a commission, which would be non-federal, with some congressional advisors. This would be essentially a Straten II Commission for those of you that followed the work of the Straten Commission in the '60s. It would take a comprehensive look at ocean policy and issue a report at some point. The Hollings Bill would also create a council within the administration. The premise is that this council would have more clout and would be expected to do more than the different interagency entities that exist to date. There are several of them floating around. The council would include all the agencies you would expect and its chairman would be appointed by the President. There's an interest in a number of agencies in having the President appoint the Vice President, but we'll see about that.

If the Hollings/Farr legislation gets enacted, I think it's likely to happen in the spring, then people will say -- and they're beginning to say it already, well, what's this council going to do? You know, where's the beef? And I can't tell you the Bering Sea is going to be part of the beef but I can at least tell you that somebody's going to be saying, where's the beef? And the Bering Sea is one of the things that could be thought about and activity in respect to it, so it's worth noting that.

The other thing that's happening, which may raise the profile of ocean issues and might help on the Bering Sea is discussion of whether there should be a White House conference on oceans for 1998, which has already been designated as the year of the oceans by the United Nations. It's not certain, but it's a good shot. The Commerce Department and the Interior Department are strongly supportive of it. The Defense Department and the State Department seem to be amenable. And I guess the White House, at this point, is to be decided. If it happens the conference is likely to be in June, a one-day conference. But again it's a vehicle for raising the profile of issues. And we've already engaged, informally, in a discussion of what might be deliverables. Now, of course, I have to tell you the deliverables that people are talking about are all things that could be done without new money because that's the way it is. But it would be -- it's worth thinking about and I will think about whether what I've heard about the Bering Sea, what I've learned more about it, would make it a deliverable that we should – some aspect of it a deliverable that we should support.

And these things -- I mean, I bring these up because it is a tough environment to get new resources and there really is no other way to do than finding way to raise the profile of issues. And all the money will not be federal that can come from a raised profiled. I mean, I do find it very encouraging that the Center for Marine Conservation, the World Wildlife Fund and the Nature Conservancy somehow, apparently independently, all decided the Bering Sea was a priority. It all came up at once and I'm sure really shocked people up here as to why they were doing this. That's interesting and that will make a difference in this process.

And if the - so these different kinds of things, this Marine Research Board in a specific way, the oceans bill that is likely to get passed, the White House conference that is likely to go forward. I guess I lay them out to you as in the dark cavern in which priorities and money lie, those things are glimmers of those animals, and you might be able to catch one or two of them.

## State of Alaska Perspective

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Always makes me nervous when Dr. Low gets his camera out. For those of you who don't know me, my name is David Benton. I'm Deputy Commissioner over at the Department of Fish and Game for the State of Alaska. And I also regret that Larry Merculieff likened, in some ways, this conference to the movie "Groundhog Day." For those of you who have been around this issue for a while, Larry could certainly be the Bill Murray of Bering Sea conferences, he's been to most of them. Some how or other I sort of feel like that buddy of his in the movie, who was the cheap insurance salesman that was run over by the car.

But, anyway, I think that both Steve and Bill have said a lot of the same things that I wanted to say on behalf of the State. I guess I'd like to pick up on a couple of comments they made, and maybe make a few statements about them. One of the things that strikes me sitting here and listening is that there is -- that it's no accident that the Center for Marine Conservation of the World Wildlife Fund or other groups like them are here. It's because there's a constituency that is out there in the world that cares about what happens in the Bering Sea, and the constituency is just part of a greater constituency that cares about what happens to the world's oceans.

I was in Monterey just a few days ago and I went to the Monterey Bay Aquarium that is a wonderful facility. They had a very nicely done, walk-through display, on the status of the world fisheries, and environmental problems associated with the world's oceans. And it was really very well done and there were a lot of people going through there and paying a lot of attention. Part of that display had to do with the North Pacific and the Bering Sea, and a lot of it had to do with other parts of the world. The point being that the public interest in what happens in the oceans and their interest in what happens to the marine environment and those communities that depend on our oceans and our marine environment, is growing by leaps and bounds all around the world. And certainly it is very strong in the United States.

With regard to the public interest in the Bering Sea, that constituency group has grown from those people that live around the coast of the Bering Sea. I think they're the ones that started building that sense of urgency and importance that ultimately led to this conference as well as the other Bering Sea conferences that have happened in recent times. It started with groups like the Bering Sea Coalition and the Alaska Marine Conservation Council. It's grown to include other kinds of groups and organizations from around the state and the nation, but they're the ones that have really brought about this interest and focus.

I think this is really important for those of us in the resource management agencies to remember and be cognizant of that pay and attention to. We often times get wrapped up way too much in what's possible given our budgets, or what's possible in next year's budget. We worry about what the Congress or the Legislature is going to do, and lose sight of that bigger picture of where the constituents might be taking the issues and where the constituents may be taking those congresses and those legislatures.

The Dinkum-Sands money didn't come about because of the Alaska Department of Fish and Game and the National Marine Fisheries Service thought it would be a neat idea to take some of that money and create a new research organization for the North Pacific. It came about because an opportunity was there, and there was a constituency for increased marine research in our part of the world. And I think that that's important, I think that's something that we all really need to pay a lot of attention to.

And I bring that up because, when we think about next steps, and we were challenged by a number of folks here today about next steps, we must not lose sight of where the initiative is coming from. I think that for those of us here, the three of us of the agencies we represent, we've got to look at the next step as being something that needs to also incorporate those constituents directly in developing what we're going to do. That we need to have a bottom up kind of an approach not a top down kind of approach. Top down doesn't work, it never has, never really will. We have to have something that has a community base in it and we have to make sure that communities are informed, and that communications are opened and actively maintained. That means we have to take the initiative to do that. We have to put the effort into that and make it happen.

One of the things that Bill said, just as an aside, is that Interior is thinking about taking a leadership role, and getting back involved in some of these things. I welcome that. I think a number of us here, and in one of my old former lives I had dealings with the Interior Department before I went to work for the Department of Fish and Game. A different life, a very different role. We would not have been too eager for Interior to take an expanded role. But the kinder, gentler Department of the Interior is very welcome.

We have to remember that one of the things, in addition to the bottom up approach, in addition to the community-based information, that has to happen is that the agencies must work together effectively. We must work together well and we cannot afford any longer to have conflicting agency missions get in the way of what we really are trying to do. And the reason I made the comment earlier about the kinder, gentler Interior Department is that it made me think of the Bristol Bay oil lease sale, something that happened quite a few years ago and because - I believe many of you know, there was a mission at the time in the Interior Department to promote leasing for oil and gas development in Bristol Bay, a very important area. That lease sale did occur, but it was a very expensive decision because those leases eventually had to be bought back. That happened because of concerns about the marine environment, now it happened because of the interest groups that were involved. Their drive and their ability to change and shape public policy eventually overrode the bureaucratic drive that was going on at the time. This cost a lot of money and wasted a lot of time. So, it's very welcome to see Interior stepping up to the plate, and taking the leadership role that Deborah Williams took to bring about this conference ant make these things happen.

So, turning to the next steps. What are they? I think Steve laid out a reasonable good pathway. I think I would focus on a couple of things. First, there have been a lot of these kinks of conferences, with a lot of recommendations. Very similar to the kinds of things that we've heard here today. And yet there's been very spotty of no follow through. The reason for that, in my mink, is that there's not been a forum or a focus that had longevity and had consistency to it, or had the ability to carry things beyond just the conclusion of a conference or next year's budget cycle.

The Dinkum-Sands money and the new marine science board might be a place to provide that kind of focus and might be a place that can provide that kind of longevity. We don't know that yet. There's a lot of work that needs to be done to put it together. The funding in my mind is not secure because it's subject to appropriations. But it is an opportunity. It's something that, if we all work together, I think we could make it a big success. And the appointments that are made to that board are going to be very crucial and I think that the interest groups that have been behind the drive to get that money and the interest groups that are behind the drive for the Year of the Ocean and those kinds of things, have got to play a central role in how we shape what that board does and its composition.

Second, I think that once the board is in place we need to have a very solid research plan. And, as you said Steve, we need to coordinate that effort with the Exxon Valdez Oil Spill Restoration Fund as it's created. I think the kind of peer review process that EVOS uses for particular projects is something that we really should take a strong look at because it seems to be working. It seems to be a pretty solid way of doing business and it avoids perhaps the problem that you can get into of just horse trading to fund somebody's pet project. That's very important.

One thing that we can do is, I hope, pull together all the Bering Sea research plans and recommendations from various organizations that have already been out there. I don't think we need to reinvent the wheel. And we certainly can learn a lot from those past efforts and hopefully capitalize on them as we get organized.

A final point that I want to mention is that we – and I heard it today and I'm sure it was said more that once – we cannot forget our international partners in what we do with the North Pacific and the Bering Sea. With regard to specifically just for the Bering Sea, we've roughly half of it under control. Our Russian friends have the other half. Their research and management institutions are somewhat under attack and certainly not well funded, and in some disarray. We've got, as you know, problems over there in terms of stability of their government. Their economy is in transition and it's manifesting itself in ways that affect our interests in the Bering Sea. We need to work with those organizations and individuals in Russia that are of like mind with us, or that are carrying out important research and management functions to try to help them through some tough times. Sometimes we're going to be on opposite sides of the fence with them and sometimes we won't, but we really have to make a more concerted effort to deal with what's going on in the Russian Far East and with Russia generally. And through other organizations – the AMAP process is another one that Carl mentioned – we need to bring in other entities on the international scale and try and use, perhaps, this research board and any funding we have there to ensure that projects compliment projects or programs accomplished under the auspices of other internal or international organizations.

Thank-you very much.

# BERING SEA WORKSHOP OVERVIEW

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I think that we have already had an overview of the conference. The panel did a wonderful job - the questions brought out many of the issues that were raised during all of the sessions and the last three speakers have said much of what I was going to say. I am going to speak, therefore, from the academic viewpoint as the other perspective has been very well covered in an interesting and informative way.

First, I would like to make a comment. The opening sessions of the workshop prepared the framework for the agenda extremely well but posed some impossible dilemmas. First, we were told by Dave Fluharty, that management will be forced to adapt to ecosystem considerations and that this reflects new values of society with respect to resource exploitation. We also heard from Deborah Williams that we are supposed to be thinking in terms of the very long view. We are supposed to have vision. Long time frames and instantaneous adaptive management are two different things. Since we are supposed to initiate this kind of an approach immediately, that may be unrealistic and result in less effective approaches to our research planning than we might have if we only take, or have to take, a short-term perspective. That is a danger. Perhaps what we have just heard is comforting, especially as Dave Benton points out, this may be an opportunity for long-term thinking and long-term pursuit of research. In that case, this is wonderful. It also means we have got to be very clever about how we design the whole system so that the fine tuning and the adaptation of the research as it develops, not just the management, is as good as it can be. This presents a real opportunity. However, one of the things that concerned me about the way we presented information in this workshop was that we treated ecosystems as though they are just conglomerations of species. Ecosystems are much more than that. They are, in fact, structures that adapt to the environment. The environment was discussed in some of the physical presentations Ultimately, however, we keep coming back to databases of organisms. We must have that, but our thinking has to go beyond that. This is because ecosystems are structures that adapt to climate. By definition, “management” of an ecosystem to achieve our own ends is impossible. However, we may be able to manipulate parts of it, given more information than we have now, so that within a decade or two, we might be able to accomplish some of the things we want to. If we try manipulating the whole scale, what we end up with is probably not going to be what we want. What we are talking about is managing ecosystems to suit our own ends and nature doesn’t work that way. Thus, we need to be careful about holding an anthropomorphic point of view.

The other issue which is very similar to the one I just mentioned is that if, indeed, there are long-term environmental changes that are affecting the Bering Sea ecosystem, and at the same time (as Don Schell pointed out), we are harvesting a lot of protein from the Bering Sea which removes nitrogen, then we have two compounding factors going on simultaneously. Both of these driving forces are affecting the system and we are dealing with an extremely temporally and spatially variable system. We have a difficult problem to study, maybe more difficult than most of the other regions which have been studied from the ecosystem point of view. We have a good idea about what is there. We also have good databases.

The databases we heard about previously at this workshop are very detailed and excellent. We have proposals for how to manage these databases, and as Alan Springer pointed out, we academics are not very good with data. We don’t like to deal with that kind of thing - we’d rather think about it. It’s very good that the agencies are tackling this problem for us and I think we should probably leave it to them to work out. It is clear that they are doing this and that it will be taken care of.

Knowledge sharing is a different question. This is something that I believe we all must do together. I think things like the Lowell Wakefield Symposia, Internet communications, etc., are excellent. As this research effort develops, such knowledge sharing is going to be very important. Obviously, it is going to involve many constituents - not just scientists. Whatever plan is designed, from the scientific point of view, we must ensure that there will be some mechanism for fine-tuning. This mechanism should allow the key people to be brought together to look at what is happening and to make sure that it doesn't just become an enclave of research projects that go along into perpetuity. It must be a dynamic and evolving system that parallels the ecosystem that it is studying. Another thing that concerned me during this workshop is that I haven't heard the word "hypothesis," nor the term "conceptual framework," during the entire two days. All we have heard about is data. I think we have to remember what science is, that we need to apply the scientific method and to have a conceptual framework. This is more important than the science plan. We have lots of science plans. It very often works well to have a conceptual framework and to let the scientists design the science plan as they go along, because that is what is going to happen anyway when they turn in their proposals. I know of several good science plans for the Bering Sea and I do not think we should discard them. I believe that we really need to let the scientists do that planning and not just those scientists who happen to be called together into a room for a particular occasion. The planning needs to be broader than that. This is something in which we academics can help because if you work with students a lot, especially advanced graduate students, you had better be thinking conceptually because otherwise, they are way ahead of you!

Another concern I have is regarding the interdisciplinary aspect. Again, we cannot look at simple populations of individual organisms - we must look at the whole system and how it functions and interrelates. This is bound to be quite complex. Also, scientists must come and go. You have to bring key specialists in at certain times to the program - at other times, they will not be needed. Here, again, I speak for academics because we are very good at this since we have short-term people available of very high quality, i.e., our Ph.D. students. They come and go, hopefully they finish at some time and then disappear. That is one way in which you can bring in expertise for a fairly short period of time. Even faculty (although they do not come and go quite as easily) can function in this way. In fact, they are rather persistent. The advantage is that you can involve them in a project for a short time (or a year or two), and then they can move onto something else thereby avoiding the hiring/creation of an infrastructure. The main point is that we have to have agencies working together. Agencies are obviously going to be the lead in most of this. I think that academics and other organizations can play an important part also in conducting research. They will have their own particular strengths with respect to the research.

There is the scale question - global scale. I don't think this was brought out very strongly and I may be going out on a limb on this one but I like to do that! One of the reasons the waters are so productive in the Bering Sea is because it lies at the end of the global conveyor belt of ocean circulation. It was brought out that the Pacific waters are washing up onto the Bering Sea shelf. This is the end of a long process that starts in the North Atlantic. If, indeed, the flow through the Bering Strait is slowing down, then it is a telecommunication with the whole of the global oceans. It is not just the North Pacific - it is a widespread phenomenon. We do not know that this is happening, but there have been some publications that suggest it could be. This would tie in with Don Schell's idea that the productivity in the Bering Sea is declining. The only reason productivity could decline, would be something like that. Even then, I don't see how it could be because there is usually excess nitrate over the most productive part of the Bering Sea, which is over the shelf, so that a slowing of the conveyor belt should not really immediately result in low production. This also ties in with Alan Springer's comments about the flow through the Bering Straits. We cannot ignore the global patterns of atmospheric or oceanic patterns in looking at the Bering Sea, especially if you want to know what the driving factors are.

There is also the issue of international cooperation. I must mention my "pet" organization - the North Pacific Marine Science Organization (PICES). PICES had a Bering Sea working group that was chaired by Dr. A.V. Tyler of the University of Alaska Fairbanks. Their work is complete and the report is out. Parts of it are incorporated into the PICES Climate Change Carrying Capacity Program, which includes a Bering Sea section. This is another science plan that is available. I think that the main thing that PICES can help with is that, as a treaty organization involving Pacific Rim nations, anything that comes through PICES carries some weight with governments in terms of implementing programs. It is also a useful medium for communications because there are travel monies around the various countries for people involved in PICES activities. Neither the waters nor the organisms recognize international boundaries and there is no way we can do so either. There has been a little help recently in that the State Department funded a project to translate some of the Russian literature dealing with the Bering Sea. The effort was spearheaded by Ole Mathisen and published by Alaska Sea Grant. Another book is coming out under the PICES Bering Sea working group, updating the information on the Bering Sea. Tom Loughlin of the National Marine Fisheries Service is the editor, and this too will be published by the Alaska Sea Grant Program, probably later in 1998.

We can't wait 100 years, but we do have the proxy approaches that have been discussed at this meeting. Don Schell is looking at baleen and making estimates not only about the productivity of the system, but he can tell you about food chains and where organisms have been feeding. Bob Francis has also been doing some proxy work on sediments in the nearshore areas. That is also very useful with respect to past history of fish populations. There is much data available and we must not forget that we always need to re-examine old data with new hypotheses as they are refined.

I would like to touch on the local integrated site idea. The distributed sort of research that we normally do at sea is great. It may be time to think about a single integrated site where you could focus some of the research, and the Pribilof Islands would make sense for that. It would be a necessity to involve local people. This would be a good opportunity. Lastly, another item that was mentioned this afternoon is the emphasis on the human dimension of global change that the National Science Foundation has been pushing. Clearly, we need to have strong input into this program by, and as a response to, commercial and subsistence users of the Bering Sea resources. This has to be a very serious consideration.

In summary, our vision is to be, by necessity, a human vision and must involve all the people interested in and concerned about the Bering Sea. At the same time, it must satisfy agency mandates and yet accommodate scientific rigor. This is a great challenge. I think that if this is indeed a long-term opportunity through the Dinkum-Sands Fund, that, again, we must be very careful and do a really good job. We have to ensure that the science that is proposed is based on valid scientific methods and hypotheses, and to avoid pressure for excessively short-term perspectives. This conference has been a good first step and I am looking forward to seeing what the next step is going to be.

# APPENDIX

## List of Major Organizations that Participated

**National Oceanic and Atmospheric Administration**
- National Marine Fisheries Service
- National Environmental Satellite, Data & Information Service
- Oceanic and Atmospheric Research
- National Ocean Service

**Department of the Interior**
- Office of the Special Assistant for Alaska to the Secretary of the Interior
- U.S. Fish and Wildlife Service
- U.S. Geological Survey
- Bureau of Land Management
- Minerals Management Service
- National Park Service
- Bureau of Indian Affairs

**State of Alaska**
- Office of the Governor
- Alaska Department of Fish and Game
- House of Representatives

**Universities**
- University of Alaska, Fairbanks, Anchorage, AK
- Alaska Pacific University, Anchorage, AK
- University of British Columbia, Vancouver, Canada
- University of Washington, Seattle, WA

**Other Agencies and Organizations**
- U.S. Department of State, Washington DC
- U.S. Arctic Research Commission, Anchorage, AK
- U.S. Environmental Protection Agency, Anchorage, AK
- U.S. Department of Defense, Elmendorf Air Force Base, AK
- North Pacific Fishery Management Council, Anchorage, AK
- Exxon Valdez Oil Spill Trustee Council, Anchorage, AK
- Washington Fish and Wildlife Service, Montesano, WA
- International Pacific Halibut Commission, Seattle, WA
- Bering Sea Coalition, Chugiak, AK
- Alaska Native Science Commission, Anchorage, AK
- Bristol Bay Borough, Naknek, AK
- Natural Resources Conservation Service, Anchorage, AK
- Southwest Alaska Municipal Conference, Dillingham, AK
- Alaska Management Consultants, Anchorage, AK
- Alaska Sea Otter Commission, Anchorage, AK
- Aleutians West Coastal Resource, Anchorage, AK
- Arctic Network, Anchorage, AK
- Bering Sea Fisherman's Association, Anchorage, AK
- Tanadgusiz Corporation, Anchorage, AK
- Kirkwood and Associates, City of St. Paul, Federal Way, WA

Kodiak Brown Bear Trust, Anchorage, AK
WEST, Inc., Anchorage, AK
World Wildlife Fund, Washington, DC
Center for Marine Conservation, Washington, DC
Pribilof Marine Ecosystem Research Program, Washington, DC
The Nature Conservancy, Anchorage, AK
GreenPeace, Anchorage, AK
Alaska Marine Conservation Council, Kodiak, AK
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