NOAA's Arctic Research Initiative: Proceedings of a Workshop

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NOAA's ARCTIC RESEARCH INITIATIVE

PROCEEDINGS OF A WORKSHOP

Polar Research Board
Commission on Geosciences, Environment, and Resources
National Research Council

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This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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Preface

The Polar Research Board (PRB) was established in 1958 to promote excellence in polar science and to provide assistance as needed to federal agencies. The PRB strives to enhance understanding of both the Arctic and Antarctic and ensure that U.S. research efforts are responsive to the needs of the nation. All PRB activities are conducted by volunteer experts, supported by a small staff. The nature of PRB activities varies. Often, committees are appointed to conduct focused studies that result in detailed reports such as *The Bering Sea Ecosystem* (1996) or *Science and Stewardship in the Antarctic* (1993). As an ongoing activity, the PRB serves as the U.S. national committee to two international bodies devoted to planning polar research, the Scientific Committee on Antarctic Research (SCAR) and the International Arctic Science Committee (IASC), making sure that U.S. interests are represented. We design our activities to meet the needs of our community.

This Proceedings describes a workshop conducted on July 11, 1997, at the request of the National Oceanic and Atmospheric Administration (NOAA). NOAA is responsible for a research program called the Arctic Research Initiative (ARI), which is dedicated to understanding issues related to the health of the Western Arctic and the Bering Sea ecosystem, focusing on both natural variability in and anthropogenic influences on the region. Although the program is small at only $1 million in 1997 and perhaps up to $2 million in 1998, or perhaps because it is, NOAA wished to give special attention to planning a strategy for selecting the types of research that should be supported. Thus it asked the PRB to organize and host a workshop to help NOAA orient the ARI so it meets important research needs, better supports the NOAA mission, and at the same time contributes effectively to meeting national and international needs for addressing the health of the Arctic environment. This Proceedings contains an overview of the

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workshop, transcripts of the presentations and discussions that occurred, and a variety of background materials useful in understanding the Arctic Research Initiative.

We are fully aware that a one-day event cannot provide detailed guidance on research priorities, and in fact National Research Council policy precludes us from generating recommendations without a careful deliberative process. We hope NOAA will accept this volume in the spirit intended—as a record of a thought-provoking day of informal discussions. The workshop was designed to briefly review NOAA's involvement in research on Arctic contamination and then give a wide range of participants an opportunity to comment on the Arctic Research Initiative. Some 50 people from NOAA, other federal agencies, universities, and elsewhere participated. The PRB thanks these people for giving their time and sharing their ideas. I thank the PRB members who guided the workshop discussions, student intern Kary Thompson for logistical support, and the staff at NOAA's Office of Oceanic and Atmospheric Research (OAR), especially Renee Tatusko, for their assistance and interest.

Chris Elfring, Director
Polar Research Board

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1

Overview

At the request of NOAA's Office of Oceanic and Atmospheric Research (OAR), on July 11, 1997, the Polar Research Board (PRB) conducted a workshop to bring together knowledgeable people whose views about the need for research on Arctic contamination issues would be valuable to NOAA as the agency plans for the second phase of its Arctic Research Initiative (ARI). The ARI began in 1997 with an initial appropriation of $1 million to support research in the Arctic. The original focus of the ARI was the health of the Western Arctic and Bering Sea Ecosystem, and during its first year the program emphasized two research themes: (1) the study of natural variability in the Arctic ecosystem and (2) understanding anthropogenic influences on that system. An Announcement of Opportunity was disseminated, proposals received, and funds allocated to proposals most relevant to these two themes based on scientific merit. In that first year, 57 proposals requesting over $3.5 million were received. In the end, a technical review panel selected 15 proposals for support and made awards of $900,000. The remaining $100,000 was used by NOAA and the University of Alaska's Cooperative Institute for Arctic Research (CIFAR) to run the scientific review process and for various aspects of planning and management, including this workshop.

To guide the second year of the ARI, NOAA believed that additional thought about program themes, goals, and integration with other Arctic research activities was in order. Thus NOAA asked for the PRB's assistance, and this workshop was the result of that request. The intent of the workshop was to examine the ARI as currently structured and discuss how the program might evolve. Although this workshop can only provide a "snapshot" of the opinions of the participants, we hoped that through the presentations, brainstorming, and small group discussions, the workshop participants could examine the identified research themes and give input on whether they are still appropriate, expand on

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these broad themes by proposing possible key research questions that could benefit from attention, and provide other ideas to facilitate NOAA's planning for continuation of the ARI next year and perhaps in years to come. This input is intended to help NOAA manage the ARI so it better supports the NOAA mission while at the same time contributing to meeting national and international goals for addressing the health of the Arctic environment. This proceedings serves as a record of the workshop: Chapter 1 is an overview written to summarize the day's most important discussions; Chapter 2 is a transcript of the presentations, and thus contains more detail; and Chapter 3 reproduces selected background materials used by the workshop participants.

The workshop involved some 50 participants, including members of the Polar Research Board, key staff and administrators of NOAA, representatives of various agencies with Arctic interests and programs (such as the National Science Foundation, the Environmental Protection Agency, the Office of Naval Research, the Marine Mammal Commission, the National Atmospheric and Space Administration, and the State Department), plus representatives of the Arctic Research Commission, the Arctic Consortium of the United States, and a variety of outside scientists with strong interests in the Arctic. Although funding was extremely limited, special effort was made to bring some representatives from Alaska. The goal was to involve a diversity of interests and expertise while keeping the group small to allow substantive discussions and an informal exchange of ideas.

KEY ISSUES

The workshop began with a series of presentations by NOAA staff who outlined current NOAA programs in the Arctic and their relevance to ARI themes. NOAA's mission is broad and in the Arctic it deals with weather monitoring and forecasting, fisheries management, habitat protection, and conservation of protected marine mammals. It addresses both natural variability in and anthropogenic influences on the region. Thus, Arctic contaminants—including their origin, transportation, and fate—are relevant because contaminants can affect these interests and because they play an important role in atmospheric problems such as Arctic haze, ozone depletion, and UV radiation.

Current research suggests that climate change is occurring in the Arctic and that contaminants may be involved in this change. For instance, data indicate that the snow cover in parts of Alaska apparently melts earlier each year, and there appears to be a gradual and permanent thawing of the permafrost in certain areas. Because such changes may only be partially related to human-introduced contaminants, a knowledge of the variability in the ecosystem is necessary in order to sort the natural effects from those that are anthropogenic. According to discussions at the workshop, some of the areas where research would be useful include determining factors affecting ice-pack location and density, sea surface temperature analysis over long periods of time, and a range of physical and biologic oceanographic studies that could document climate change.

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Participants also noted the importance of gaining an understanding of the role of Arctic tundra in the global carbon budget; evidence indicates that tundra has changed from being a carbon sink during historic times to being a source of CO_2 for the atmosphere.

Workshop participants stressed that the health of the Arctic marine biosphere has a real impact on people: about 40 percent of the fish consumed in the United States are taken from the Bering Sea fisheries, and the Bering Sea is critical to various local communities. Thus, there is an urgent need to understand the effects of contaminants on fish and mammals as well as the effects on humans resulting from human consumption of these marine resources. Because the food chain can be affected by UV and ozone changes, they also thought that careful work was necessary on the UV index, now an important part of daily weather forecasts, as well as the extent of ozone depletion.

Representatives of federal agencies with Arctic interests expressed concern about related matters including the consequences of thawing of permafrost in Alaska (and Russia) and the consideration of the marine ecosystem and marine resources as important international issues that will need cooperation of the Arctic nations.

What are the important research directions that NOAA should address in its ARI? How can the program be steered to better support NOAA's mission and conduct high priority work while at the same time contributing to national and even international efforts to understand and protect the health of the Arctic environment? The primary subjects discussed at the workshop fell into four major areas:

- anthropogenic influences on the western Arctic ecosystem—contaminant sources, transport and dispersion, and feedback loop effects on humans and key ecosystem components;
- Arctic haze, ozone, and UV flux;
- natural variability in the Arctic ecosystem; and
- interrelationship of NOAA's activities with the Arctic Monitoring and Assessment Program (AMAP).

The first three issues parallel the key themes used to guide the first year of the ARI, a sign that the ARI has been on the fight track. Workshop participants were given an opportunity to critique these themes or create new ones, but the general sense of the discussion was that these themes provided a solid foundation for addressing the health of the Arctic. As judged by the workshop participants, the ARI needs only to mature and evolve, and part of that evolution should be to move toward a more integrated and focused effort. Natural variability, while listed separately, is clearly a common denominator among the themes. The last item, AMAP, was the one substantive addition identified by workshop participants.

While many participants felt that the most important issue is the effect of Arctic contaminants on people, most of the related areas of concern—such as individual and community health, subsistence, and risk assessment—are outside the scope of NOAA's mandate. However, the flow of contaminants through the ecosystem, especially

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atmospheric and food chain effects, is of direct interest to NOAA and thus can be addressed by the ARI. Many workshop participants expressed the opinion that contaminant research should be science-driven. In other words, it should be the result of careful assessment of research needs and selection of priorities that give an integrated view of the problem as opposed to a more random assortment of good but not necessarily related proposals. Research should use an ecosystem approach focusing on the source of the contaminants, the interactions of atmospheric and oceanic sources and sinks, and the progress of contaminants through and their effects on the Arctic ecosystem. Better coordination of analytical techniques among the various groups conducting research is essential. In addition, it might prove useful to establish a set of Alaskan index sites and index species for a long-term study to document the effects of contaminants on the ecosystem.

Workshop participants emphasized that research on Arctic haze, ozone depletion, and UV flux should continue to be key themes for the ARI. However, they noted that an accurate understanding of anthropogenic effects on the atmosphere can only be attained if the natural variability in the different system components is understood. Research in these areas should take advantage of instrumental and paleorecords, focus on stability/mixing dynamics, and use modeling to help identify and evaluate key variables. Understanding chemical and physical characteristics of Arctic haze may help define the source areas of the aerosols. Integrating this information with our knowledge of Arctic atmospheric circulation should aid in understanding and defining long-term trends. To accomplish this objective, Arctic ozone anomalies, losses, and trends should be studied further. In addition, better understanding of Arctic volcanic perturbations of stratospheric aerosol is needed to see the effects of such phenomena on the ozone. In addition, participants thought there was a need for research on the temperature trends for formation of polar stratospheric clouds and the wintertime stability of the Arctic stratosphere vortex. Finally, because the impact of commercial transpolar aviation on the Arctic stratosphere is largely unknown, further study of this issue should be encouraged.

Workshop participants noted that there has been considerable progress toward understanding the Arctic UV flux. The UV International Research Centers (UVIRCs) provide an opportunity to use an integrative, multidisciplinary approach to identify, quantify, model, and predict the short-and long-term effects of UV radiation, and could include studies of UV-induced changes in terrestrial and aquatic ecosystems.

From the workshop discussions, it is clear that understanding natural variability is a theme common among all the ARI topics of interest and that anthropogenic change cannot be understood without an understanding of natural variability. We need to know the variability amplitude and the relevant time scales of the important environmental parameters related to natural change. To gain this understanding, we need to develop and use long-term records of Arctic natural variability now stored in ice and marine and terrestrial sediment cores. The role of long-term natural variability in atmospheric and oceanic processes, and how this contrasts with human-induced changes, needs to be better understood. Such an understanding can be enhanced by sensitivity studies and simulation

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modeling that can test the applicability of various parameters in the ecosystem. A solid understanding of coupled physical-biological models and processes, which may need to extend outside of the narrow borders of the Bering Sea, may be necessary to obtain some of this data.

Another issue that arose, first in the working group on contaminant sources, transport and effects but then again in plenary discussions, was the importance of using a systems approach to contaminants research in the Arctic. Workshop participants stressed that a comprehensive, systems-oriented approach is essential if we are to develop a real understanding of the causes and effects of contaminants in the Arctic.

One strong opinion expressed during the workshop discussions was that the United States should play a more active role in the Arctic Monitoring and Assessment Program (AMAP) (see Box 1), and that U.S. contributions to date have been disappointing. Full participation would involve at least one long-term study site in the U.S. Arctic where baseline and trend studies of environmental stressors could be made, and the provision of funding to support a U.S. AMAP coordinator. Better support of this international program would pay high dividends for the ARI as well as meet U.S. international obligations and allow the U.S. to benefit from other nations' contributions to the next phase of AMAP. Although a number of agencies are conducting and funding AMAP-related research, workshop participants thought that NOAA could play a lead role in the U.S. effort because the objectives of AMAP are complementary with the objectives of the ARI and with other elements of NOAA's mission.

Another issue discussed during the workshop was how to ensure quality proposals that directly address the priorities set out by NOAA and ARI administrators. An Announcement of Opportunity is one way to proceed in any research granting process, as was done to select projects for ARI support in 1997 and as is planned for 1998. But workshop participants noted that this "bottom-up" approach for supporting research activities may not always foster a focused effort. Dr. Garry Brass, Director of the Arctic Research Commission, argued persuasively that perhaps some portion of ARI funds be allocated in a "top down" fashion—meaning that NOAA administrators take the initiative to determine selected high priority research questions and then solicit proposals from those who are best equipped to work on those questions. Using this approach for some of the funds would allow NOAA more control in ensuring that proposals meet identified needs and specific goals.

A significant portion of the workshop was conducted in small groups, where participants focused on the major research themes and discussed a range of important research questions that might be addressed by the ARI. Three of the working groups addressed the main NOAA/ARI research themes of (1) natural variability; (2) anthropogenic influences: contaminant sources, transport, dispersion, and effects; and (3) anthropogenic influences: Arctic haze, ozone, and UV flux. Another group addressed U.S. involvement in AMAP. The groups were charged to first brainstorm a variety of potentially important research topics and then to attempt to identify some subset of those

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questions that merit high priority attention. Boxes 2, 3, and 4 provide summaries of the small groups' thinking about the major research themes.

BOX 1 THE ARCTIC MONITORING AND ASSESSMENT PROGRAM

The Arctic Monitoring and Assessment Programme (AMAP) is an international effort begun in 1991 as part of the Arctic Environmental Protection Strategy (AEPS). The main objective of AMAP is to monitor the levels of anthropogenic pollutants and assess the effects on the Arctic, including the atmosphere, the terrestrial environment, the freshwater environment, the marine environment, and human health. AMAP also was charged to document pollution trends, examine the impacts of pollution on Arctic flora and fauna, especially those used by indigenous people, and give advice to Ministers from participating countries on priority actions needed to improve the Arctic condition. The eight circumpolar countries that take part in AMAP are: Canada, Denmark, Finland, Iceland, Norway, the Federation of Russia, Sweden, and the United States. Representatives from indigenous peoples organizations and non-Arctic countries and international organizations involved in significant research and monitoring efforts also participate.

The work within AMAP is based primarily on existing national and international programs. Bringing these existing efforts together, and creating new efforts to fill in the gaps, was intended to produce the first comprehensive assessment of the state of the Arctic environment. Efforts included monitoring projects Within countries and across borders under bilateral and multilateral agreements, joint research cruises, and remote sensing. The first phase of AMAP lasted from 1991 until 1997, with publication of the AMAP Assessment Report. U.S. participation in this first phase of AMAP was disappointing and how to improve U.S. efforts has been the subject of considerable debate within the U.S. government and the Arctic science community.

Each group was also asked to develop a list of factors that ARI administrators should consider when evaluating research proposals, and Box 5 is a compilation of these suggestions. Please note that these summaries were created at the workshop by the groups and thus reflect only the views of the small groups of people with limited time to deliberate. They are provided only as guides to the types of questions experts consider appropriate for study; further effort would be needed to develop a more careful list of research priorities or a comprehensive strategy for addressing those priorities. There also was not enough time for a thorough discussion and review necessary to integrate across the ARI's theme areas; this would need to be done by the program administrators overseeing the proposal selection process. Although we have edited the lists slightly for readability, the structure and scope of the lists varied from group to group and we have not attempted to impose consistency or refine the thinking. Where items appear in bold, those items were judged by that group to be of especially high priority. Beyond grouping the bold items at the top of each list, the items are not listed in priority order.

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CONCLUSION

This workshop was intended to give NOAA guidance useful for steering the Arctic Research Initiative into its second year and beyond. This proceedings was produced to be a permanent record of the workshop discussions and an overview of the main lessons learned, and it should serve to give NOAA input to create a more focused approach for allocating funds under the Arctic Research Initiative. Our purpose in hosting the workshop was achieved: we were pleased with the amount of material covered, the seriousness of the deliberations, and the range of suggestions put forward. It was a significant level of work for a small group with only one day of effort available. But we realize that much of the real effort remains—sorting the most useful ideas from the many interesting thoughts and implementing them within the context of the Arctic Research Initiative. This step remains for NOAA, CIFAR, and the scientists submitting proposals and receiving grants from the program. Or perhaps given the liberty of a longer planning horizon, NOAA and the ARI managers might devise a mechanism to more carefully define the research priorities and questions, such as a workshop focused on each theme or a more in-depth program evaluation. The challenge is to move from the broad thinking expressed in the research themes to more specific activities without losing the overall vision for the program and in a way that makes the sum of the parts add up to some greater whole.

Beyond this Overview, this proceedings includes copies of the background materials provided to the workshop participants and, as a record of the actual discussions, transcripts of the plenary sessions. Please note that the transcripts have been edited to improve readability but no substantive new material was added; thus the documents retain the informal, spoken tone of the meeting. Speakers were given an opportunity to review and edit the transcript of their talks. Transcripts of the questions asked and subsequent discussions are provided as well, but with the caveat that these are informal remarks provided only to give the gull flavor of the workshop.

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BOX 2 RESEARCH NEEDED TO ADDRESS NATURAL VARIABILITY

- **Coordinate, share, combine information from different databases. Need to establish baseline understanding so we can understand variability**.
- **Better understand the spectrum of the variability, amplitude, and time scales of important environmental parameters. Define important parameters; develop models to describe variability**
- **Environmental monitoring of critical areas (e.g., Barrow, Alaska**).
- **Improved ability to predict fisheries stock trends, to determine what is "natural" versus "man-made" effects; to understand regimes shifts**.
- **Improved capabilities to use of anthropogenic contaminants as tracers to better understand natural variability and contaminant transport; these must be nontoxic**.
- **More sensitivity studies and models to identify parameters of variability**.
- Better quality assurance, quality control, and attention to how data is collected and analyzed.
- Better understanding of interannual variability of greenbelt processes, including shelf/slope exchange processes.
- Address ice dynamics/thermodynamics, including historical records and trends.
- Address variability Of stratosphere (ozone depletion, Cooling), long-term trends, effect of cloud, and driving forces for stratospheric stability.
- Better Understanding of coupled physical-biological models/processes including beyond the boundaries of the Bering Sea.
- Consider long-trail records (1000s of years) through ice and sediment cores to put current variability into perspective.
- Improved comparative studies in the Arctic, including comparisons of similar environments with different human usage.
- Better understanding multi-stressor problem-existing and possible future stressors.
- Better understanding of "predictability." How far out into the future do we need to predict?
- Increased emphasis on habitat change (e.g., migratory changes, permafrost, vegetation changes).
- Better understanding of the role of long-term Variability in atmospheric transport on temperature, cloud cover, and arctic haze variations (as opposed to greenhouse gas forcing).
- Increased use of common calibration procedures.

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BOX 3 RESEARCH NEEDED TO ADDRESS CONTAMINANT SOURCES, TRANSPORT, AND EFFECTS

- **Effects of contaminants on people, both now and in the future. Specific areas of concern include individual health, community health, subsistence, risk assessment, and risk communications. These areas are generally outside the scope of NOAA's mandate. However, related areas that do fall within the scope of NOAA's mandate include ecological risk assessment, the long-term study of possible sentinel species, and exposure estimates**.
- **Contaminants research should use an ecosystems .approach, focusing on the food web and biomagnification**.
- The interaction between Arctic and subarctic transport processes.
- The interactions of sources and sinks, especially land-atmosphere exchanges.
- Large scale patterns of and controls on contaminant transport.
- Large scale patterns of and controls on atmospheric CO_2 and methane concentrations.
- Studies of local sources of contamination and their effects.
- Baseline studies of local sources and effects of newly introduced chemicals should be conducted.
- An important area that has received little or no scientific attention is the decision-making processes used by and the motivations of the people who institute policies leading to serious environmental damage. Of particular interest are policy makers in the former Soviet Union. However, these issues fall within the domain of the social sciences and not NOAA.
- Contaminant research should be science-driven. This means that it should not be ad hoc, but guided by careful assessment of research needs so what results over time is an integrated view of the problem.
- Special attention Should be paid to multiple stressors and Synergy.

ADMINISTRATIVE ISSUES

- Continued efforts to improve and standardize analytical protocols so there can be calibration of the results of different studies.
- Systematic efforts archive data on contaminants (origin, transport, effects). If data are stored in dispersed locations, a network of communications between the several archives, and between the archives and researchers, needs to be created. A general policy governing proprietary rights to data must be agreed on before such a network will be able to function effectively. (To do this, the advice of scientists working on similar issues in the Antarctic should be sought.)
- A set of index sites should be established and monitored.
- A set of index species populations should be agreed upon and monitored.
- Documenting the effects of contaminants should be encouraged.
- There is a need for greatly improved communication between the members of the scientific community and Arctic residents with respect to contaminants. In this exchange, scientists should listen as well as speak.

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BOX 4 RESEARCH NEEDED TO ADDRESS ARCTIC HAZE, OZONE, AND UV FLUX

General Areas of Significance:

• **Define variability in atmospheric circulation as a driver for all 3 areas, plus**:

- take advantage of instrumental and paleo records,

- focus on stability/mixing dynamics, and

- improve modeling and Validation.

• Effects of UVB on biosphere (e.g., Aleutian low dynamics).

UV Flux

(Note: The working group the IASC document. "Effects of UV Radiation" as the basis for its discussion and selecting the following key issues.)

• **UV International Research Centers (UVIRCs): using the research stations that already exist in the Arctic to measure UV changes, we should incorporate a biological component so we can begin to develop a coordinated understanding of UV flux and its effects**.

• **Surface and Satellite monitoring and modeling of the UV radiation field**.

• **Effects of UVB on aquatic ecosystem (e.g, abundance, distribution, composition, and biogeochemical cycling of particulate and dissolved organic matter in diverse aquatic ecosystems)**.

• Effects of UV on terrestrial ecosystems. UV-induced changes in plant chemical composition.

• Effects of UVB on human health.

• Social impacts of UVB radiation, e.g., perturbation of food chain and impact to indigenous populations.

• Effects of arctic haze and clouds on UV radiation

Ozone: Stratosphere

• **Characterize ozone anomalies, loss, and trends**.

• **Understand temperature trends for formation of polar stratospheric clouds (PSCs)**.

• Wintertime stability of Arctic stratosphere Vortex.

• Volcanic perturbations to stratospheric aerosol and effects on ozone.

• Impact. of current commercial transpolar subsonic aviation (current and projected). on Arctic stratosphere.

Arctic Haze

• **Understanding and defining long-term trends**.

• **Understanding chemical and physical characteristics of Arctic haze**.

• Atmospheric circulation variations.

• Understanding source regions of aerosols.

• Comparisons of databases in U.S. and Russia.

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BOX 5 BRAINSTORMING RESULTS: FACTORS CONSIDER WHEN EVALUATING RESEARCH PROPOSALS

- Be high-quality science, as judged by the peer review.
- Address identified gaps.
- Greatest socioeconomic impact.
- Reasonable cost.
- Strong impacts/effects.
- Relevance to identified three theme areas.
- New finding; current need related to human health and environment.
- Meet the intent of Congress (as specified in authorization).
- Help honor U.S. international commitments (e.g., AMAP).
- Study design must be based on clear paradigms (study locations, spatial and temporal resolutions, risk, assessments, etc.).
- Must be a fair and open selection process.
- Relevance to societal needs and basic research.
- The contribution of the research to an understanding of systems.
- The extent to which the research involves partnerships, cost sharing, participation of Alaskan Natives.
- The extent to which the research is built on existing programs (i.e., leveraging).
- Individual efforts must integrate to equal something greater than or equal to the parts.

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2

Presentations and Discussions

ORIENTATION TO WORKSHOP GOALS

Welcome

Welcome Dave Clark, Polar Research Board

On behalf of the Polar Research Board of the National Research Council, it is my pleasure to welcome you to this workshop[1] concerned with NOAA's Arctic research initiative. The principal focus of this workshop is to develop a series of suggestions that the NOAA will find useful in guiding the next phase of the Arctic Research Initiative.

Today, as I have watched people file in this room, I thought that things have changed in the Arctic in the last few years. Thirty years ago all of those in the U.S. who were concerned with the Arctic would have fit in just one comer of this room. Yet this year alone, I have attended five Arctic research meetings, most of which included different people than are here today (and the last meeting had 200 in attendance). People like Garry Brass and others here have probably attended even more Arctic-related meetings with different people.

This is good because it represents a dramatic shift in research emphasis in this country. We recognize new problems in the Arctic, problems that we want to address today. During the past 30 years, we have developed new techniques to solve some of the old problems. Perhaps most important is that the funding available now for research to solve some of these Arctic problems is at a more substantial level than it has ever been. The really good news is that with so much activity in the Arctic now, many of the problems that we worried about for years are being addressed and addressed in a good fashion. And of course, we are learning more about this intriguing and strategic part of the earth than we hoped to learn 30 years ago.

[1] The papers in this volume were developed from transcripts of recordings made at the workshop. They have been edited for clarity but not changed in substantive ways nor have we attempted to alter the informal tone of the discussions. Some speakers provided copies of the overheads that illustrated their talks, and these are included here, but we could not guarantee quality reproduction.

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The bad news for those of us who have been involved for a long time is that we no longer have a monopoly on Arctic research. This includes the annoying fact that our manuscripts are criticized more heavily and we don't get as much money for our personal research because there are so many more people working in the area. Nonetheless, the fact that Arctic research is moving forward is a great thing, and the Polar Research Board, among many other groups, is very appreciative of NOAA's initiative.

Today we have a specific objective and only a few hours allotted to accomplish it. We have many speakers scheduled and, more importantly, many issues to discuss. The proceedings of this workshop will be published by the National Academy Press, and we hope that our discussions will be useful in guiding NOAA's Office of Oceanic and Atmospheric Research in defining and pushing forward their Arctic Research Initiative. Just how good these proceedings are and just how useful they are to NOAA depends, of course, upon the full participation of each of you in attendance. So, we are ready to go. I will ask Walt Oechel, who is serving as the chairman of the workshop, to define our specific plan of action for today's activities.

Workshop Structure and Goals

Walter Oechel, Polar Research Board

I think this is a fantastic opportunity to have some formal input into NOAA's contaminant research program. What we would like to do today is review the key gaps in areas requiring research in Arctic contaminants, review what NOAA has done up to this point, and what it is doing now. After that what we will try to identify the areas where NOAA is best able to make a contribution, and this includes looking at what other agencies are doing and what NOAA's unique capabilities are.

So, we should consider NOAA's capabilities, the possible synergism with other agencies and institutions, and try to identify major gaps in contaminants research. As we use the term here, contaminants research is fairly broadly defined. We want to help NOAA build a coherent program, something that is identifiable and can move the field ahead.

The structure of today's workshop is to briefly review NOAA's Arctic Research Initiative and, also, hear a bit about the U.S. Arctic contaminants research meeting from Fairbanks last August. Jim Baker, NOAA's top administrator, will talk about "the big picture" and how the issue of contaminants and the Arctic Research Initiative should fit into that larger context. We'll then have a series of talks reviewing various NOAA programs and how they contribute to our understanding of contamination in the Arctic. We will also look at perspectives from outside NOAA to make sure that what NOAA is doing fits in the broader context. All this will easily take all morning. Before we break for lunch, we will have a general brainstorming session to look at the large research questions and try to identify additional research points that we may want to discuss in the breakout groups. Then during lunch we will ease into the breakout discussions, and after

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lunch have focused discussions on the three major research questions. We'll return here for a plenary discussion and reports from the breakout groups.

Time is very limited and we have a very ambitious agenda for one day. PRB member Gordon Cox has volunteered to be the timekeeper. So, he has a large hook, and will be ruthless in its application.

Your meeting books contain a description of the Arctic Research Initiative, which you'll note focuses on the Bering Sea region and Western Alaska. The main elements within the program have been a study of natural variability and studies of anthropogenic influences, including contaminants transport and fate plus issues like Arctic haze, ozone, and UV changes. NOAA has been very interested in the impacts on ecosystem structure and function. So, those are the major issues that we want to talk about today. We need to ask not just what research is need but where can NOAA make the largest contribution? How can NOAA best work with other agencies' programs and in the end come up with a coherent, well-focused program.

So, with that I would like to ask Joe Friday to give us a general introduction. Joe Friday is the Assistant Administrator for OAR, for anyone who doesn't know.

Welcome

Joe Friday, NOAA's Office of Oceanic and Atmospheric Research

I have been the Assistant Administrator for NOAA's Office of Oceanic and Atmospheric Research (OAR) for only two weeks now, but I wanted to welcome you because this is an area that I am looking forward to with great enthusiasm and great interest. I am not a newcomer to the Arctic issues. I served as the Department of Defense representative to the Interagency Arctic Research Coordinating Council back when I was Director of Environmental and Life Sciences as a young, dashing Air Force colonel. That is many years ago unfortunately, 1979 through 1981.

At that time, some of you may remember one of the things that we were involved with doing in that time period was trying to evaluate the physical plants and everything else that should be there, and this was the time frame in which the Navy recognized it was probably cheaper to deploy from the lower Forty-Eight than it was to maintain the full capacity up at NARL (Naval Arctic Research Laboratory). As a result, it phased down some of the activities up at Barrow.

During the 16 years that I spent in the National Weather Service, I visited every one of our Alaskan sites in January or February because I didn't want the folks to think that I just went up there to do salmon fishing. I have never been salmon fishing in Alaska, as a matter of fact, but I have visited every one of the sites there. I participated in a joint review of the high Arctic sites in the Canadian Environmental Service, Alert, Eureka, Resolute, Mould Bay. When we landed at Mould Bay our plane contained 14 people, and we tripled the population of the entire island.

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I am looking forward to understanding the current state of the science in the Arctic. I don't want to run afoul of the timekeeper or take time from Alan Thomas because he will be giving you the directions and expectations from OAR's perspective, but I would say one thing. I like the point of view that this is a short meeting. Short meetings are better than long meetings, I think, but we have to remember what we are trying to accomplish. I am in the process of preparing our quarterly management reviews, and as I went through the various things that were listed as accomplishments in the last quarter there were several meetings listed.

I, personally, do not view a meeting as an accomplishment. Descartes' definition of management may be "I meet, therefore, I am," but I think that is wrong. What we have to do with meetings is really try to focus and accomplish something, as both Dave and Wait pointed out earlier. I think Alan is going to be carrying the same message. We really want to come away from here with a direction to go.

I probably won't be able to contribute much to the breakout sessions because my database is too stale, but I am looking forward to understanding what the issues are and the status of things. And again, I welcome everyone here.

I'm not one to be accused of micro management, except occasionally, and I don't intend to micro manage the laboratories and the activities in OAR either. I do want to understand what is going on, and I do want to be able to focus on what the real issues are and make sure that we are contributing in real ways. Again, I am glad that you are all here, and I hope you have a productive meeting.

PRESENTATIONS

NOAA and Arctic Contaminants Research

Alan Thomas with Eddie Bernard, Dave Hofmann

I will be sharing my time with Eddie Bernard and Dave Hofmann, but let me just start by talking a little bit about the context; context is important because you always have to know the agency's mission. One of the points I keep making is that there are lots of things we can do, but somehow we have to relate it back to what it says on that sign on our door.

In general, NOAA has a lot of interests in the Arctic. Probably the primary two are forecasting and warning of the weather in the Arctic and fisheries management. We have other programs like the role of the Arctic in climate, but one of the things we have found very hard is to find an integrating way of handling activities in the Arctic. One of the things that is clear to me is that when we look at some of these research issues, we have a kind of an integrator. One of the things that I am particularly interested in is how do Arctic activities relate together, and one of the reasons it is a problem is that our missions tend to be global or very large scale, and the Arctic is one component of a much

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larger mission area, whether it is forecasting the weather globally or climate or fisheries management.

This frustration on how you coordinate within an agency was one of the rationales behind us setting up the Cooperative Institute for Arctic Research (CIFAR) a number of years ago. One of the things we found in our interactions is that many times universities, where they have certain loci themselves, allow a lot of people to come together in a way that it is hard here in Washington. At universities, you start with the substance, and then you worry about the policy.

So, that the context of what we are doing. The Arctic Research Initiative has been driven by a lot of activities. Garry Brass and the Arctic Research Commission have been very interested in NOAA and our opportunities. Also, the Arctic Monitoring and Assessment Program (AMAP) is one of the main driving forces, and I want to just recognize Ed Myers from NOAA who has worked hard on a very skimpy amount of resources to try to coordinate AMAP activities throughout the federal agencies and at least do something from the U.S. side. So, for a lot of reasons we have arrived at having the opportunity to implement a small, but hopefully useful new program, the Arctic Research Initiative (ARI).

We took this opportunity driven by a number of forces, and it came to focus fairly quickly last year. To implement the ARI, NOAA initially reached out to the universities and hopefully down the road to the international community. The ARI received $1 million its first year. That's not a lot, but there are many significant things you can do for a million dollars. We started with having this cooperative institute. We asked Gunter Weller, Patricia Anderson, Ted DeLaca and others to help pull together the first makings of this program. I talked to the Polar Board about a year ago that we were going to do something. Hopefully, today we can report on what we have done in year one.

In setting up the first year of the Arctic Research Initiative we invited input from key NOAA players. Fisheries Service was represented by a couple of people from their Seattle-Alaskan Fishery Center and NOS and NWS and I talked to Walt Planet about NESDIS input.

Because of the short time frame available to plan the first year we dealt largely with University of Alaska scientists. We had a good turnout; there were a number of others from the state and, through Garry Brass, we had input from the Commission. We advertised the availability of support through NSF.

ARI funds did not go only to the University of Alaska; although because of the process we used a lot of the support there. The kind of criteria that we put on is that we wanted to build partnerships between NOAA scientists and university scientists, and that would be a good way of trying to get both very high-quality science and mission-relevant activities.

We also paid attention to ongoing activities so that we could add value to some of the activities that are ongoing. We obviously stayed within our mission but we tried to address some of the Arctic policy issues and concerns that were coming out of AMAP.

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I think we now have a better idea what AMAP is proposing, and so one of the things that we wanted advice on today is how can we put that into our plan, and, also, how we focus on achievable results. We actually have a process going. We have some research ongoing, and that is moving forward.

Now, in terms of the focus, both this past year and a general sense in the future, NOAA is very interested in natural variability. That is one of the things that we have done for a long while, and that is very important. We think it is important that when we look at contaminants we still look at the natural variability in the environment, particularly because the polar regions have enormous natural variability. Also, and Walt referred to this, contaminants is a very broad area.

Last year, for example, if you look at points four and five on the list of research themes, No. 5 is really marine contaminants, and there is a lot of effort on that within NOAA, and that certainly is one of the areas in which there is a lot of attention. But we also are going to look at Arctic haze and UV, and I think in the broader sense carbon flux is really going to be something that is important from a climate perspective. So, I wanted to emphasize that we view this in a very broad context of what needs to be done, and so, we hope that you look at it in that sense.

Then just very quickly, the two really major areas were one, the Bering Sea green belt and processes in ecosystem production. That has been a focus of some interest to our Fisheries Service, interest to our research program and other parts of NOAA, and we were able to add, I think, value to some of the activities that are going on, as a part of our study of the variability in the Bering Sea and Western Arctic. The other major activity was anthropogenic influences on the Western Arctic and Bering Sea. So, those are the two larger topics that will be addressed later.

Before I turn this over to Eddie Bernard and Dave Hofmann to talk in more detail about what was supported, let me add that what we did last year was to run a process that actually ended up getting implemented in FY 1997. That was one of our goals: to show that we could manage a successful program, one that included an open process for input from other universities and agencies.

We intend to run a process that has an international dimension and tries to leverage the resources that we have here since we want to be able to do our part in terms of upholding the U.S. role in things like the Arctic AMAP program and the International Arctic Research Center program as well as some of the other international activities.

As I said before, monitoring and data collection in terms of contaminants in the traditional sense is certainly one of the things that we are interested in because of the fisheries and the native populations and the interests around Alaska. But the broader issue of UV and related stratospheric ozone depletion is also important and in fact there was a major program up there this year, the Polaris program that had NASA, the universities, NSF and NOAA participation. And then there is climate change, which we did not fund this year but I think is of ever-increasing importance.

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In terms of our expectations, we are looking for how can we improve the ARI; what is the best way of going about broadening the program, recognizing that we probably can expect somewhere in between 1 and 2 million dollars this year.

You have to think about what you can do for that kind of money, and in NOAA we want results because we are a mission agency. We want the science to be as relevant as we can to the issues addressed by our Fisheries Service, National Ocean Service, the Weather Service, or our climate program. In that context I think I would be remiss to say that I believe that we have not focused on the Arctic from a climate perspective as much as we need to. We have spent a lot of time in the tropical oceans and topical areas over the last 10 years. So, we ought to try to see what we can do within the Arctic with the resources we have. Any questions?

Questions/Discussion

PARTICIPANT: Alan, you mentioned a one-to-two million-dollar level of effort. Do you envision this to be a long-term NOAA program that would eventually be part of the NOAA base effort?

DR. THOMAS: That is always our hope. We don't give up easily.

DR. OECHEL: Alan, what was the process by which you got to the Bering Sea area and Western Alaskan Arctic as a geographic focal point?

DR. THOMAS: Internal to NOAA we have a number of activities. The Bering Sea is very important for the Fisheries Service. We have done work on fisheries oceanography in that area, the donut hole problem on the international side.

Also, there is some evidence that was presented at our workshop that there are some climate signals like the North Pacific Oscillation and others that we need to pay attention to, some very large changes in that area, and you know, Alaska is an enormously productive area. So, we are driven by our mission to work there. Also, that is not to say that we wouldn't work in the Arctic Ocean because in fact, we have a monitoring station at Barrow. That is a very important area for us, and if you look at the haze and the UV, there is an interest, but for us Alaska is the Arctic. It is the first order, that we do work in Fram Straits and various other parts. We do, and we would like to, but if you look at it from a practical sense, our support comes from working on fisheries management, weather forecasting, climate and things like that.

DR. OECHEL: But to understand contaminant impacts, even in the Bering Sea, it seems like large-scale transport processes are extremely important, and yet I don't necessarily see those reflected in the program right now.

DR. THOMAS: Probably not at the million-dollar level. Ultimately we would like to model that, because certainly large-scale processes are relevant. But our program, for now, is rather small for that. As time goes on, I think we will work with the Weather Service and the university in looking at atmospheric transport, and this is an outgrowth of things like looking at volcanic and other activities. For now, though, the question is what can you do usefully for $1 million?

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DR. OECHEL: I guess my question was about the process, but it sounds like it is almost more obvious within NOAA that that was the area to go rather than opening it up and then coming down to that area.

DR. HILD: My name is Carl Hild. I am with the Rural Alaska Community Action Program. The question I have, the Department of Commerce does have an American Indian Alaskan Native policy. How was that applied last year for the expenditure of $1 million, and how do you anticipate it is going to be applied for this coming year?

DR. THOMAS: We are going to try to get input. We will have workshops as we did in Fairbanks. We sought input probably not as broadly this year as we should but we are going to try to find out who and try to invite interested parties to the workshop. I think we supported some work ultimately in areas of interest to the native population of Alaska as I believe through one of the proposals. So, we have gotten a little bit, and I am just saying that that is one of the issues in front of us; how do you broaden this participation.

DR. HILD: Would it be possible to put something in the announcement of opportunity that you anticipate people should reflect this policy because it is a Department of Commerce policy?

DR. THOMAS: Right. One of the other issues that I think we talked a little bit to Garry Brass on the sustainable development, Arctic sustainable development activity, and certainly that is a part of what NOAA is interested in.

I would like now for Eddie Bernard to come up to talk about the first area of natural variability and then Dave Hofmann will talk a little about the contaminant area.

Eddie Bernard

As Alan indicated, nine of the 15 proposals were associated with natural variability. The motivation for this is to understand the existing productivity of the Bering Sea. This is a composite of numerous years of investigation, and it identifies a high zone of productivity along this shelf.

This is the topography of the Bering Sea. This is a deep basin by this wide shelf here, and so, as a result of this high productivity the United States derives about 40 percent of its tonnage of fisheries from this body of water, and actually about 10 percent of the entire biomass of the planet is actually produced in this area. One of the questions is why such high productivity, and over years of investigation we have come up with a schematic concept of the way the circulation works in this area. There are lots of detailed mechanics involved in this that we need to talk about in order to understand some of the variability.

NOAA's interest, as Alan said, is in fisheries and because the fisherman are out there, of course, the Weather Service wants to provide good forecasts so that when vessels ice up and when they hit big storms we don't lose lives unnecessarily.

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So, this is the general circulation pattern. There is a big gyre that goes in the basin and then as this gyre follows the contours of the bathymetry that gives rise to a lot of interaction. That is the key right there, this confluence of high productivity with these physical mechanisms seems to be one of the products that we want to focus on. And just to give you an idea in terms of natural variability, there were two studies in the Bering Sea ecosystem that focused on bioindicators. One is the analysis of seal hunting up in the Chukchi Sea area to look at hunting for 50 years from 1920 to 1970. Since 1970, there has been pretty good population dynamics but to use the indigenous people of Siberia to sort of understand how their hunting went up and down. A second bioindicator is a spotted seal study that is done by the Alaska Fish and Game Department in which they tagged 21 seals from 1991 to 1993, and these data are being analyzed to see what the correlation is between ice pack and fluctuations in the marine mammal populations.

Okay, so, those are sort of gross bioindicators of what is going on. The other projects that are funded are process studies, and the hypothesis driving this is that there is a lot of interaction fight here and in order to take advantage of some NOAA activities, the Coastal Ocean Program is sponsoring a program called the Southeast Bering Sea Carrying Capacity. They had several cruises lined up for this spring to collect data in this green belt.

Now, although the green belt image I showed you earlier is a composite of many data, no one has actually gone and systematically surveyed this area until the first cruise in May, and so, let me just show you some preliminary results of that cruise. First of all, the first cruise went out and deployed some moorings and some drifters, and this was all money that was supplemental to the Coastal Ocean Program Southeast Bering Sea carrying capacity. Investigators included several people who were looking at both the nutrients and the physical transport.

There is a web page in Colorado that puts out near real time altimetric measurements, and this is the Aleutian Archipelago here and this is the Bering Sea covered here. What you are looking at here is a high elevated area here that represents an eddy, and it seems like these features, these eddy features, are a dominant mechanism in which transport takes place from the deep ocean, nutrient-rich waters to the shelf where it supplies food that sustains this high productivity.

This information is brand new. This collaboration didn't exist before the Arctic program was under way, and now, after a few discussions this is available over the web page.

We took our ship fight out to the middle of this because it was under way, made surveys in real time of the current velocities and what you are looking at here is a cross section.

Let me guide you here. You are looking at a cross section through this eddy, fight through the middle, okay? This is a circulation pattern, and there is a clockwise eddy. So, the flow is coming out of the page and into the page, but notice that this eddy is not symmetrical. It is distorted toward the shelf side, and in measuring chlorophyll inside the eddy and outside the eddy we found that it was greatly intensified inside the eddy. So it

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looks like this eddy stretching mechanism is actually acting as a vertical flux in bringing nutrients from the deep ocean up to the shelf and supporting the nutrients, and this is the first data we have that actually supports this hypothesis that has been advanced, and we are very excited about it.

In addition to making direct measurements we also seeded this eddy with drifters, and there you see the drifters. It is hard to tell from this, but they are going in a clockwise direction, and these drifters have chlorophyll measuring devices on them. So, you can actually track the chlorophyll inside the eddy. As we would expect, these are high.

This one that got pulled out of the eddy is low. So, what we see here from the preliminary results is that it looks like the eddy structures are very important in transporting nutrients from the deep ocean basin up to the shelf which supports sustained productivity.

In addition to the oceanographic features that cause these eddies, what supports them is a study of the meteorological programs, and we are studying the natural variability by looking at the changes in the Aleutian low and one pattern that has emerged is that it looks like if you take a look at some long period fluctuations in climate you will see that the Aleutian low actually seems to prefer two modes.

One mode is in the Gulf of Alaska, and the other mode is in the Bering Sea. If you look at the time period between 1989 and 1996, versus the 1977 to 1980 time frame, it looks like over that period there have been some shifts in sea level pressure, and for the non-meteorologists in this area this represents a rising of the sea level pressure which would depress, would suppress the intensity of the Aleutian low, and then this would be lowering in this area the high pressure system. So, in effect, this is lowering gradient and lowering some of the intensification that is taking place in the high Bering Sea. For us simple oceanographers it seems like the obvious thing that is going on here is that when you have an intense low pressure system that sits here it brings up warm air from the south, and it creates lots of mixing, and it is a very energetic system.

When it is in this system, when the Aleutian low sits over here, it is bringing in cold air. It is less intense. There is not as much misting, but them will be more ice because of the cold. So, these are the natural variabilities that we are studying. We are, also, studying the planetary boundary layer at Barrow, Alaska to see what changes have taken place.

So, all of this is loosely woven together. Like Alan said, all of these programs are linked to other programs, and probably about one-third of the funding from the Arctic program is actually being supplied for all the science that is being accomplished.

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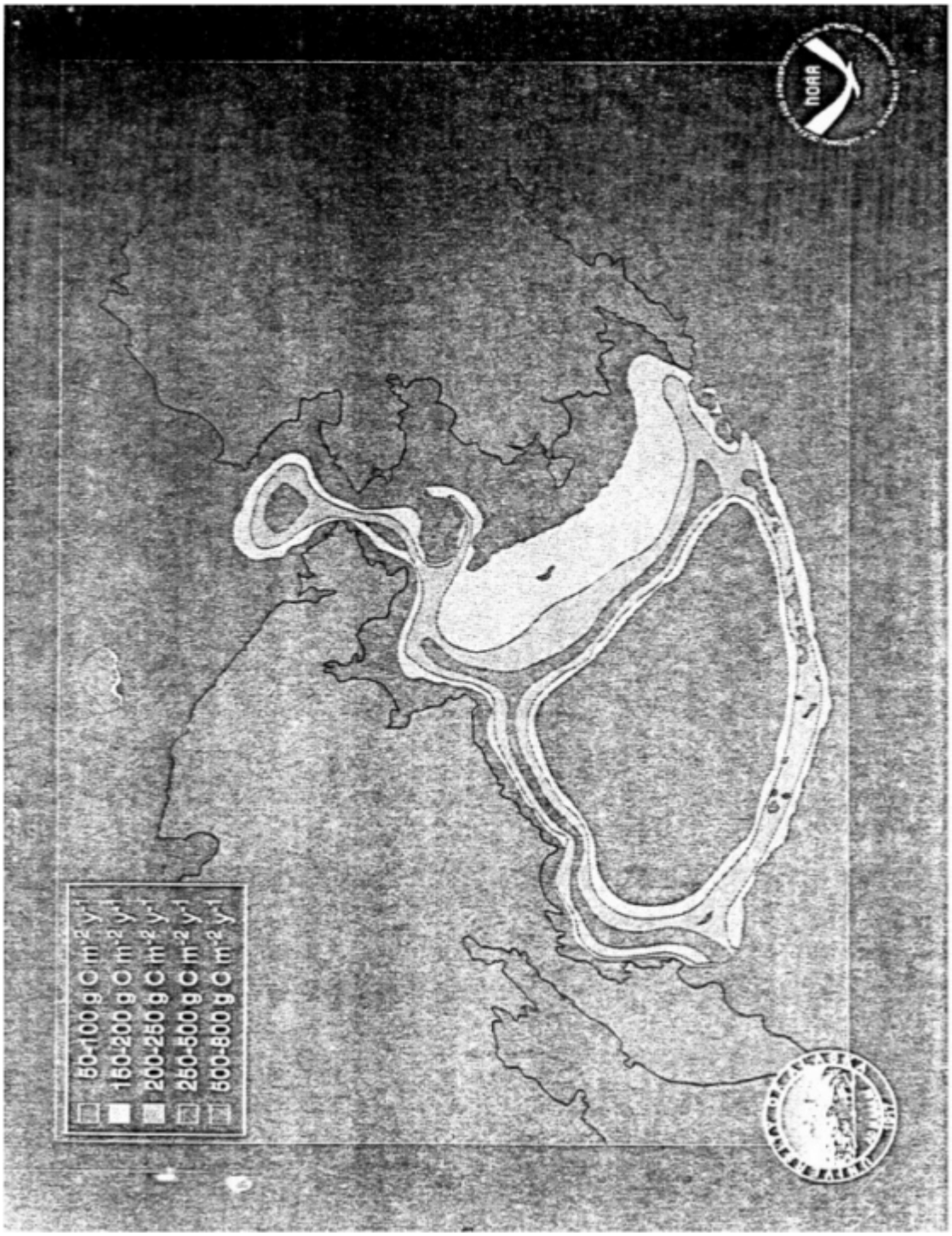

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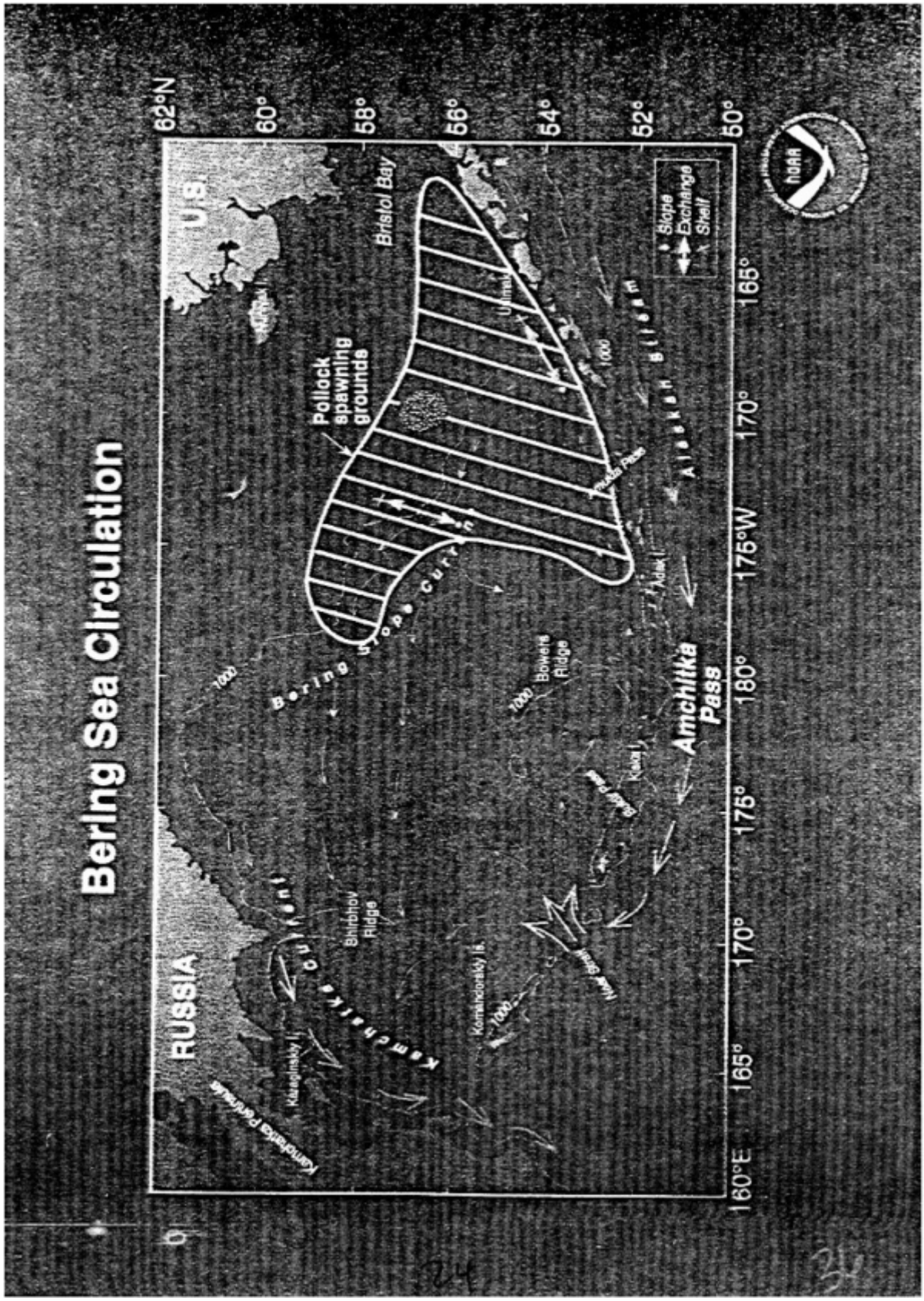

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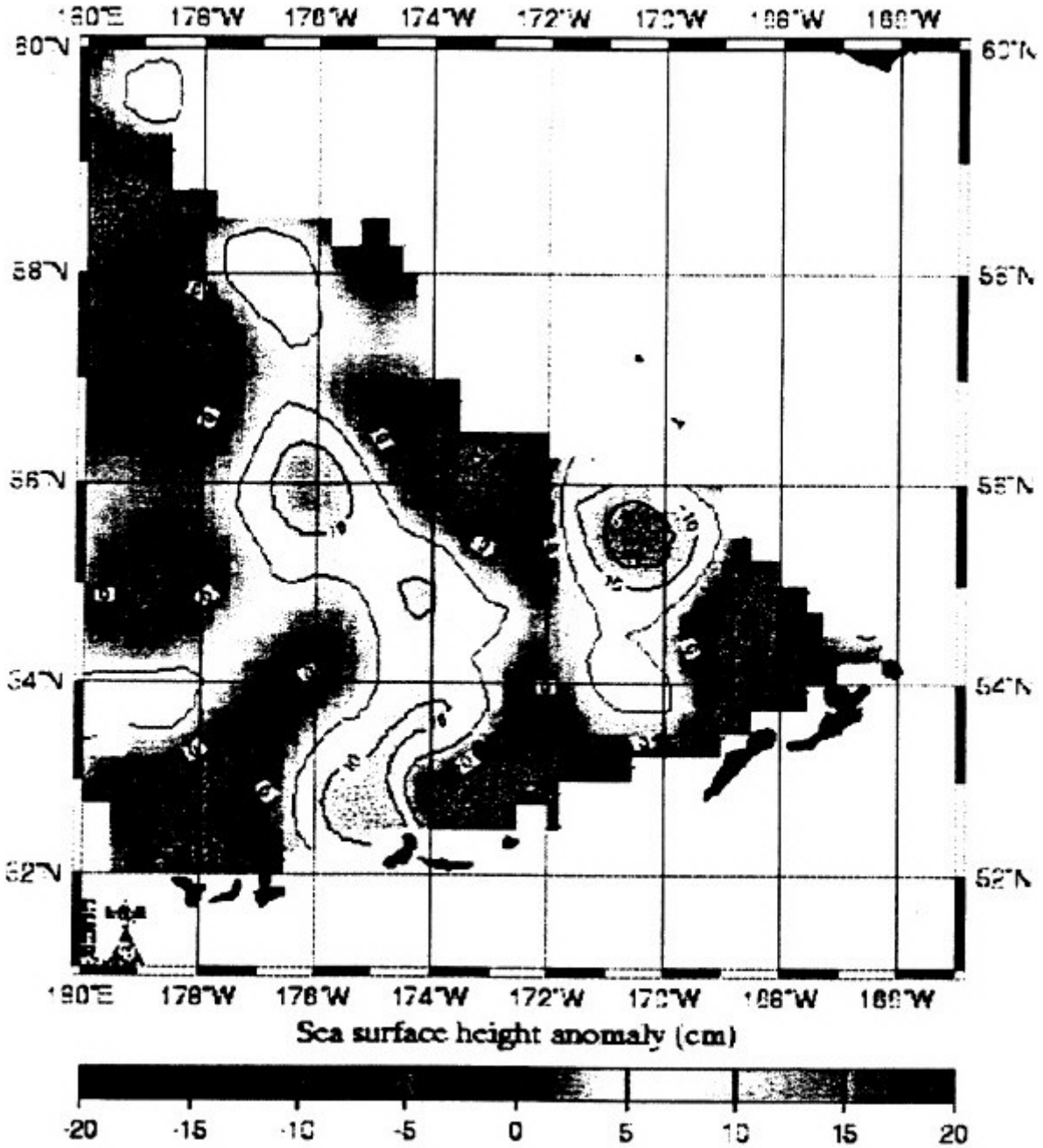
TOPEX/ERS-2 Analysis June 12 1997



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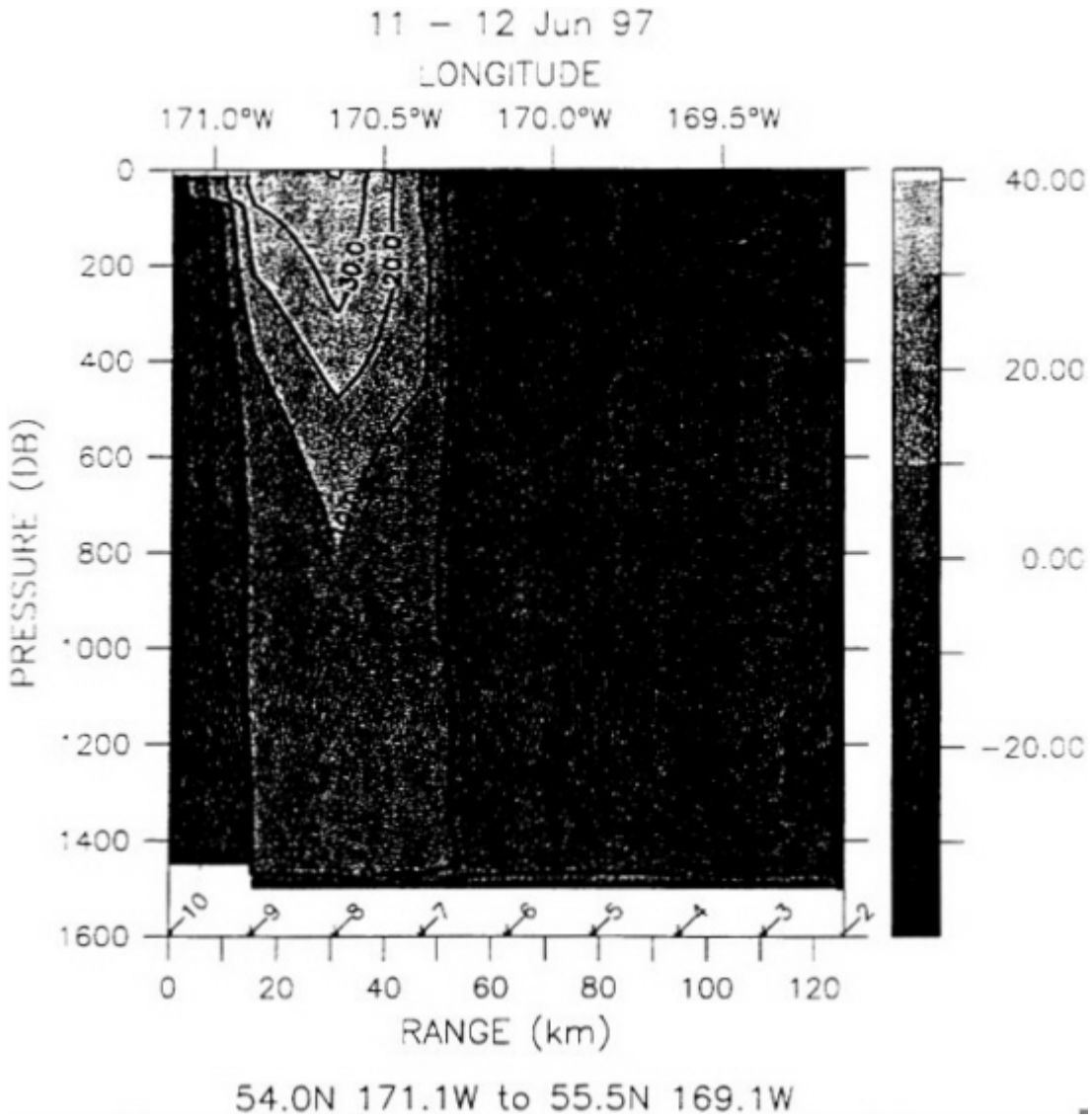
GEOSTROPHIC VELOCITY IN THE EDDY



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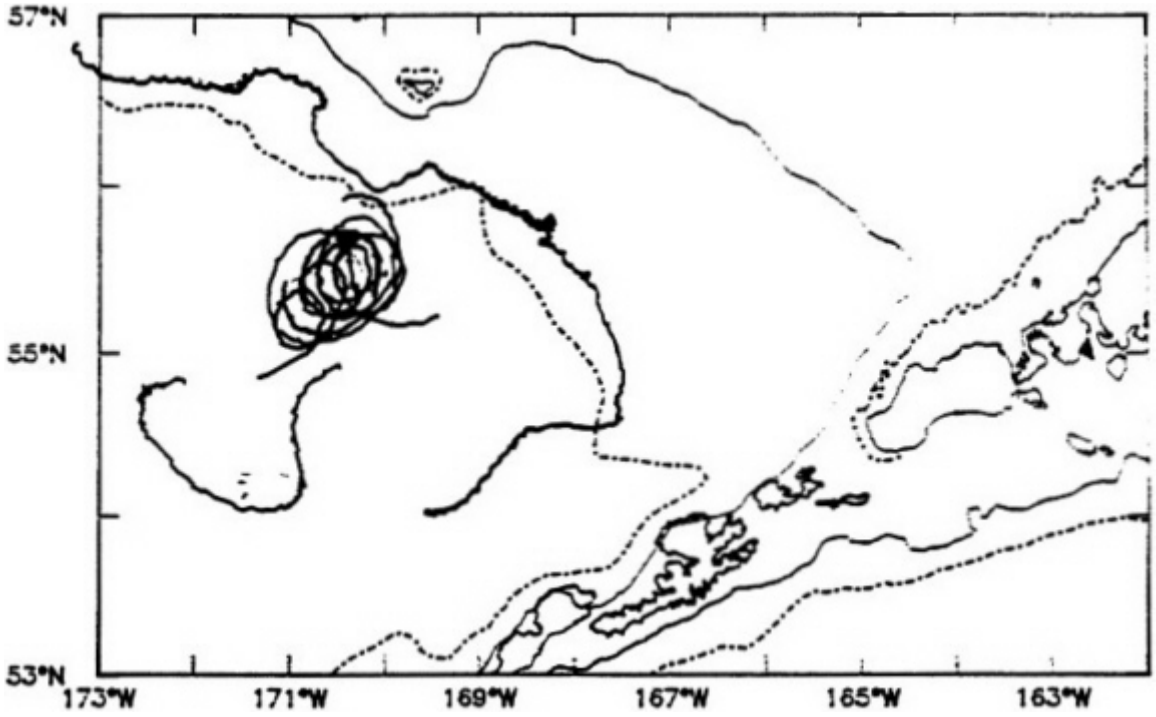

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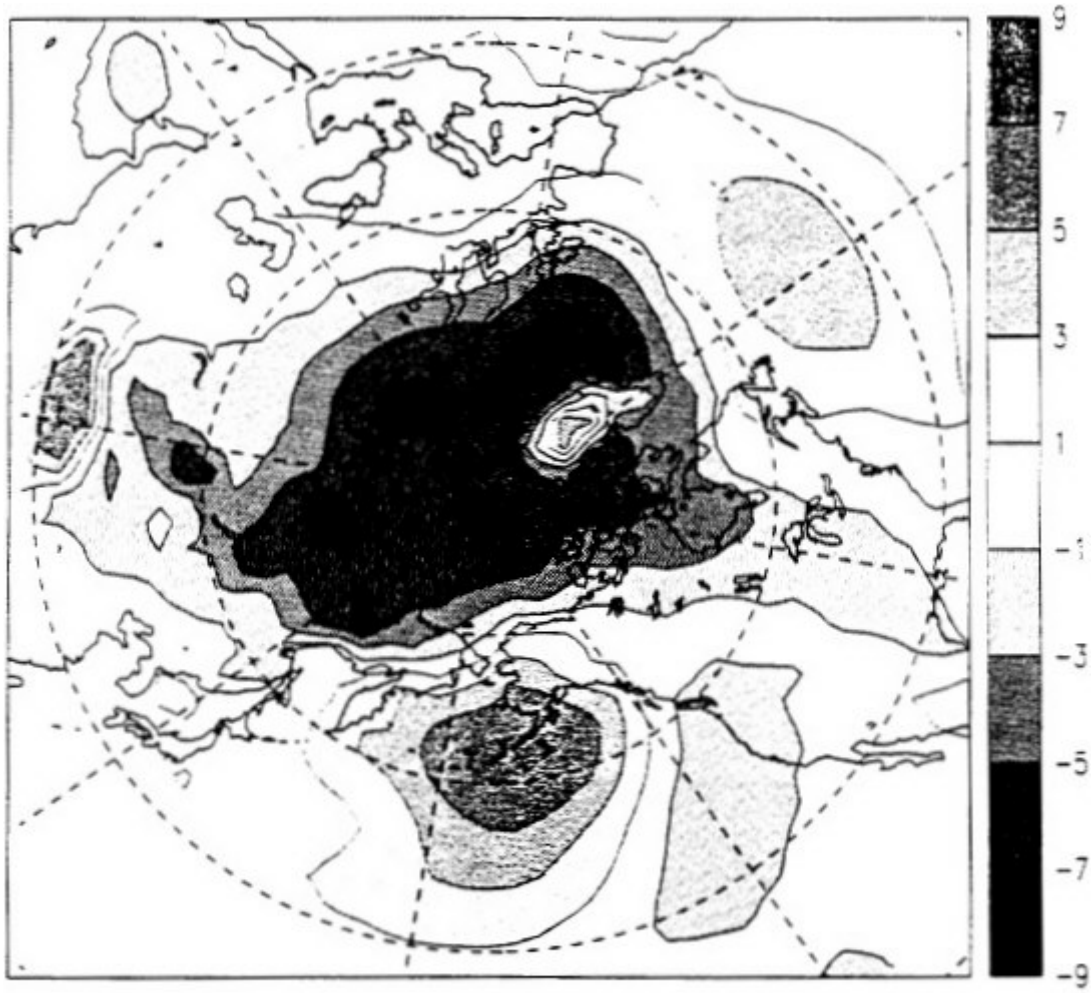
ARCTIC/NORTH PACIFIC COUPLED CLIMATE CHANGE



JAN-FEB MEAN SEA LEVEL PRESSURE DIFFERENCE
(1989-1996) minus (1977-1988)

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Dave Hofmann

That was an overview of the ocean part of the Arctic Research Initiative. I am going to say just a little about the air part. There are actually four laboratories that are either involved at the present time or are going to be involved in the Arctic research involving atmospheric research. There is the Aeronomy Lab doing stratospheric ozone work with the Polaris mission at the present time, and the Air Resources Lab doing surface energy balance and flux. The Environmental Technology Lab develops instruments which will be applied in the Arctic through various programs, and then I am associated with the Climate Monitoring Diagnostics Lab, which has been in the Arctic for a long time. I am going to say just a little bit about how the research that we have been doing in the past 25 years in Barrow has played a role in the new initiatives.

NOAA has been in the Arctic for a long time through various programs. This is just an example of the carbon cycle group's measurement program here in Alaska, the main observatory in Barrow, and we, also, collect samples at a number of other locations for our climate carbon cycle studies.

We have been doing research in the Arctic for a long time, and three of the programs that were funded under the Arctic Research Initiative involve long-term trends in arctic haze, measurements of UV radiation in the Arctic, and we do actually have a program aimed at climate change in the Arctic. I am going to focus in on that one because it seems to be related to this issue which is one that is very well known and that is arctic haze.

Back in the eighties it was a big deal. Arctic haze was very obvious. It was considered a product of transport of industrial emissions, some thought from Russia but probably Eurasia. Our monitoring at Barrow suggested that over the years this is the scattering that you would get if you brought this air into a box and shined a light on it. So, it tells you how many particles are in the atmosphere.

Along about in the late eighties this thing leveled off and is now rather constant and the first idea that was put forward was that it was because of the Soviet Union's economy changing and things like that. But there are other indications that things are changing in the Barrow area. One of these is the history of Barrow snow melt date. This is in town where it is obvious snow is melting earlier in the year by a week or two, which suggests climate change.

Our observatory is somewhat out of town over the tundra, and while they were in reasonably good agreement back then, they are now quite a bit different. The snow melts in town quite a bit before it does out at the observatory, and while both seem to be getting earlier, this difference seems to be getting greater. So there is a question: is there some effect of urbanization? Perhaps the most interesting thing is the actual climate trend measured at the observatory over the last 30 years: in the last 30 years average temperatures for the year increased by about 1.4 degrees C, which is substantial, and one of the research programs is specifically looking into explaining this, and it seems not to

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be related to increases in greenhouse gases. While that may be a component of it, that is not the driving force.

If we look at, for example, by month, in February we definitely see this is getting warmer, and we also notice that it is correlated with cloud cover. So, as it has been getting warmer, it has been getting cloudier over the last 30 years. But if we look at another month, in November, we see a completely different picture. On average it is getting colder, and it is getting less cloudy. So, it is not a simple change in climate as you might expect from greenhouse forcing. It is a much more complicated situation, and we have been looking at, for example, the question of this transport changing, is circulation in the Arctic changing, and if you look at some of the obvious things like the frequency that southwest winds occur, and you see, also, the correlation both in the speed of the winds. In February, when it is getting warmer the frequency of southwest wind is increasing, and the wind speeds are increasing slightly, while in November when it is getting colder the frequency of southwest winds is decreasing.

So, at least initially it clearly looks like it is a transport phenomenon, a change in the general circulation. This could even be related to large-scale changes. So, this one program is going to look at this in more detail and try to pin down why climate is changing.

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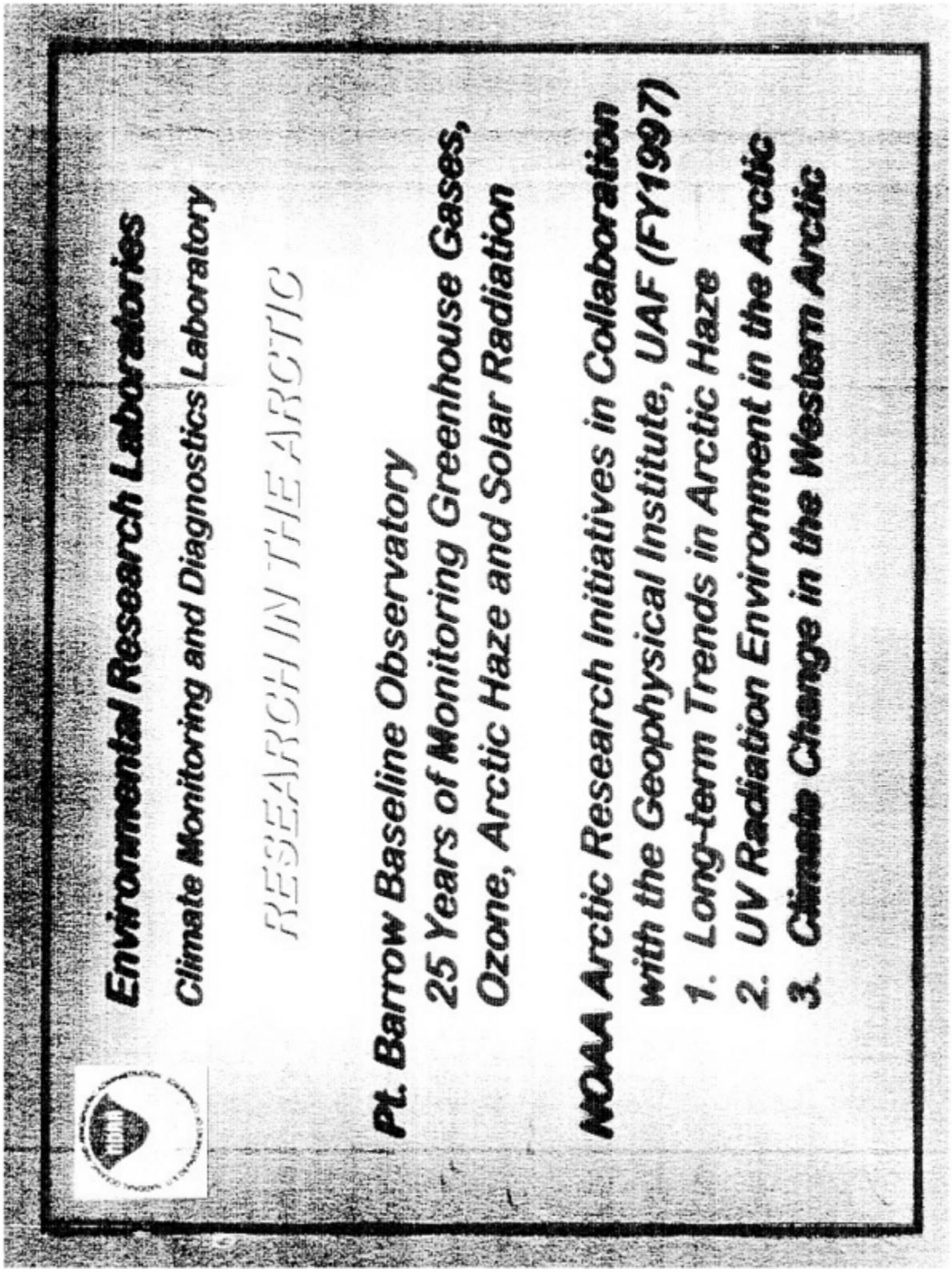

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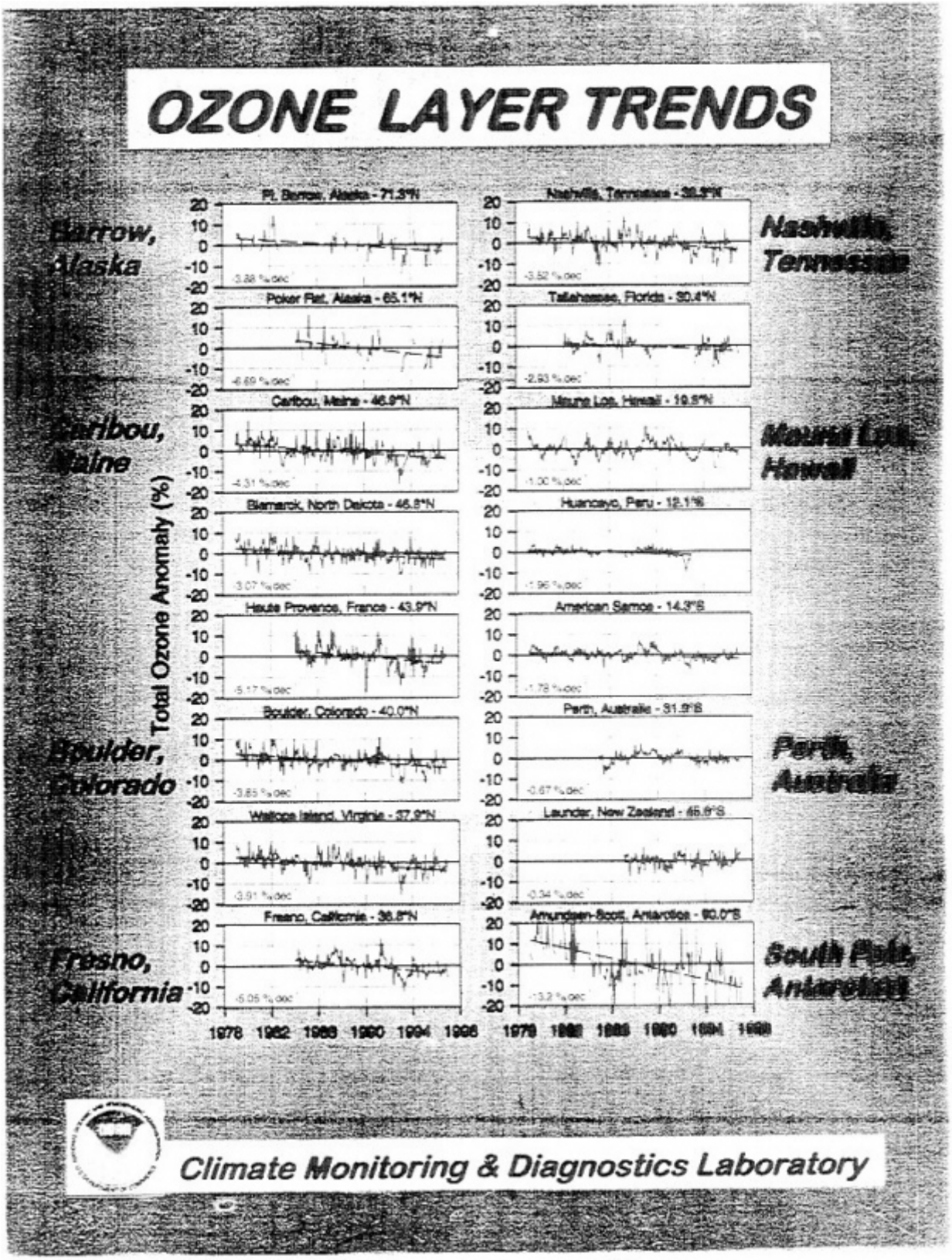

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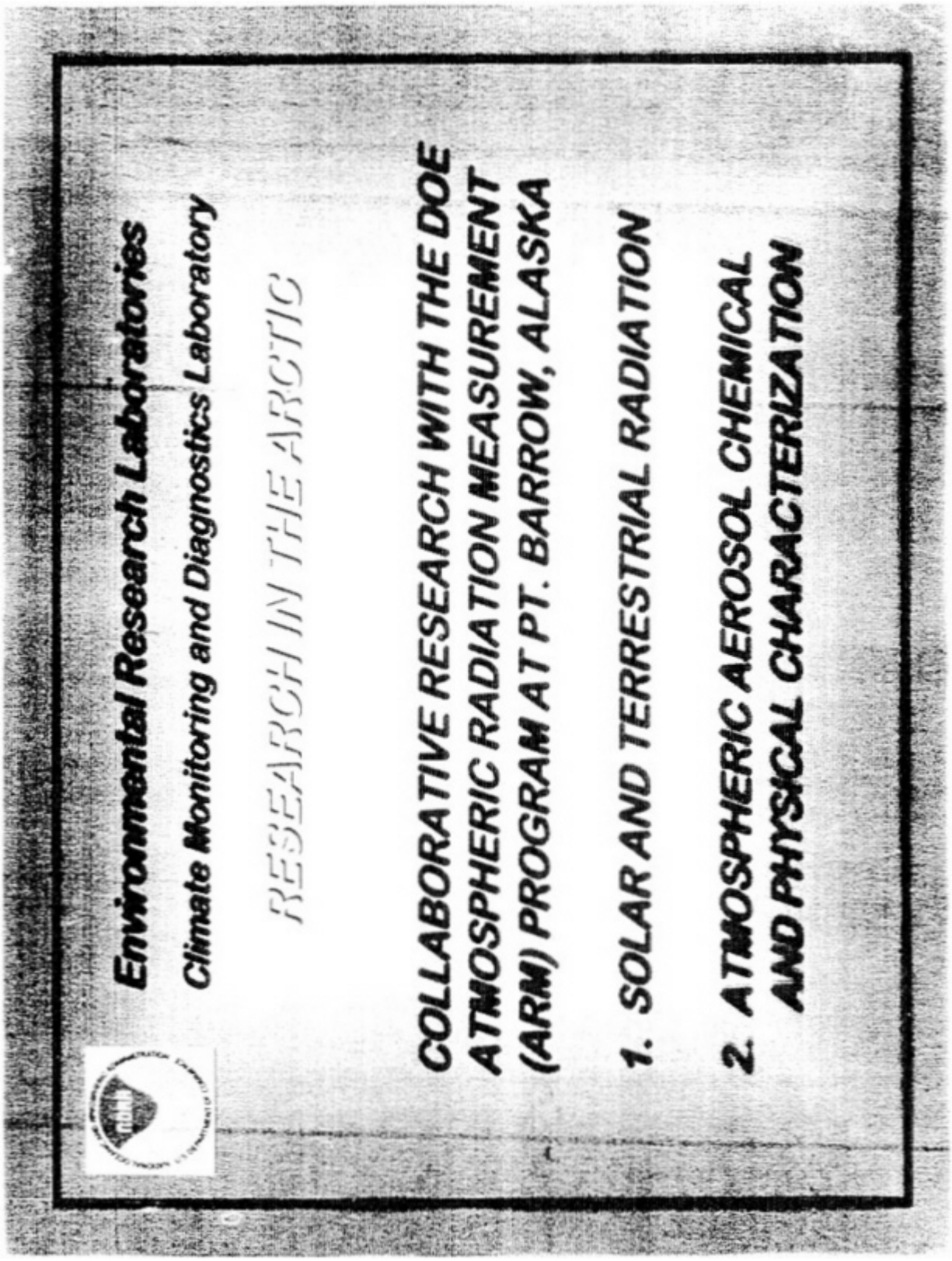

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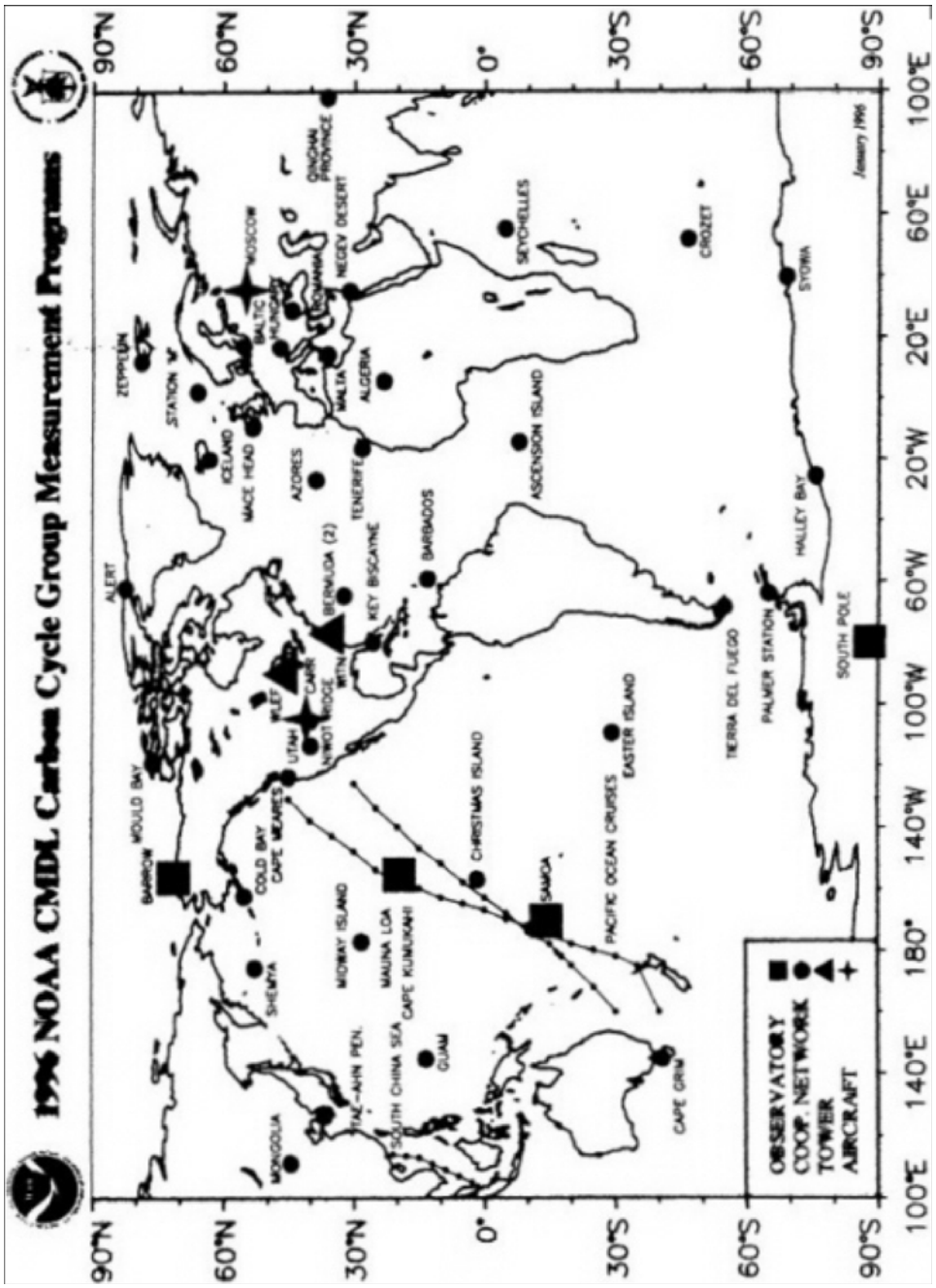

The NOAA CMDL Carbon Cycle Group maintains 4 measurement programs. In situ measurements are made at the CMDL baseline observatories: Barrow, Alaska; Marina Loa, Hawaii; Tutuila, American Samoa; and South Pole, Antarctica. The cooperative air sampling network includes 45 fixed sites and 3 commercial vessels. Measurements from very tall towers and aircraft began in 1992. Presently, atmospheric carbon dioxide, methane, carbon monoxide, hydrogen, nitrous oxide, sulfur hexafluoride, and the stable isotopes of carbon dioxide are measured. Group Chief: Dr. Pieter Tans, Carbon Cycle Group, Boulder, Colorado, (303) 497-6678. ptans@cmdl.noaa.gov.

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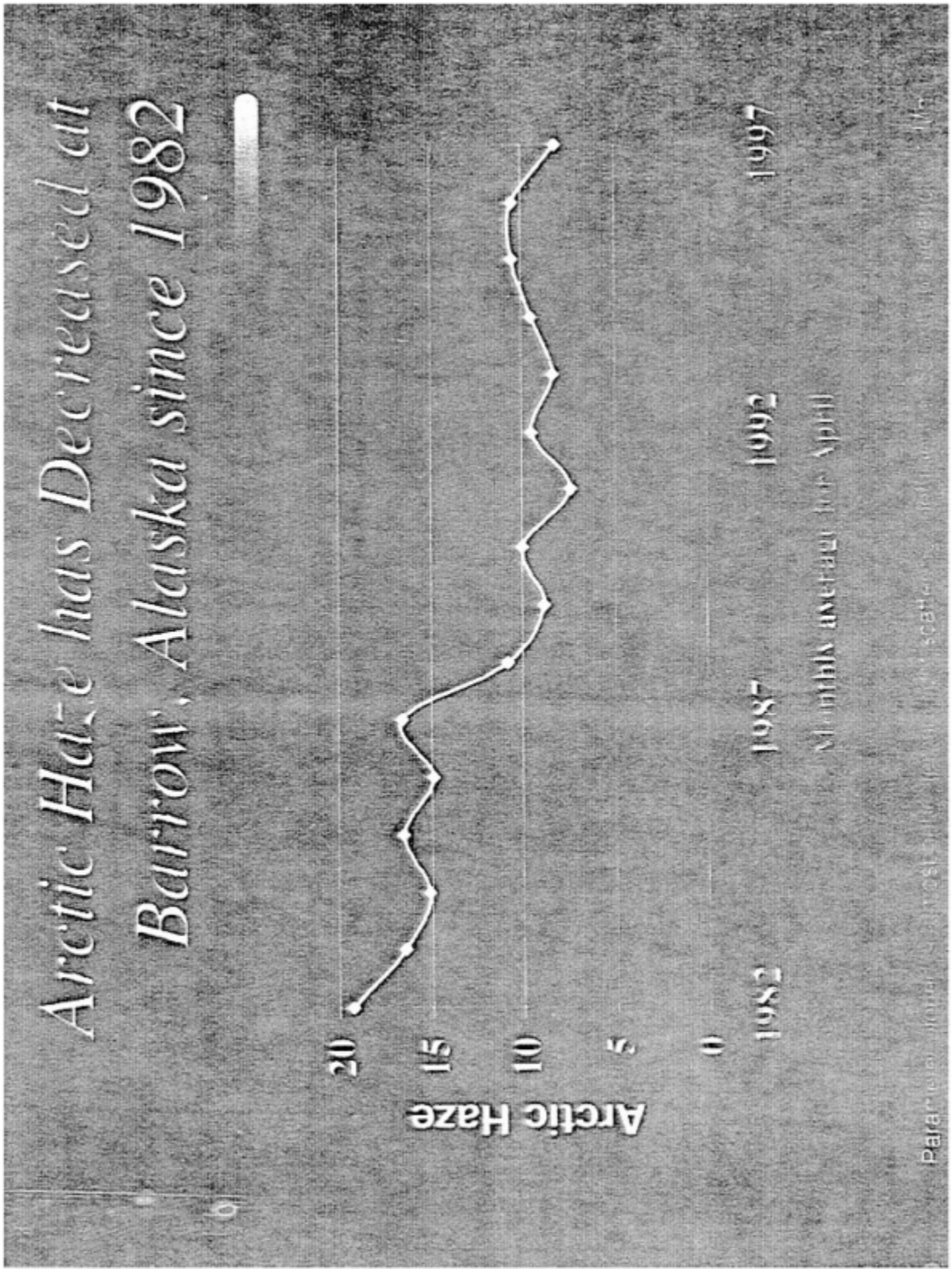

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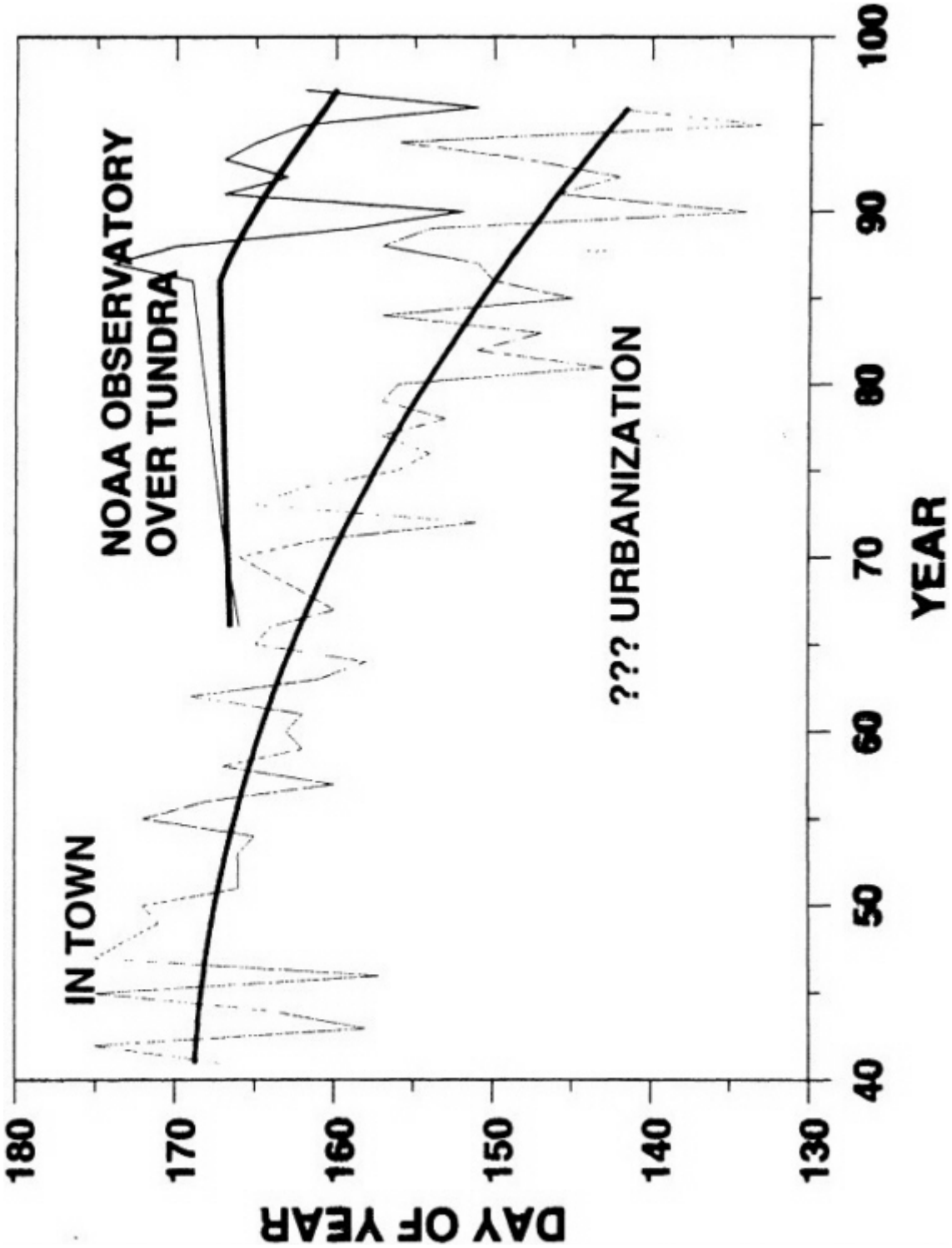

HISTORY OF BARROW SNOW MELT DATE

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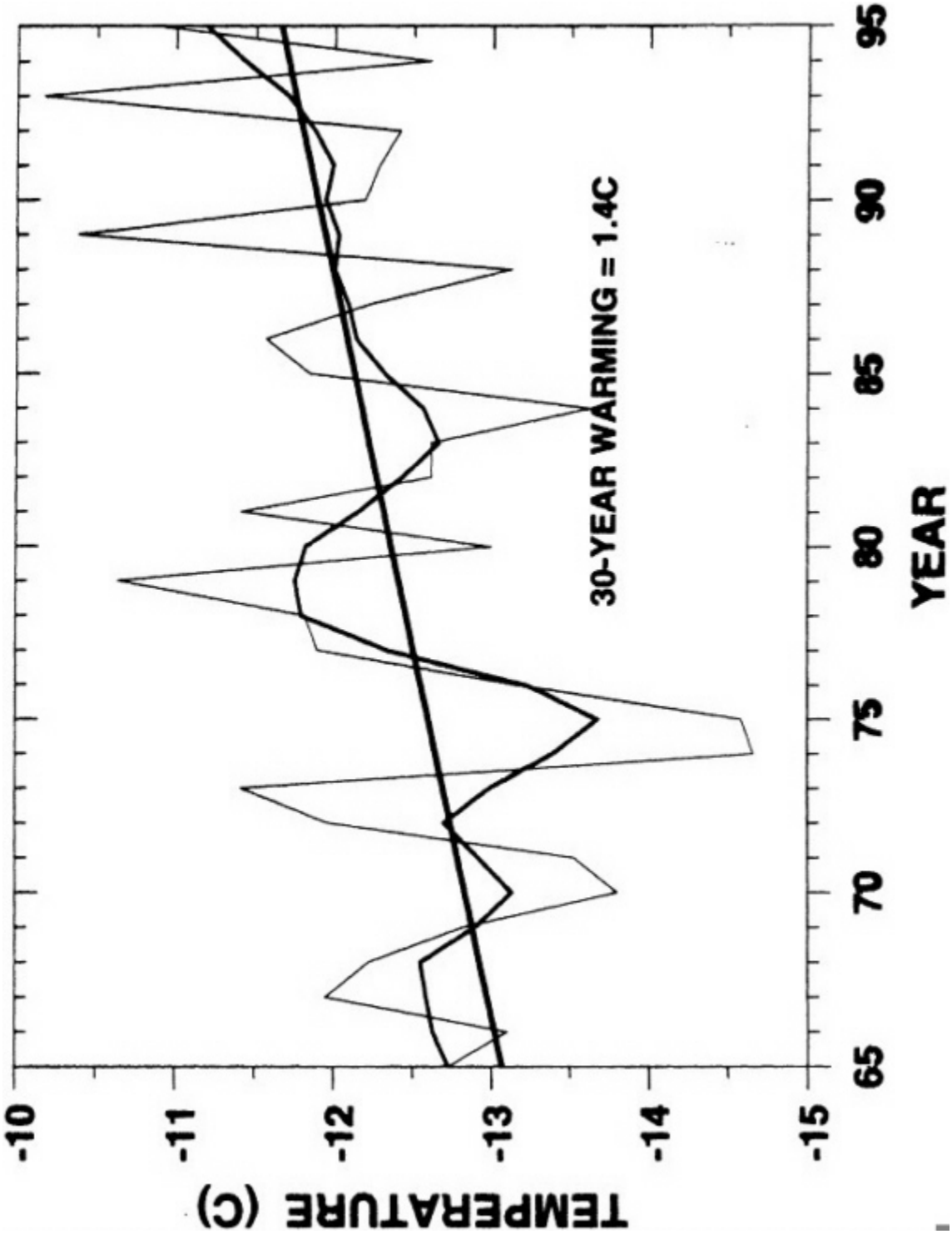

BARROW ANNUAL TEMPERATURE

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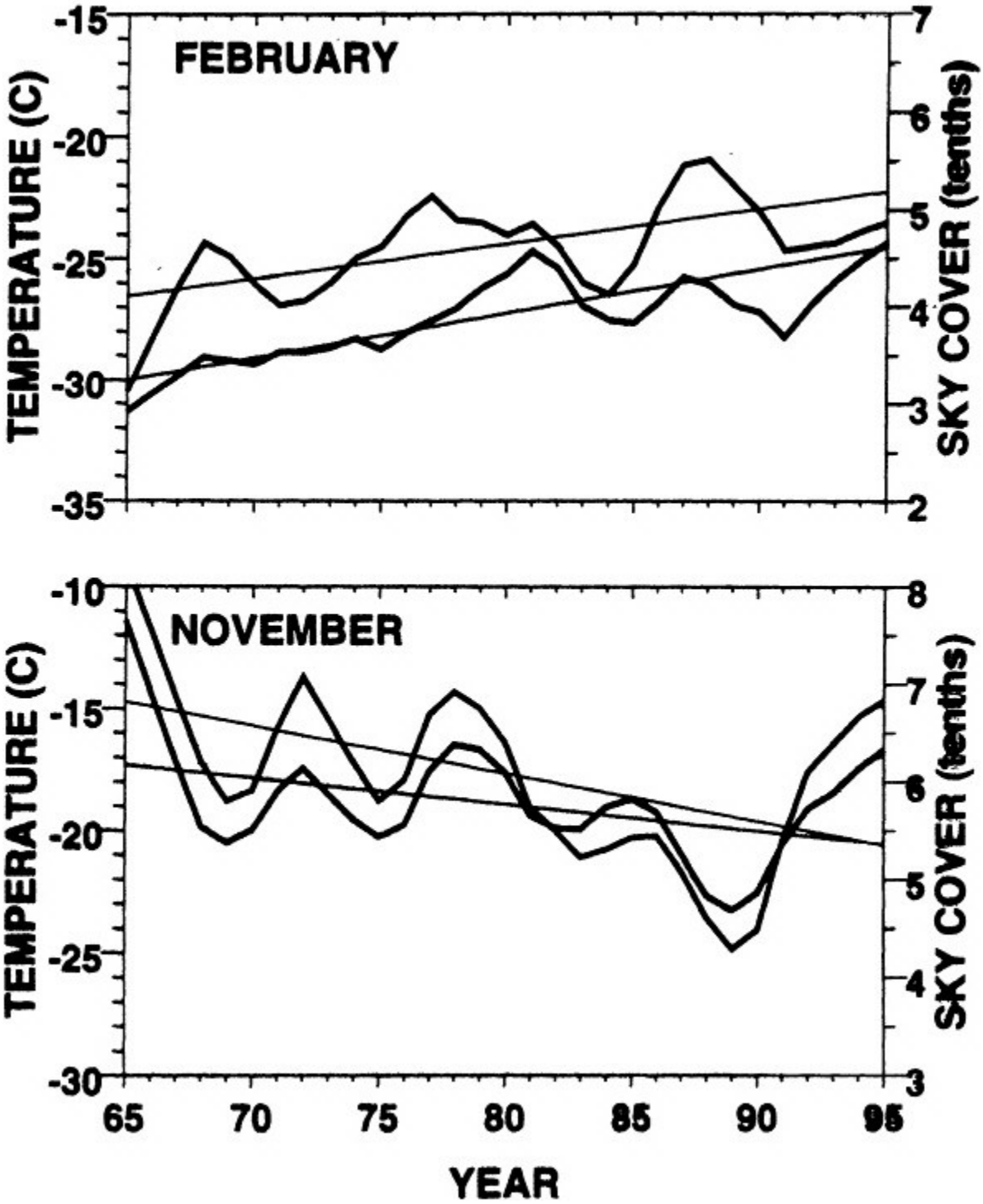

BARROW, ALASKA

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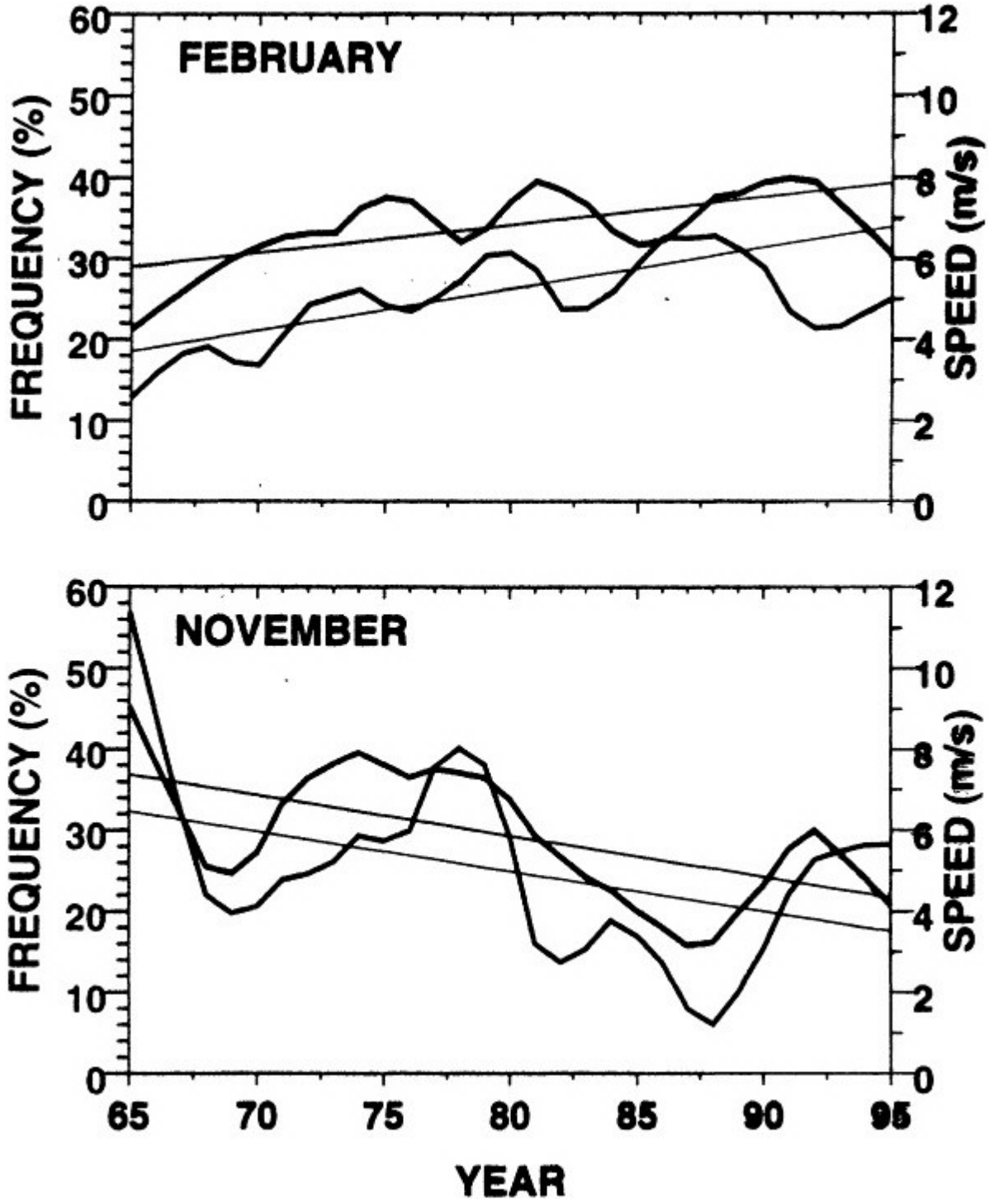

BARROW, ALASKA (SW WINDS)

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Questions/Discussion:

DR. FRIDAY: I wanted to give a glimpse of some kinds of activities I think aren't reflected here—such as a couple of projects at the Fisheries Service and the university. I hope Fisheries will have 5 minutes, and I hope that we can get input on that contaminant program.

DR. COX: I have a general question. There is a document that we were provided called NOAA Backgrounder pertaining to the ARI, and it is interesting that in this backgrounder some key performance measures were identified for the Arctic Research Initiative for year 1, 2 and as the program moved forward. Can you comment on whether or not the year 1 performance measures were met or are in the progress of something being done for them?

MS. ELFRING: This is a document that the Board got as background when we were preparing. So, you might want to tell what that performance measure is because other people don't have that document. (This document is reproduced in Chapter 3.)

DR. THOMAS: Ed Myers is here, and he wrote the backgrounder, I believe. I don't want to put it all on his shoulders. This is a 3-year-old document, I think. Obviously from a practical standpoint, that was something we set out a number of years ago. What I think we started is a much more modest effort. Instead of an MOU we have brought some people together, and we intend to extend that including the state and we have tried to work with other agencies through programs that are up there. The ARM program, for example, a number of the projects build on ARM, and SHEBA and things like that. So, we haven't formally gotten to there, but you are right, that was one of the things.

DR. COX: One other important measure here that none of the awarded studies addresses is the involvement of the Alaskan Native community. There is a measure in the initiative of formal accords and other arrangements for involvement in the initiative of the North Slope and other regional organizations.

DR. THOMAS: We don't have formal arrangements. It is our intention to make it more formal. That was discussed as part of the planning process, and it seems to me there is a proposal that has cooperation in it.

DR. COX: I was very impressed with the amount of work and planning that went into developing the ARI and the call for proposals, but when I looked at what was eventually awarded there seemed to be a bit of a disconnect in terms of meeting some of the key objectives of what was originally developed in the planning process.

DR. THOMAS: All I would say there is it was recognized that we built ongoing and natural variability more this year than ultimately we probably will, partly because the nature of what was available was more developed, that is we, one of the reasons we actually got involved and asked the PRB to come is we need I think more program development, more planning in the area of what should we do in the contaminant part of the program broadly defined, and that is partly why we are here. That was discussed at the time. Given the time line we took the best things, and so, we probably allocated more on the natural variability.

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The Big Picture: A CENR Perspective on Contaminants Research and Remarks from the NOAA Administrator

D. James Baker

When Alan and I talked about asking the PRB to organize this workshop, our goal was to get more action in the Arctic in research. I wanted to get the PRB involved because I have a special place in my heart for the Polar Research Board. It was the first Academy committee I was ever on, and it was one of the places where I learned how one operates in an Academy committee. It showed me one of the major purposes of the National Research Council, which is to bring able scientists together and talk about issues and generate ideas; it lets young scientists meet famous old scientists and learn from each other.

Larry Gould was the Chairman of the Board when I served in 1972, and he must have been 80 years old then. He looked like he had just come back from the Antarctic. Back then, most of the members of the Board were Antarctic explorers and scientists who had been on Antarctic expeditions, and in fact, I think that was one of the criteria. There was a strong Antarctic slant to the membership.

The Board, a committee then, was known as the Polar Pals, and I remember Gould, with his gravelly voice, welcoming me to the Committee. I think I was one of the first oceanographers to be on the Committee, and he said, "Well, what are you going to do on the Committee?" I was just appointed, and I didn't know what you do on Academy committees, and he said, "Well, you are going to be Chairman of the Subcommittee on Oceanography."

I said, "I am?" And so slowly various members explained to me what I should be doing. It was a great experience, and we wrote a document called "*Southern Ocean Dynamics: A Strategy for Scientific Exploration 1973-1983*," and out of that we did the International Southern Ocean studies experiment. Our input was critical in making that happen.

These are not just rambling comments, but I am leading up to what I wanted to talk about. Having outside communities involved with federal research planning is something we have been trying to push very hard on the Committee on Environment and Natural Resources (CENR), and I think we are making some progress. Let me just say a little about what we are doing on CENR and why I think this kind of community interaction is so important.

If you watched the federal process over the years, there have been various attempts to coordinate federal research activities. In the Bush Administration there was the FCCSET, Federal Coordinating Counsel for Science, Engineering and Technology, a group of federal agencies coming together to do planning. One of the things that the Clinton Administration asked is how do you build on the FCCSET and try to make it even more comprehensive than before. To do this the Administration formed the National Science and Technology Council. The point of the Council is to cover all science and technology issues, and try to coordinate those across the Federal Government. Under the

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Council was established a set of committees that would cover all the different subjects in science and technology.

Under the NSTC, we have nine committees, and one of the committees is the Committee on Environment and Natural Resources. This committee is a follow-on to the previous Committee on Earth and Environmental Sciences, the CEES. I have cochaired that Committee with the person who is the Associate Director for Environment in OSTP. That was Bob Watson and is now Jerry Melillo. We have tried to have that Committee look at what is being done in the Federal Government across all of the areas of the environment and natural resources, not just environment and not just natural resources, but looking at the whole thing. There are about 15 agencies that are involved in these subjects. We then put together seven or eight committees, plus a couple of cross-cutting committees, to focus on some specific initiatives that we could accomplish in the Administration.

As we have gone forward with that process there have been a number of things that we have been able to accomplish. We put together a national environmental technology strategy and a program for national earthquake loss reduction.

We organized a big conference on climate impacts on human health. We launched a North American research strategy for tropospheric ozone, the NARSTO program, and we have continued a very strong emphasis on global change and on natural disasters.

So, through our efforts, we have been able to continue some important initiatives and get some focus in the budget process. We have in this past year picked up five areas that we are trying to focus on as we look forward, and the National Science and Technology Council has actually endorsed those five initiatives for the 1999 budget process.

Endorse means that OMB sends a message out to all the agencies and says that these are things that you should be supporting, and if you do support these areas we will look favorably on that in the budget process. Global change is one that we continue to have as a very high priority, and some of the things that you talk about in the Arctic are related to that. Natural disasters is another issue that we are pushing very hard, and we are looking there for a large new initiative, large in terms of dollars. We also are going to continue the North American research strategy for tropospheric ozone, the NARSTO program.

Finally there are two that I think are of special interest in relation to the Arctic and Arctic contaminants. One is the environmental monitoring initiative and the other is the endocrine disrupters. These are both subjects that the community and the agencies have felt are important areas where we need to do something new.

If you look at the environmental monitoring, one of the things that I think we all felt is that we need to build up our environmental monitoring on the ecological side to be as good as we are doing on the physical climate side. We know that we still have some real problems in terms of ecological monitoring, particularly terrestrial ecological monitoring; how do we handle that? So, this idea of a national environmental monitoring initiative is something that Jerry Melillo and others have pushed very hard. Some of you

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have been involved in this. Also, this relates to the Vice President's idea of having some kind of report card on the health of the environment that would be produced roughly in the year 2000 or 2001. So, the idea on the national environmental monitoring initiative is to see if we can put in place a monitoring system which will allow us to monitor both the ecological and biological side of earth as well as we are doing with the physical and climate side. With that, we can start to get some real indicators about how things are changing.

The other initiative relates to endocrine disrupters, those estrogen-like compounds in the environment that causes problems with reproductive cycles. We are seeing more and more evidence of the problems caused by these compounds. Obviously, this is related to the whole contaminant problem.

So, we will be looking at those two areas that will be of particular importance. We have in this past few months, reduced the number of committees that we have in the Committee on Environment and Natural Resources. We now just have five, each one focused on what we see as one of our major initiatives. We have the Global Change Committee headed up by Bob Corell. We have a Natural Disaster Reduction Committee headed up by Bill Hooke from NOAA, Bob Hamilton from USGS, and Bob Volland from FEMA. We have an Air Quality Committee. We have an Ecological Systems Committee and then a Toxic Substance and Risk Committee. Under these five committees, we are looking at ways that we can both identify major new initiatives, ways that we can coordinate with lesser amounts of money, and activities that we think need attention but don't require any new funds. We are trying to put together a kind of pyramid of initiatives. I don't have viewgraphs today, but this is all up on the home page for the Committee on Environment and Natural Resources, and you can get there through www.WhiteHouse.com or OSTP.com. All of that is kept up to date so you can see reports, the initiatives, and where we stand in terms of funding.

Let me say a word about the issues that we see facing these federal committees because this is really the important thing. We are into the balanced budget mode where it is very hard to find money. Roughly half the money in the federal budget is in entitlements and those are things that tend to grow rather than go down. Then the other half is divided into three parts. One is national defense. One is interest on the national debt. And the other is everything else in the federal budget. So, we are down in the 16th percent of everything else, and even as the economy gets better and better, as it has been doing, the government and the public expects us to live within a limited budget. So, we have to find a way to do that, and it means that whatever we want to put forward we have to have a very strong case for it.

The other thing that I am trying to do, and this is a kind of meeting that exemplifies it, is to get outside input to government agency planning. Now, this is not as easy to do as one would think. It seems like a logical thing to do, but some federal agencies don't really welcome it.

The academic community tends to think on longer time scales than the agencies, which tend to think on yearly budget cycles. So, you have different time frames between

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the government and academia. You have cultures that are not used to being mixed up. During one of my first meetings with the Committee, I said, " I propose that we have some academic people come in here and sit with us and help with the planning," and I thought everybody was going to say, "Yes, great." But, the reaction was more negative than positive, "Why do we want to do that?" I think we are now at a place where this kind of joint meeting should be more the norm than the exception. I am now trying to work some formal arrangements so that we can have the outside community, the academic community, private industry and environmental groups, come in and be part of the planning process. We have found that the more we engage the stakeholders in the planning process the better job we do of doing planning and of making sure that everybody understands what we are trying to do.

So, stakeholder involvement is very important. Then the final thing is that we are continuing to try to make sure that the President and the Vice President are aware of the issues. If you have seen recent speeches by the President, you will hear him speak about global change, about environmental monitoring, about the importance of the environment in general, and this is because of the process of the National Science and Technology Council, which is headed by the President and has Jack Gibbons as the person directly responsible. This puts us at a higher level in the process, and as we've worked through the first four years, I think we are seeing some progress.

Questions/Discussion:

MR. MYERS: I am Chuck Myers representing the Interagency Arctic Research Policy Committee. I was particularly interested in your two priority areas, environmental monitoring and endocrine disrupters. Environmental monitoring has been a topic for the Arctic for the past seven years, and in fact, we have in the several agencies been contributing to the Arctic monitoring and assessment program. They have just published a report, State of the Arctic Environment. So, we are actually four years ahead of the overall federal effort. the second area you mentioned was the endocrine disrupters. This is a major part of the U.S. Arctic research plan. We have a section on the assessment of risks to environment and peoples in the Arctic. The question is, how do we translate this planning, which has been going on for several years, into actual resources through the CENR?

DR. BAKER: This meeting is one example and another is the Arctic Research Initiative in NOAA; both are examples of how to work the process. There have been lots of committees and there are lots of good reports that have been written about what is to be done. What we need to do is to turn those reports into some real new resources. The way we do that is by convincing Congress that this is a good thing to do.

We do have a number of important members of Congress who have a special Arctic interest. Senator Ted Stevens, Chairman of the Appropriations Committee is from Alaska. He has an automatic interest in polar arctic issues, and thus it is important that he and his staff and other people continue to be aware of the things that can be done.

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We are trying to make the best possible case for environmental issues as we go forward in the federal budget process. So, in our 1999 budget in NOAA you will see requests for things that are basically built on the initiatives that you and Garry Brass and other people are putting together. Your planning helps us make things happen.

DR. COX: Is there some kind of listing of what the nation's priorities are with respect to science and engineering needs, science and technology needs?

DR. BAKER: Yes, every year the National Science and Technology Council puts out what is viewed as the priorities both for this year and then for the long term. In fact, there is a White House document just out called Science and Technology Priorities for the 21st Century. It has a very nice section on the environment and reflects all of the priorities of the Committee on Environment and Natural Resources. I am sure it is pretty widely distributed.

Once again, you can pick that up on the White House home page, go to the National Science and Technology Council and you will see those priorities there. I would expect that most of you had an opportunity to comment on those, and that is something that we are continuing to try to do is to make sure that we have this kind of joint process as we go forward.

DR. WEATHERHEAD: Betsy Weatherhead, University of Colorado. In talking about your priorities I thought it was very interesting that you had no mention of AMAP, the Arctic Monitoring Assessment Program, which seems to lead straight into the priorities that you were talking about, setting up a report card and doing environmental monitoring in addition or in conjunction with the physical monitoring. The U.S. involvement with AMAP has been so terrifically low I think it is noted in the first AMAP report that data from the U.S. is lacking on a variety of subjects.

Can you comment on what you see as the reason for the lack of U.S. involvement and what might be the future for U.S. involvement in this sort of activity?

DR. BAKER: I was trying hard not to mention any specific program because there are lots of very good arctic programs that have been put forward that are woefully underfunded. I believe the U.S. needs to do a better job in standing up to its responsibilities here. The whole point of looking at arctic contaminants as we have here in this workshop and then trying to broaden out an initiative is something I am very interested in trying to do.

AMAP is a program that was discussed with me when I first came in as NOAA Administrator. Alan Thomas and Ned Ostenso gave me some very good briefings on that, and we have been looking for ways. In fact, I think the conversation that we had was, "This is a good program. We have to figure out how we can get this funded," and we are continuing to try to address the issues that you are mentioned.

This is a first step here as we look at priorities how we can handle funding; if we can continue to make a strong case, hopefully we can do better. There is a dilemma: you have responsibilities and needs and new things that ought to be done, but budgets which are flat at best. How do we make things fit? How can we get enough attention on arctic issues now?

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There is new technology. There is sympathy in Congress. There is enough interest that we can make something happen. The problems in the Soviet Union with nuclear waste and the attention this has brought has alerted some people; this may help eventually get resources onto these problems.

It is difficult, but I think AMAP has done a good job in terms of identifying what should be done. Hopefully we can do better in participating.

A View from the National Ocean Service

Jawed Hameedi

Good morning, ladies and gentlemen. Most of you know that Dr. Nancy Foster is the new Assistant Administrator for National Ocean Service. Coincident with her appointment there are likely to be some significant changes in the structure of the organization and probably will affect the way we do business. I do not know what those changes are going to be. Dr. Foster could not be here in person.

My name is Jawed Hameedi. I have been associated with NOAA's National Status and Trends Program for about 4 years. Before that I was associated with the Outer Continental Shelf Environmental Assessment Program for about 12 years in Alaska and before that I did some marine acoustics work in the Chukchi Sea and before that I taught oceanography at the University of Washington. If somebody asked me to write the vision and mission statements for the National Ocean Service it would read something like that.

There is a very strong connection between the economic well-being of the country and the quality of the environment, and if you read the mission statement that I have listed here, the concept of environmental quality or conversely that of environmental contamination sort of pervades through all of these items.

We do a number of things in the National Ocean Service that deal with the environmental contamination. Most is done in the Office of Ocean Resources Conservation and Assessment, and most significantly in the National Status and Trends Program where we monitor contaminants in the coastal areas to identify spatial and temporal trends, define spatial extent and severity of sediment toxicity and in situ changes in biota and ecosystems.

What we do is national in scope. The Arctic is an important part of our efforts only in the sense that there are some new emerging problems in the Arctic relative to contamination. The Arctic still is regarded as a pristine environment that is very rich in natural resources. There is very extensive petroleum development and production operation going on the North Slope of Alaska and we know that there is widespread occurrence of contaminants in nearly all aspects of the arctic ecosystem; more recently, we found some evidence of new generation pesticides widely distributed in the air, fog, seawater and the surface layer in the Bering Sea and Chukchi Seas.

I would like to address three issues relative to contaminants in the Arctic and what we have done about it. One important consideration is the occurrence of radionuclides,

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particularly in animals of subsistence use in the Arctic. We have found that the typical consumption of caribou meat would add a very small amount of radiation dose, which is 0.0045 milliSievert. This is very small compared to what the natural radiation brings to the humans and, also, from some other anthropogenic source such as x-rays.

Now, this was based on the terrestrial food chain. In the case of the marine food chain, the impact from the consumption of subsistence foods is really minimal, almost negligible. We have also found that global fallout seems to be the primary means of distributing radionuclides in the Arctic.

Metal contamination is a quite different issue because it is very complicated. Here is an example of very large amounts of accumulated cadmium in the kidneys of walruses; this number, 147 to 204 parts per million, far exceeds an amount that is known to cause renal disruption which is about 50.

Now, if you look at this data there is obviously magnification in the food chain, and again, this number is fairly high compared to what we find across the country. We don't have data from the Chukchi Sea and very few data from the Beaufort Sea. One explanation proposed is that there is a zinc mine which is being developed in the Chukchi Sea and that probably provides a lot of cadmium. We do not have the sort of information that we would like to have to really know if this is the case.

The third issue is very difficult only in the sense that we do not have adequate data on it, and that has to do with persistent organic pollutants. As Betsy Weatherhead mentioned, if you look at the AMAP report you will find essentially vacuums and gaps wherever there is supposed to be information about Alaska and the U.S. Arctic. However, where observations have been made we have found that there are PCBs and there are isomers of hexachlorocyclohexane, which is an insecticide in small amounts. But, if you look at the concentration in marine mammals in Alaska it is quite appreciable, but the levels are not very high. The question sometimes arises when people are looking at the concentrations of contaminants in other parts of the Arctic and then not relating to how the contaminants really are comparable or not comparable to the Alaskan area. Often they are making the connection that if terrible things are happening elsewhere, they ought to be happening here as well.

I think fisheries people have a lot more to say about this than I do. A few years ago there was a very large article in the Anchorage Daily News about the contaminants in the subsistence foods, but it was very realistic. Now, I am hearing that some terrible possible problems are going on. I think it behooves NOAA and other resource management agencies to try to relate as to what the real scientific data are and what the implications might be.

I have only shown five of many overhead transparencies included with this talk, but most of them are self-explanatory. You've asked each of us to say what we think NOAA ought to do: one of the important things that I would really like NOAA to set up a long-term multiparametric (meaning various contaminants) and multimedia (meaning air, water, sediment and biota) monitoring program in the Arctic. I have been proposing that for the last 5 years, so far with no success.

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Questions/Discussion:

DR. OECHEL: How does this program interface or how should it interface with the Arctic Research Initiative?

DR. HAMEEDI: When the Arctic Research Initiative was developed 2-1/2 years ago, Ed Myers and I worked together. I was the one who put together the information from all the various NOAA elements in that draft that was then distributed. So, we are very involved in this one from the point of view of planning and so on.

Now, the other side of the coin is that in the last go-round of the Arctic Research Initiative funding, that had to do with these kinds of questions that I talked about, was zero. So, we sort of are there but sometimes not there.

DR. OECHEL: All that is lacking is money, right?

DR. HAMEEDI: I don't think so. I think it is a little more than just money.

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Vision:

Healthy, safe and economically productive coastal and oceanic environments for present and future generations

Mission:

- Protection of life, property and the environment
- Effective management of the coastal zone and sustainable use of its resources
- Assessment of the condition and productivity of coastal ecosystems
- Reduced costs of pollution abatement and monitoring

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NOS — Office of Ocean Resources Conservation and Assessment (ORCA): Missions

Provide Improved Capabilities and Information for Use in Coastal Management

- *Monitor Contaminants in Coastal Areas to Identify Spatial and Temporal Trends, Define Spatial Extent and Severity of Sediment Toxicity, and Describe in situ Changes in Biota and Ecosystems*
  (NOAA's National Status and Trends Program)
- *Provide Scientific Support to Manage the Cleanup of Spills and Discharges of Hazardous Materials*
- *Evaluate Damages to Natural Resources from Spill and Discharges of Hazardous Materials*
- *Conduct Comprehensive Strategic Assessments of the Multiple Uses of the Coastal Zone*

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NOAA's National Status and Trends (NS&T) Program

Long-Term Goals

- ***Assess the status and trends of environmental quality in relation to levels and effects of toxic contaminants, radionuclides, and other sources of pollution in US marine, estuarine, and Great Lakes environments;***
- ***Develop diagnostic and predictive capabilities to determine effects of toxic contaminants, radionuclides, and other sources of environmental degradation on coastal and marine resources***

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US Arctic

- *Widely regarded as a pristine environment that is very rich in natural resources: oil and gas, fish, timber, coal, hard minerals, and wildlife; rapidly expanding non-exploitative activities, such as tourism*
- *Continued petroleum production and development at a very high level (Prudhoe Bay, Kuparuk, Endicott, North Star, Liberty, Badami, and Alpine)*
- *Widespread occurrence of contaminants, particularly "persistent organic pollutants" in all components of coastal ecosystems [long-range transport; "cold trapping" or "global distillation" hypothesis; scarcity of the hydroxyl radical]*
- *Recent evidence of "new generation pesticides" [e.g., triazines, organophosphates] in air, fog, seawater, and surface microlayer in Bering and Chukchi seas*
- *Heavy reliance on subsistence use of animals; 40 different species are harvested (marine mammals, caribou, anadromous fish, and eiders predominate)*

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Petroleum Hydrocarbon Pollution

NOAA's Involvement in OCSEAP, 1974-92
Fairly Good Information

- Spilled Oil Trajectory Calculations — Diagnostic, Probabilistic and Real-Time Modeling
- Spilled Oil Weathering Routines
- Environmental Sensitivity Index [Spilled Oil Retention Potential] — Beaufort and Chukchi Seas
- Movement of Oil in the Presence of Sea Ice
- Knowledge of Environmental Constraints to Technology, e.g., Sea Ice, Permafrost, Seismicity
- Exposure Characteristics, i.e., scale and timing
- Nature of Biological Effects — Laboratory and Microcosm Experiments
- Diagnostic Measures to Infer Petroleum Hydrocarbon Sources, e.g., LALK/TALK, PRIS/PHYT, N/P, FFPI, etc.

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Petroleum Hydrocarbon Pollution

Not So Good Information

- Evaluation of Compliance Monitoring Data
- Biological Effects at Hydrocarbon Concentrations Observed in the Field
- Oil Spill Counter-Measures in the Presence of Sea Ice
- Susceptibility of Indigenous Human Populations

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Radionuclides in Animals of Subsistence and Ecological Value

- ***We have recently demonstrated that in the Barrow area:***

- ***Typical consumption of caribou meat, having 24-36 Bq/kg of Cesium-137, adds a very small amount (0.0045 mSv) to the average annual effective dose equivalent of ionizing radiation from natural (3.0 mSv) and other anthropogenic sources, such as x-rays, consumer products, and air travel (0.6 mSv)***
- ***Subsistence foods derived from marine food chains pose much smaller and negligible radiation dose; radionuclides in blubber, muscle, kidney, and liver of marine mammals are below detection or extremely low, less than 0.5 Bq/kg dw of Cesium-137***
- ***Global fallout appears to be the only significant source of radionuclides in the region***

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Cadmium in the Arctic Environment and Biota

	Ag,	As Cd, µg/g dw	Zn
(Sediment)			
SE Bering Sea (n=12)			0.08
Off Yukon River (n=4)			0.03
Norton Sound (n=13)			0.09
Chukchi Sea			No data
North Slope (n=4)			0.29 [NS&T "high" 0.54; ERL 1.2]
(Walrus, n=509, prey species)			
Mya sp.			6.8 [NS&T "high" 5.7]
Serripes sp.			0.7
Mactromeris sp.			1.3
Tellinids			2.7
Echiurus worm			2.7
(Walrus kidney)			
1981-89, mean values		147-204	
(Mammalian kidney)			
Renal disruption		50 [LMW proteinuria]	
Correlation with age?		very possible, only weak correlation found	

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Persistent Organic Pollutants

- *A very sparse, almost inconsequential data base suggests that POPs (notably PCBs and HCH isomers) are widespread in the US Arctic; no discernible pattern can be surmised*
- *POP concentrations in marine mammals is appreciable (e.g., ca. 0.5 µg/g of PCBs in seals and 5 µg/g polar bear) but considerably lower than reported high values elsewhere in the Arctic (e.g., 4 µg/g in seals off Russia, and 50 µg/g in polar bears in Svalbard). {Note: Mean level of PCBs in human adipose tissues is about 1 ppm, and ca. 4 ppm in those involved in electrical equipment repairs}*
- *A somewhat muted concern in Alaska about the presence of POPs in subsistence food species three years ago (see Anchorage Daily News, June 19, 1994) has now blown into a major hyperbole (based on possibility of hormonal dysfunction, immune-suppression, porphyria, cancer)*

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What NOAA Should Do to Succeed:

- *Restate its policy and institutional commitment to addressing Arctic contaminant issues on a sustained basis*
- *Develop a mechanism to ensure equitable participation by pertinent NOAA line offices and programs; given item #1 above, NOAA must establish a long-term, multi-parametric and multi-medium monitoring site — an "index site" — treat Barrow.*
- *Build on its reputation of scientific excellence and trust in reporting of scientific results to the public — Reach Out and Communicate*
- *Seek and implement collaborative interagency efforts that would be mutually beneficial*
- *Take an active role in fostering bilateral and international accords, such as:*

- Assisting Russians in settling up a scientific program for prudent development of oil and gas resources in the Arctic
- Seeking collaborative efforts with Norwegians on POP measurements
- Ensuring effective and best available representation at international fora

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Benefits of Comprehensive Environmental Monitoring off Barrow

- *Demonstrate NOAA's leadership in orchestrating a multi-disciplinary environmental monitoring program*
- *Demonstrate feasibility of a comprehensive approach to environmental contaminant monitoring*
- *Implement NOAA's existing quality assurance and quality control procedures in a multi-agency context*
- *Provide opportunity to residents of the Arctic to participate in research and monitoring to assure them on the region's environmental quality, well-being of their traditional food resources, and health of the ecosystems they depend on for subsistence*
- *Effective use of the region's facilities and talent in cooperation with State of Alaska and local government agencies*
- *Serve as an important US contribution to AMAP, and fill a key void in existing contaminant monitoring sites in the Arctic*

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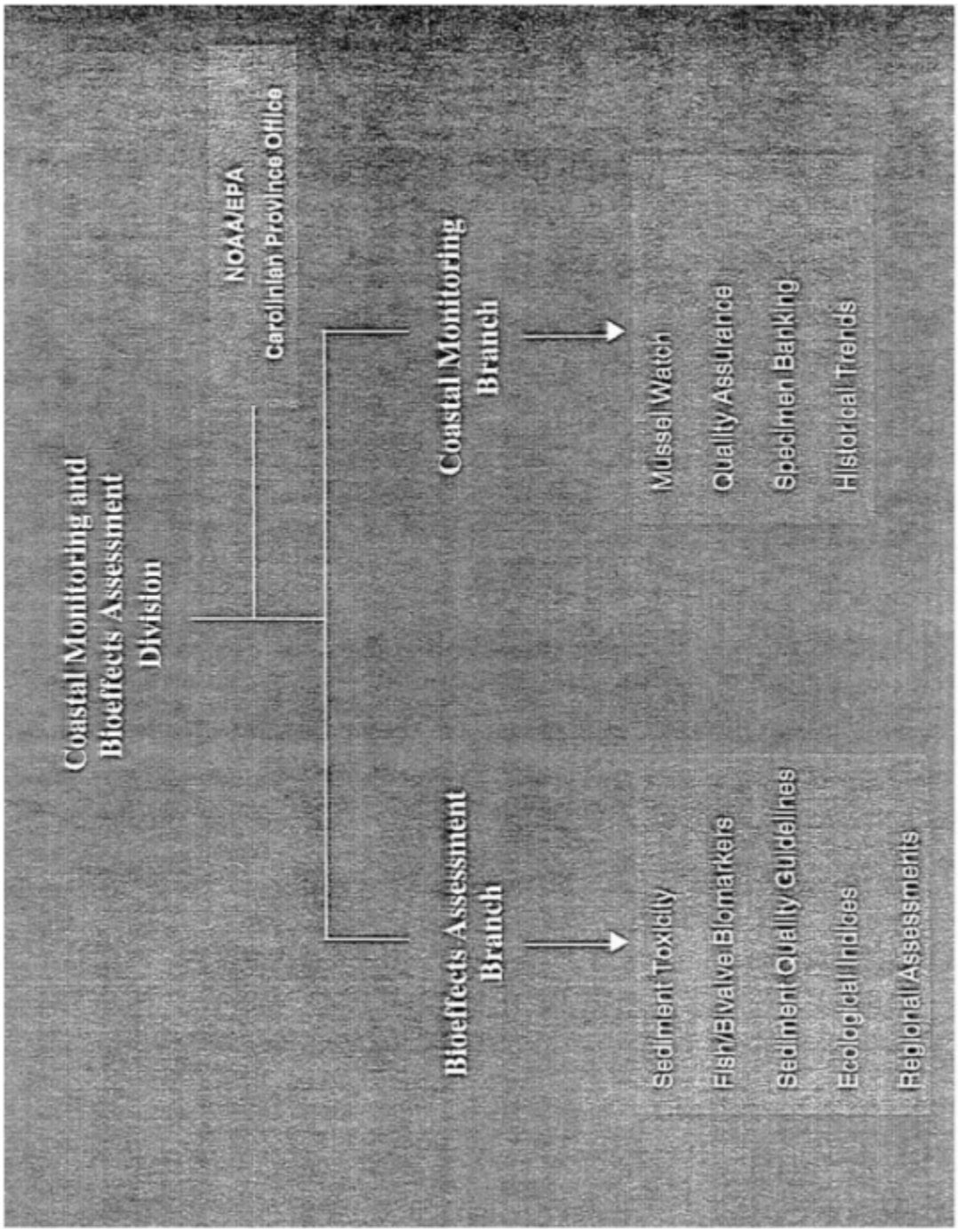

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NOAA'S National Status and Trends Program: Alaska Sampling Sites

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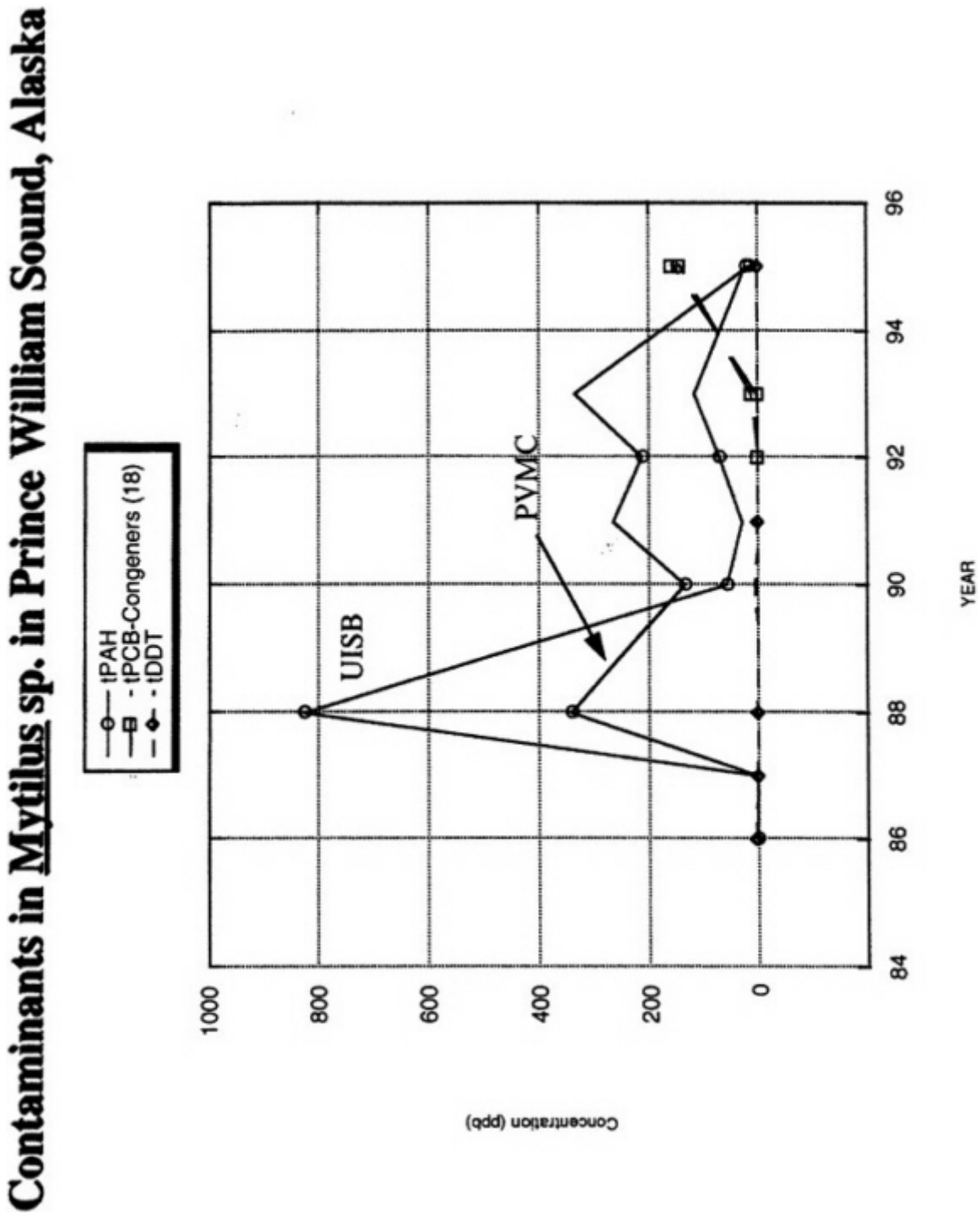

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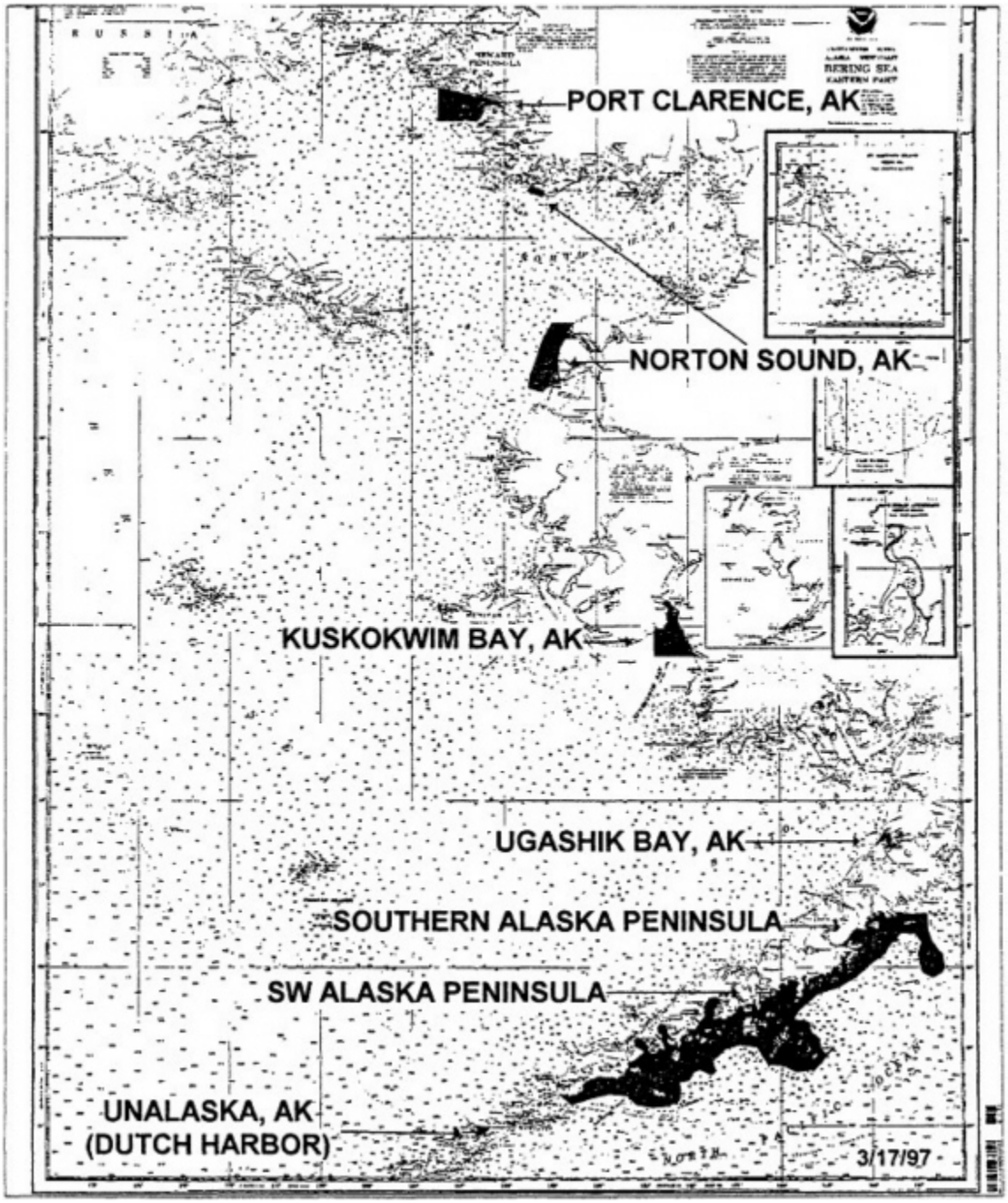

NOS CRITICAL HYDROGRAPHIC SURVEY AREAS

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A View From The National Weather Service

Robert Reeves

I am Bob Reeves with the Office of Meteorology in the National Weather Service. You heard Dr. Friday's opening remarks. He has a lot of history with Arctic and polar issues. Unfortunately I cannot claim that same long history, although fortunately, maybe for the length of this presentation. I am counting on our people in the Alaska region for major contributions in the arctic contaminants area.

The NWS role with respect to arctic contaminant research is primarily one of data collaboration and support, and of course, there will be users of end products. There are some activities specific to the Arctic and I will highlight some from the Alaska region.

Ice pack location, density analysis and 3-day forecasts for all Alaskan marine areas are being done in the Alaska region. The analysis is based heavily on visible microwave and infrared digital satellite imagery from NOAA and defense polar satellites. The second one, high-resolution sea surface temperature analysis for the ice-free areas of the water in that region, and the hydrologic forecasts of the Jokulhalups which is the sudden release and flood of water from glacier-dammed lakes during the summer melt season. Moving right along to activities related to contaminant issues, and this may be a little bit of a stretch for us, is transport of contaminants in water bodies, and thus there is an interest in the ocean sea circulation.

NCEP is indirectly involved with contaminant transport and fate issues through its contribution of ice modeling efforts. Bob Brombine is here from NCEP. I am not going to try to review these because he will be here through the rest of the day to address those specific topics.

The Alaska region also supports some of the Department of Energy research along the arctic coast and the central interior. They are measuring atmospheric constituents, looking at contaminants and arctic haze in stratus. We receive some of their data from their meso networks and low-level wind profilers.

Stratospheric ozone monitoring—our people at the Climate Prediction Center are involved in that. I believe Walt Planet is here, and I will defer any comment or discussion about that area to Walt. And of course, a routine prediction of volcanic clouds is made in the Alaska region in our operations there.

Regarding key research strategies related to the Arctic, one of the things that Jim Kemper raised was long-term temperature variations and Dave Hofmann and Eddie Bernard have whetted our appetites with some of their illustrations this morning.

I would like to see a lot more of this kind of work. We talk about global warming and again there is some question about whether some of that is anthropogenic and whether in the rural areas you are actually seeing some of that warming. Some people feel that the tundra is dying. The permafrost is melting. Glaciers are melting, and there is a tremendous impact on animals and humans.

When you look at the total percentage of CO_2 absorbed, the tundra takes 25 percent according to our people. So if the tundra is dying it is going to have some effect

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on CO_2 absorption. The NWS offices in Alaska are collaborating with staff at the University of Alaska, Fairbanks under a common initiative to work on mesoscale modeling in the Arctic. A couple of the models are being run there. They feel that much more needs to be done in modeling the Arctic atmosphere and boundary layer for such things as ice, snow, water cover tundra cover and permafrost layers.

Also, they feel to the extent that the course or grid models tend to miss mesoscale features which are recurring then this can have a negative feedback on our estimations of climate change. So, mesoscale modeling is an important area. The primary role for the Weather Service, when I use the term "monitoring" here, I am talking about observations, atmospheric observations primarily; mesoscale model development to help with the transport problem and data integrity. The issues of data quality and continuity I think are very important. Where we can have an impact in those areas is ensuring that these things are carried on and that maintenance of instrumentation is kept up, and that is my presentation.

Questions/Discussion:

DR. OECHEL: You mentioned the tundra dying, and I am not sure how accurate that is. Climate change will cause replacement of tundra by other vegetation types and species, but I don't know if dying is really an appropriate way to look at it. You are aware that the tundra historically in the recent geologic past has been a sink for carbon and that carbon is stored in the soils; the amount of carbon stored is about 300 billion metric tons. So, it is significant relative to the atmospheric CO_2 levels; Over the last couple of decades it has shifted from a sink to a source, and the size of the source varies seasonally, but virtually every year for Alaska every year since the early eighties the tundra appears to be a source of CO_2 to the atmosphere rather than a sink. So, it has shifted from that significant ongoing long-term sink now to a source.

DR. FRIDAY: Walt, are the quality of measurements on the changing from a sink to a source enough to indicate trends of any consequence, because this is one of the doomsday scenarios on global warming that has been postulated in the past, and I am curious to know if the data really support it yet.

DR. OECHEL: My personal opinion is that the data on long-term carbon accumulation are pretty good. They are spotty, but they are pretty good because they are based on C14 analysis and P profile. I think the data on measurement of fluxes that were made during IBP are quite good. Then from the eighties to current, we have a pretty good indication of the trend, the UV variability and carbon flux, and what all those data show together is that the long-term history is a sink of one-or-two-tenths of a gigaton per year for the Arctic.

In the seventies it was at least that or maybe a bit more. By 1982, areas that were measured were a source and through the late eighties it was source along the haul road, and comparisons were made at Barrow which I think were quite solid. That was a major effort and fairly sophisticated approaches in 1991-92, and there what you see is 1971-72

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through 1974-75 was a strong sink; 1991-92 was a seasonal source just during the summer, and then if you add the winter losses of carbon, then the source is even larger.

I think we have enough data to say that the long-term pattern is one of a sink. The seventies it was a strong sink. The eighties to nineties it has been a variable source. The remaining questions include things like what is the ecosystem acclimation; what is the potential for ecosystem acclimation; how much ecosystem acclimation have we already seen; and what can you do with the record that we have of 10 or 15 years now to project into the future, and that is a big uncertainty.

DR. OECHEL: I gather from your presentation that there is more handshaking between the Arctic Research Initiative and your program than maybe some of the other programs; is that true?

DR. REEVES: I don't have a good feel for that. I just got a sense from Jim Kemper that he was wondering where the meteorology fit in from last year, but what I see in the guide from the booklet that was handed out, there is a lot of room for atmospheric involvement in this program.

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NOAA's Arctic Contaminants Research

The NWS role with respect to Arctic contaminant research is primarily one of collaboration and support

Responsibilities of the NWS in the Arctic

Ice pack location, density analysis, and 3-day forecasts for all Alaska marine areas: Bering Sea, Bering Strait, Cook Inlet, Bristol Bay, Chukchi Sea, and Beaufort Sea, based primarily on satellite imagery.

High resolution sea surface temperature analysis for open water in the Bering Sea and Gulf of Alaska, including Cook Inlet, Bristol Bay, Prince William Sound, and southeast Alaska.

Hydrologic forecasts of Jokulhlaups

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Activities Related to Arctic Contaminant Issues

Transport of contaminants in the water bodies, thus there is an interest in ocean and sea circulation in the Bering, North Pacific, Beaufort Sea, and Chukchi Sea.

NCEP is indirectly involved with contaminant transport and fate issues through its contribution of ice modeling efforts (for shod and medium range forecasting), and forecast surface winds and surface currents that could be used for hazardous spill forecasts

1) Sea ice drift model —
2) Automated sea ice analysis —
3) Full sea ice model —
4) Sea ice thickness assimilation research with NASA —
5) Effects of ice on atmospheric circulations —

The Alaska Region support of Department of Energy research in Alaska along the Arctic coast and in the central interior. Arctic haze and stratus. NOAA special rawinsonde releases. DOE mesonets and low level wind profilers located near Barrow.

Stratospheric ozone monitoring using ground-based and satellite measurements No. Hemisphere Winter Bulletin published annually in April

Volcanic Cloud Predictions

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Key Research Issues Related to Arctic Contaminant Inputs, Transport, and Effects from Natural Variability and Anthropogenic Influences

Long-term temperature variations impact vegetation and animal life dramatically in the Arctic. Because Alaska is warming, which causes the tundra to die, the permafrost to melt, and glaciers to melt, there is tremendous impact on animals and humans.

Improved Mesoscale Modeling

The NWS offices in Alaska are collaborating with the meteorology staff at the UAF under a COMET initiative to work on mesoscale modeling in the Arctic. Jeff Tilley is adapting the NCAR MM5 model to Alaska and is successfully running very early versions of the model on the UAF Cray and HP workstations. Peter Olsson is adapting the Colorado State RAMS to Alaska and is running it on the Cray. It is these projects we had in mind for support coming from the CIFAR.

Much more needs to be done in modeling the Arctic atmosphere and boundary layer for such things as ice/snow/water cover, tundra cover, and permafrost layers. To the extent that the larger grid models tend to miss recurring mesoscale features, then better mesoscale modeling can serve both real-time and climate interests. Modeling advances which provide more realistic air and water transport of contaminants will provide more accurate representation of the Arctic contributions to climate events.

Primary role for NWS-monitoring, model development, and data integrity

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A View from the National Marine Fisheries Service

Teri Rowles

I am going to do a quick overview of the National Marine Fisheries Service's (NMFS) role and mission. Basically, the NMFS is steward of our living marine resources, and our role is broken into three parts. One of NMFS's responsibilities, which is national but also relates to the Arctic, is to maintain sustainable fisheries. NMFS is also involved in efforts to recover protected species, which is dominated in the Arctic by marine mammals. NMFS is also working to maintain healthy living marine resource habitats.

Some of the legislation that drives NMFS and gives it the authority to act include the Marine Mammal Protection Act, the Endangered Species Act, and the Magnuson-Stevens Fishery Conservation and Management Act. The only one that targets contaminants per se is under the Marine Mammal Protection Act. All of NMFS's management is based on science, and NMFS is beginning to involve more of the native communities and the local people into the science and program decisions.

We have several specific programs related to Arctic contaminants. The first program is the Marine Mammal Health and Stranding Response Program (MMHSRP). This program is an extension of the Alaskan Marine Mammal Tissue Archival Program, which has been ongoing since 1987. The MMHSRP is primarily a banking and a biomonitoring program for contaminants and health issues.

By combining the biomonitoring and the banking portion of the program, we have about 1600 individual animals that are in the process of being analyzed or have been analyzed, and well over 250 of those are from the Arctic.

The second NMFS program of interest would be the contaminants center of expertise, and Suzanne Bolton (who is here) is in charge of that program. She is identifying nationwide where we have expertise in contaminant issues, so we know what resources, both people and technology, that we can draw on to answer specific questions. She can talk a little bit more about that during the break-out sessions.

Third, the National Marine Analytical Assurance Program (NMAAP) is performed in cooperation with the National Institute of Standards and Technology. It looks at banking and quality assurance issues related to contaminants. It grew out of the MMHSRP, and participation is required for any NMFS-sponsored or NMFS-performed research on contaminants. This program ensures that our data are comparable and that we know what we are reporting. Also, we have an external review group that evaluates our efforts. Both NMAAP and MMHSRP are coordinated internationally with Canada and the Nordic countries.

Fourth, we have the Environmental Conservation Division (ECD) of the Northwest Fisheries Science Center, which is our main contaminants lab, located in Seattle. The ECD is not the only contaminants program within NMFS.

Finally, the Alaska Fisheries Science Center does a lot of the biological monitoring. In order to interpret ecological effects or impacts you have to know a lot about the biology and the trends, both long term and short term, in the actual biota.

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If we look at the future, No. 1 on my personal list is coordination, both within the agency of NOAA and also, within the other federal agencies. We are trying to do that through the MMHSRP because that is where we have our legislative mandate for contaminants. Also, quality assurance is important to make sure that we are all talking about the same thing, and that we can compare data. NMFS is focused on the ecological effects and not as focused on human health effects. However, we do provide data to human health risk assessors and risk assessment groups. Risk assessment and risk communication are very important and we are sorely lacking in how we are going to communicate and what advice we are going to provide to local communities.

Most of the current NMFS contaminant analytical reports relate results to the FDA human food consumption level. Again, we are not focused on the human risk assessment, but use this just to give the public an idea of levels and relative safety. We're involved in archival assessments of data, making sure that we have databases that keep track of data. That way, in 50 years we can look at the actual tissue specimens or at the data that was compiled from them. This is an overview of what we are doing within National Marine Fisheries Service.

Questions/Discussion:

DR. HILD: Jawed mentioned earlier about the cadmium levels in walrus kidneys, and when that report first came out from U.S. Fish and Wildlife Service there was a lot of concern because these are high levels, and people wanted to know if this was a problem.

Two questions: one, at your contaminants center would they be willing to look at those samples and try to get a better handle on whether or not these levels are actually higher than baseline from walrus or are at levels that are causing some kind of physiological damage to these animals, even though walrus are under U.S. Fish and Wildlife Service and not under National Fisheries?

My second question is whether you are providing any kind of assistance in regards to that risk communication back to the community about what the data really mean. In that report it stated that the cadmium levels were 13 times what you find in the cow's kidney. What does that tell me?

DR. ROWLES: To your first question, I can address it in the marine mammals sense in that we have a cooperative agreement, a memorandum of understanding, with Fish and Wildlife and the Biological Resources Division to coordinate the programs, and DOI provides some of the funding for the program. We are doing some analyses on walrus tissues.

A lot of the times in the past we have just looked at tissue residues, but now we are making sure that we collect health indices and biomarkers so that we can look at potential impacts. And yes, these levels do exceed the levels that we see effects in terrestrial mammals. The effects we will expect in marine mammals may be very different because physiologically they are different. Walrus kidney cadmium and the

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bowhead whale kidney cadmium levels from that same area are both high. We are looking at both of those in collaboration with North Slope Borough and DOI.

To your second question about risk communication, basically, we are not in the business nor do we have the expertise for human health risk assessment. What we are doing is providing data to human health risk assessors so they can then advise.

Also, when we get samples in from native communities as part of the agreement, we send a report back to them. Again, we say, "This level, how it compares to what the FDA levels are for human food consumption," and that is about as far as we can take it with our expertise.

PARTICIPANT: What risk communicators do you communicate with, and what are they saying to you?

DR. ROWLES: Right now we are turning over all of our data to the Alaska Department of Health and Human Service, Grace England, and we are giving her our data. They are building a database. We have also turned over data to the University of Alaska, Anchorage.

The problem, the biggest gap that I see is what happens to contaminants during processing and storage. That can change what is bioavailable to the consumer. That is the data gap right now for the risk assessors.

PARTICIPANT: Teri, what about multiple stressors? I have heard a lot about multiple stressors, such as heavy metals, hydrocarbons, etc., and UVB. Maybe Ed would like to mention something about that. I don't think anybody has been addressing that issue adequately.

DR. ROWLES: I agree with you. It is very, very difficult in the marine environment or in any environment to look at multiple stressors when you cannot do actual experiments in which you can test them and piece them out. For instance, we know that UVB affects immune function. We know that many of the contaminants that we see can affect immune function, and we are going to have to look at it cumulatively. A lot of times for marine mammals we are not allowed to do directed experiments but they can do some kinds of experiments in other countries. Scientists in Norway are investigating lab studies of immune function and POPs and NMFS/UAF are doing some field studies that were funded through this program last year. It will be advantageous to compare what we are seeing versus the directed simulations that we are doing in Norway. Multiple stressors just complicate these issues. Mixtures and multiple stressors are a real problems for investigators trying to identify what they do and how they work together.

PARTICIPANT: Yes, that is a very key point because evidence is now just beginning to come in that there are these synergistic effects between UVB and these contaminants, both in terms of photosensitization of species and in terms of photo-product production which then is harmful to species. So, I am glad to hear and see that there is emphasis now in this direction, but we need a lot more.

DR. ROWLES: Yes, certain contaminants can alter an organism's ability to live within a certain temperature range. That is going to have a real impact on some animals survival.

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A View from the National Environmental, Satellite, Data, and Information Service

Walter Planet

I want to make some brief comments on contributions of the Geophysical Data Center in the Office of Research and some brief comments, also, on satellite observations in general, not necessarily specific to any one area. The Geophysical Data Center has put together an Arctic bibliography following a workshop that was held in 1993. The bibliography contains something like 750 citations, and it was distributed to 250 members or participants of that workshop.

That was put together by the National Snow and Ice Data Center. The Marine Geology and Geophysics Division archives analytical data on several thousand sea floor samples from the Bering Sea and the Western Antarctic. They have been working with NRL to put together a CD-ROM and their activity was to be a joint effort between NOAA and NRL, but due to some programmatic changes, it appears that NRL will make that just a single agency effort, and NOAA's NGDC activity in that area is yet to be determined.

That is the data information side. I would like to briefly discuss some satellite ozone measurements. ESDIS, of course, operates the NOAA operational weather satellite program, and we do give data to other people. Bob Reeves mentioned some of the work that was being done by NCEP of the National Weather Service. They are using the data. This figure happens to be a northern hemisphere projection for one day in April, and this is total ozone observed by the instrument on one of the NOAA satellites. This is the SBUV/2. This is an analysis of global ozone. The black spot is a region of no data.

These data are gathered every day. They are used for NCEP during for ultraviolet index. We are coming into the age where ozone profiles are going to be going into the numerical weather forecast. This instrument gathers total ozone; it also gathers the vertical profiles on a daily basis

Our primary interest to date in looking at ozone has been trend analyses, and here is a view of the distribution of the anomaly in total ozone. The general area that we are interested in is the north and mid latitudes, but we do have total ozone coverage and vertical profile coverage throughout the globe. There are several things that you can see here. This very purplish region is of a very marked depletion of ozone in the northern mid latitudes. Again the black regions are areas of no data.

There are ozone data that are available that are archived for pretty close to 20 years. A database does exist, and whether or not it can be focused on a very specific region such as the Bering Sea is something that has to be looked at. Again, to date our ideas have been looking at global depletion of ozone at best regional depletion, and we have not yet gotten down to small regions.

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Questions/Discussion:

DR. HALLET: Is there a general understanding of the trends you showed in the last slide? It looks like the amplitude of the ozone increased quite a bit through the early nineties and then decreased more recently.

DR. PLANET: Especially in this region?

DR. HALLET: Right.

DR. PLANET: Yes, there is association with volcanic eruptions at that time. There was very marked depletion in the north and mid latitudes around that time. Everybody saw it. Everybody's measurements saw it. There were something like 20 or 30 papers that discussed the depletion.

PARTICIPANT: Those data slides that you are showing are extremely valuable for people like myself in the effects area for UVB and I get them off the Internet, and it has been such a useful resource. I hope, A, you will continue and B, you will continue to get funding to make sure that that is out there.

DR. PLANET: These data are from an operational program, and the way I understand it is funded to 2020 or something like that, long after I am retired.

PARTICIPANT: I have a quick question, not so much about NESDIS but about the data centers. One of the roles that the data centers are supposed to play is in data rescue from the former Soviet Union, and there are many issues involved there that are extremely important to understanding the Arctic, and I wonder if someone from NOAA can comment on what they are doing in data rescue.

My particular hobbyhorse is that there is tons of hydrologic data about to be used to heat homes in the winter. We need to understand the 100-year and 500-year floats, what they are likely to do in remobilizing.

DR. PLANET: I cannot address that question in any way. You would have to go to the data center itself.

PARTICIPANT: I have a connection to that National Snow and Ice Data Center, and I will say that in their case they cannot answer your kind of question, but they are working with IRE on data rescue for the Arctic Ocean, the sea ice and the meteorological information that is gathered out of the polar drifting stations. That data is out, and some of that data is now available. So, at least within their realm of data that they work with, they are working on that kind of data.

DR. COX: The private sector is, also, addressing that issue, and I can give you some information later.

PARTICIPANT: There is, also, a UN center at Octon I think. I have not explored what they are doing, but I think this is an important aspect of contaminants.

PARTICIPANT: Gary, I just talked to Sid Levonitz. His program is still going strong, and he has got hundreds of thousands of data points from Russia, and it is continuing.

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A View from the Coastal Ocean Program

Michael Dowgiallo

Eddie Bernard laid a nice context out for what I am going to talk about here. The Coastal Ocean Program sponsors one of the projects in the Bering Sea, the Southeast Bering Sea Carrying Capacity Project. In 1991 the Coastal Ocean Program initiated the Bering Sea Fisheries Oceanography Coordinated Investigations, which focused on the Bering Sea. The Bering Sea focus did two things. It identified the stock structure and then the recruitment for Walleye pollock. Walleye pollock is the largest single-species fishery in the United States, and in all of the Bering Sea fish and shellfish it accounts for 10 percent of the landings for the entire world and 40 percent of the United States landings. So, this is a very critical area for fisheries in the United States.

The main lesson is that we do not fully understand the fragility of the Southeast Bering Sea ecosystem, and the main issue is that pollock population levels fluctuate widely under natural variability and this is coincident with some declines that have been seen in the 1970s and 1980s in seabird and mammal populations, which are at the upper trophic levels of the food chain in that ecosystem.

The objectives of the Carrying Capacity project are to understand the ecosystem, to provide a better understanding of the Southeast Bering Sea Shelf and the associated high productivity, with pollock as a nodal species. Pollock as a nodal species means that a high percentage of the energy flow within the system passes through pollock, and pollock is both predator and prey in the system. Ultimately we would like to provide a pollock recruitment index to be incorporated into stock assessments by National Marine Fisheries Service to recommend allowable biological catch estimates to the North Pacific Fishery Management Council.

The project is a 5-year study. It is multi-disciplinary. It is a NOAA academic partnership. It has retrospective observational process and numerical modeling studies. The focus is on natural variability not contaminants, although the research on the physical transport and the effort to identify the components of the ecosystem would certainly have relevance to the potential effects of contaminants.

This image shows walleye pollock spawning habitat and currents. The circulation patterns here are such that the water flows down the Alaska stream, makes its way through two of the main passes, and then flows on the north part of the Aleutian Islands up towards the slope. Once the water reaches the slope it flows northward and then on to the Asian continent. I wanted to show you that to set the context for a later slide which would show the potential route for contaminants. Generally contaminants from the Gulf of Alaska, North Pacific and Aleutian Island areas could reach the Bering Sea through this mechanism. On the green belt image there is a continued introduction of nutrients into the euphotic zone, which causes the high productivity along the shelf of the slope.

Eddies are a very common feature in this region, and the eddies can contain high concentrations of pollock larvae. The eddies tend to interact with the bottom topography

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and when they do this they seem to enhance upwelling and further fuel the productivity of the green belt.

On the altimetry image shown earlier, this was a part of the carrying capacity study and a minor component of carrying capacity. Eddies are a very important feature and this definitely needs to be incorporated into the study. Most of the circulation studies that are involved in carrying capacity are actually on the shelf and not on the slope area, and the shelf exchange processes are very poorly understood. This is a very interesting area that might be a focus of the Arctic Research Initiative.

This image shows satellite track drifters. They show fairly clearly some shelf-slope exchange and possibly a retention mechanism here. This contour right here, the Aleutian Islands, is a 1,000 meter contour which is approximately where the slope is, and once these eddies occur, there is retention and transport onto the shelf.

To wrap up, the shelf and slope exchange processes are not well understood. Eddies may be an important transport feature not only for nutrients and organisms but, also, for contaminants. Once these materials reach the shelf they could have a direct effect on the massive abundance of marine life including crabs, pollock, and salmon, and Carrying Capacity will be documenting not only the ecosystem structure but the interannual variability of the entire ecosystem all the way from primary productivity to marine mammals, thus providing a much better understanding of what is at risk and it will show the pathways, hopefully, that water-borne materials such as contaminants could enter and affect the ecosystem.

Questions/Discussion:

DR. BURCH: The slides you showed and some of the earlier ones have most of the biological activity going on in the eastern or southeastern part of the Bering Sea. Is that because most of it occurs there or is that because most of the studies have been done there? Might there not be something comparable on the other side?

DR. DOWGIALLO: In terms of the green belt, the productivity spreads all over. The green belt shows high productivity. The green belt covers the slope area of the whole Bering sea, but the key feature here in terms of our research in the Coastal Ocean Program is we found out that while pollock are spread all over the Bering Sea this is a focal point in terms of larval recruitment, high chlorophyll abundance and it is just a hot spot of activity for pollock. So, in terms of our research that has been our focal point.

DR. HALLET: I am trying to reconcile this map with the sort of snapshot showing the one eddy. Do the eddies sort of form all along the green belt or do they move along the green belt or what is the connection here?

PARTICIPANT: Some are transient. Some are stationary. That one fight there has been there for about two months. Others are transient.

DR. HALLET: The green belt is the locus of where these form and move along?

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PARTICIPANT: The prevailing currents take you up along the slope. So, as they shed off they can be transient and some are more stationary. So, it is a combination. It depends on meteorology, too.

DR. DOWGIALLO: In this particular image this eddy right here is closer to the green belt than the one that was here. This one was of more interest because it was directly adjacent to the green belt, but there were eddies that were found offshore.

DR. HALLET: I have another naive question here following up. I think of an eddy as being an area where the water has been sort of accelerated by centrifugal acceleration.

So, I expect a low there, and yet I see that the water is actually mounted up in there. *PARTICIPANT:* It is clockwise, anticyclonic clockwise.

DR. HILD: Have you done any work with the local communities to find out more since you are looking at carrying capacity about changing capacity and use of some of the native language for their understanding? The reason I bring this up is I know a friend of mine told me that the Aleutic word for cod is sometimes disappears and so there is a longstanding observation that some of these fish sometimes are there very abundantly, and other times they were not there.

DR. DOWGIALLO: Yes. Research was coordinated with local populations on the Pribilof Islands.

DR. HILD: I am glad to hear that.

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Southeast Bering Sea Carrying Capacity

Issue:

• Pollock population levels fluctuate widely co-incident with declines of seabird and mammal populations

Project Objectives:

- **Understand the ecosystem of the Southeast Bering Sea Shelf and its associated high productivity with pollock as a nodal species.**
- **Provide pollock recruitment index to be incorporated into stock assessments to recommend allowable biological catch estimates**

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NOAA Coastal Ocean Program Southeast Bering Sea Carrying Capacity

Southeast Bering Sea Carrying Capacity (SEBSCC) is one of the newer projects sponsored by NOAA's Coastal Ocean Program. Begun in 1996, SEBSCC is a five-year, interdisciplinary, regional ecosystem study. The southeast Bering Sea is a major ecosystem and economic resource, boasting an abundance of high-latitude marine life and some of the busiest fishing ports in the nation. This ecosystem responds to changing conditions in ways that we observe as fluctuations in abundance of commercial fish and shellfish, sea birds and marine mammals. To manage the economic resource we need to understand what processes perturb the ecosystem and how it responds.

In its present form, the southeast Bering Sea ecosystem has a dominant species: the pelagic, commercial fish walleye pollock. Because of its prevalence, pollock is a nodal species, constituting an integral part of the region's food chain as both prey and predator. SEBSCC researchers are studying the ecosystem in that context. Research topics concern the role of the physical environment, the sources and fates of nutrients (the building blocks for all productivity), and the food chain from phytoplankton through zooplankton to pollock and other fish, seabirds, and mammals. Techniques include retrospective analyses, ecosystem monitoring, process studies, and modeling, with an emphasis on developing annual indices of pollock juvenile abundance.

SEBSCC engages agencies, groups, and investigators with broad ecological interest in the southeast Bering Sea. As described in the SEBSCC Home Page (http://www.pmel.noaa.gov/sebscc/), the project is managed by a unique NOAA-academic partnership, with research performed by two NOAA laboratories and five universities. Results from SEBSCC research relating to short-term forecast of pollock recruitment will be incorporated into stock assessments used by NOAA's Alaska Fisheries Science Center to recommend "allowable biological catch" estimates to the North Pacific Fishery Management Council. Other project results pertaining to the availability of juvenile pollock to upper-food-chain predators will assist Council decisions regarding restriction of fishing around marine mammal rookery areas. The Council is incorporating ecosystem factors into its management decisions, and information provided by SEBSCC will expedite this effort by improving knowledge of the role of pollock in the southeast Bering Sea. The project's focus on the response of the ecosystem, and in particular juvenile pollock, to changes in environmental conditions will provide a context for resource management in a changing environment.

For more information, contact SEBSCC's project coordinator, Allen Mackiln [tel. 206-526-6798; e-mail macklin@pmel.noaa.gov] or Mike Dowgiallo at COP [tel. 301-713-3338, ext. 129; e-mail mdowgiallo@cop.noaa.gov].

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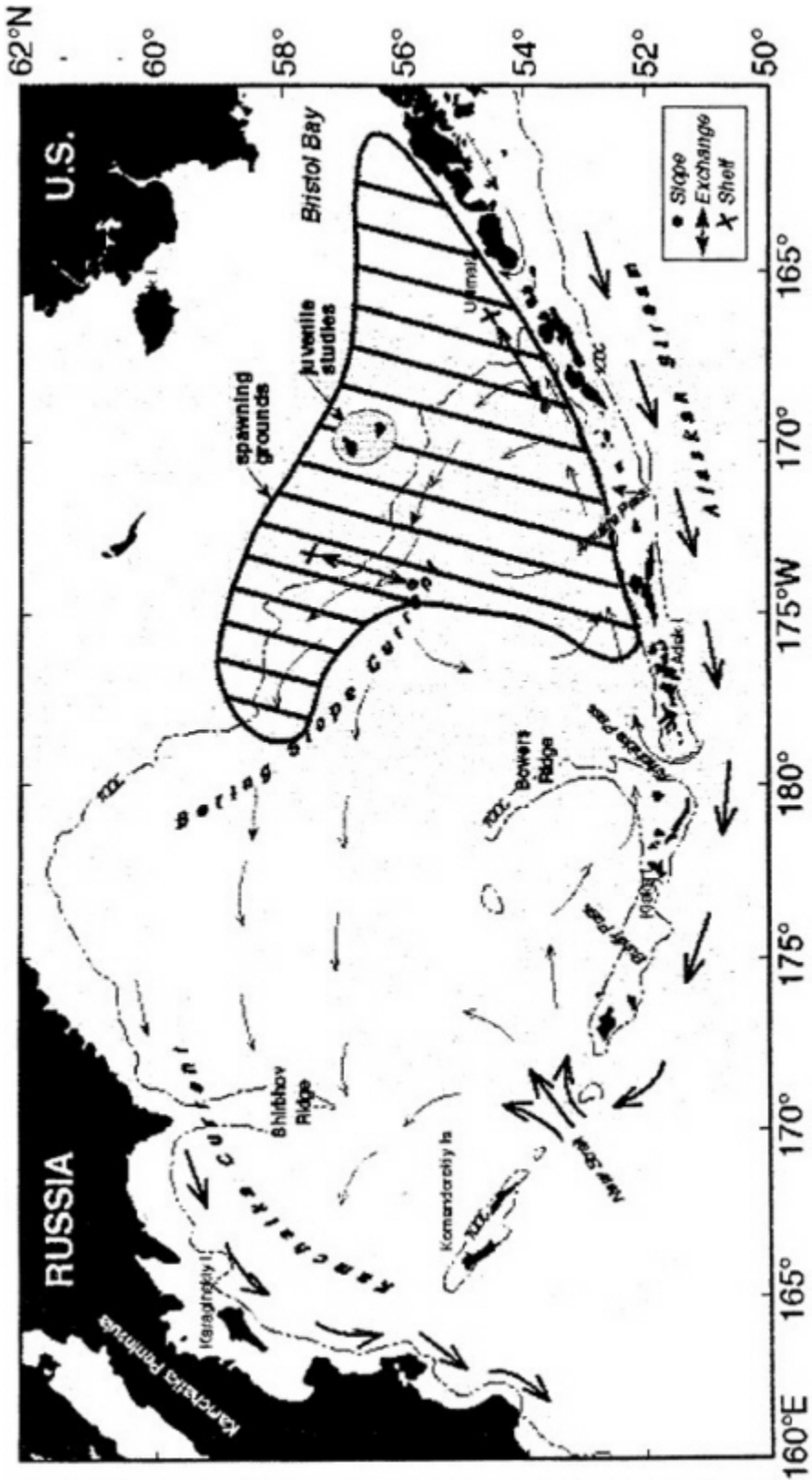

Bering Sea circulation and walleye pollock spawning habitat

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Prolonged Biological Production, Ocean Color and Eddies in the Green Belt of The Southeastern Bering Sea

Prepared by Drs. J. D. Schumacher and P.J. Stabeno, both at PMEL

The shelf edge in the eastern Bering Sea is a region of prolonged productivity as a result of the continued introduction of nutrients into the euphotic zone (Springer et al., 1996). This band of enhanced primary and secondary productivity is generally referred to as the Green Belt (Figure 1). Eddies are a common feature of this region (Schumacher and Stabeno, 1997; Schumacher and Reed, 1992). They can contain high concentrations of pollock larvae (Schumacher and Stabeno, 1994) and are hypothesized to interact with topography to cause upwelling of nutrients which fuel Green Belt productivity. A knowledge of eddies and their biophysical dynamics is vital toward understanding natural variability in this region of prolonged production (Springer et al., 1996).

To locate an eddy in a timely fashion so that field operations can examine these features is a challenge we have surmounted. During NOAA's Coastal Ocean Program (COP) Bering Sea FOCI, coordination between researchers at PMEL (Dr. Phyllis Stabeno) and Colorado Center for Astrodynamics Research (CCAR: Dr. Robert Leben) occurred. In order to direct field operations for her study of ocean color (funded in FY97 for one year by COP's Southeastern Bering Sea Carrying Capacity program), Dr. Stabeno needed information on the presence of eddies in the Bering Slope Current. She contacted Dr. Leben who now provides satellite measurements of anomalies of sea surface height (ssh) through the world wide web* in near-real time.

A positive anomaly (clockwise eddy) located south of St. George Island (approximately at 55 N 170 W) has consistently appeared for several months (Figure 2). This from was chosen for the SEBSCC ocean color study of production within and outside of an eddy over the slope as observed from satellite-tracked drifters equipped with ocean color sensors (Figure 3). A cross-section of density (sigma-t) and the inferred geostrophic velocity (Figure 4) reveal an asymmetric distribution of mass and speed. This may indicate that the eddy is "robbing" against bathymetry of the inner slope/outer shelf and experiencing the affects of friction. During this process, nutrients may become displaced vertically and thus become available to phytoplankton in the euphotic zone. The distribution of chlorophyll across the eddy (not shown) reveals that higher concentrations of chlorophyll existed within the eddy and over the shelf edge than over the basin. The use of near-real time satellite altimetry together with satellite-tracked drifters equipped with ocean color sensors provides an important tool for examination of biophysical processes in the Green Belt. The drifters will continue to monitor chlorophyll concentration and circulation for the next six months, thereby providing a time history of the eddy and associated prolonged production.

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FIGURE CAPTIONS

1. A composite pattern of primary productivity in the Bering Sea. The high productivity of the Green Belt (indicated by the dark green) is centered on the shelf edge. (From Springer et al., 1996).
2. Contours (5 cm interval) of sea surface height anomaly from satellite altimetry on 12 June 1997. The eddy selected for investigation is located south of the Pribil of Islands at approximately 55.5 N, 170.5 W. The center of this eddy has surface relief of about 20 cm.
3. Shown are the trajectories of two satellite-tracked drifters deployed four weeks prior to 12 June and a set of four drifters deployed between June 11 and 13 in and around the eddy. These latter drifters carded ocean color sensors to measure an index of production within the eddy and in the adjacent Bering Slope Current water. The drifter trajectories reveal clockwise rotation of the eddy of ~40 cm s-1.
4. The distribution of density has been used to provide estimate of geostrophic velocity (cm s-1) in the eddy. Note the reduced speed in the eastern half of the eddy. This is associated with shoaler water and the spin down of the eddy as it interacts with topography. The highest concentrations of chlorophyll were found at the eastern most station and within the eddy, with very low concentrations found at the western edge of the transect.

This document is available through the *What's New* sections of PMEL World Wide Web sites maintained by Southeast Bering Sea Carrying Capacity (http://www.pmel.noaa.gov/sebscc/) and Bering Sea and North Pacific Theme Page (http://www.pmel.noaa.gov/bering/).

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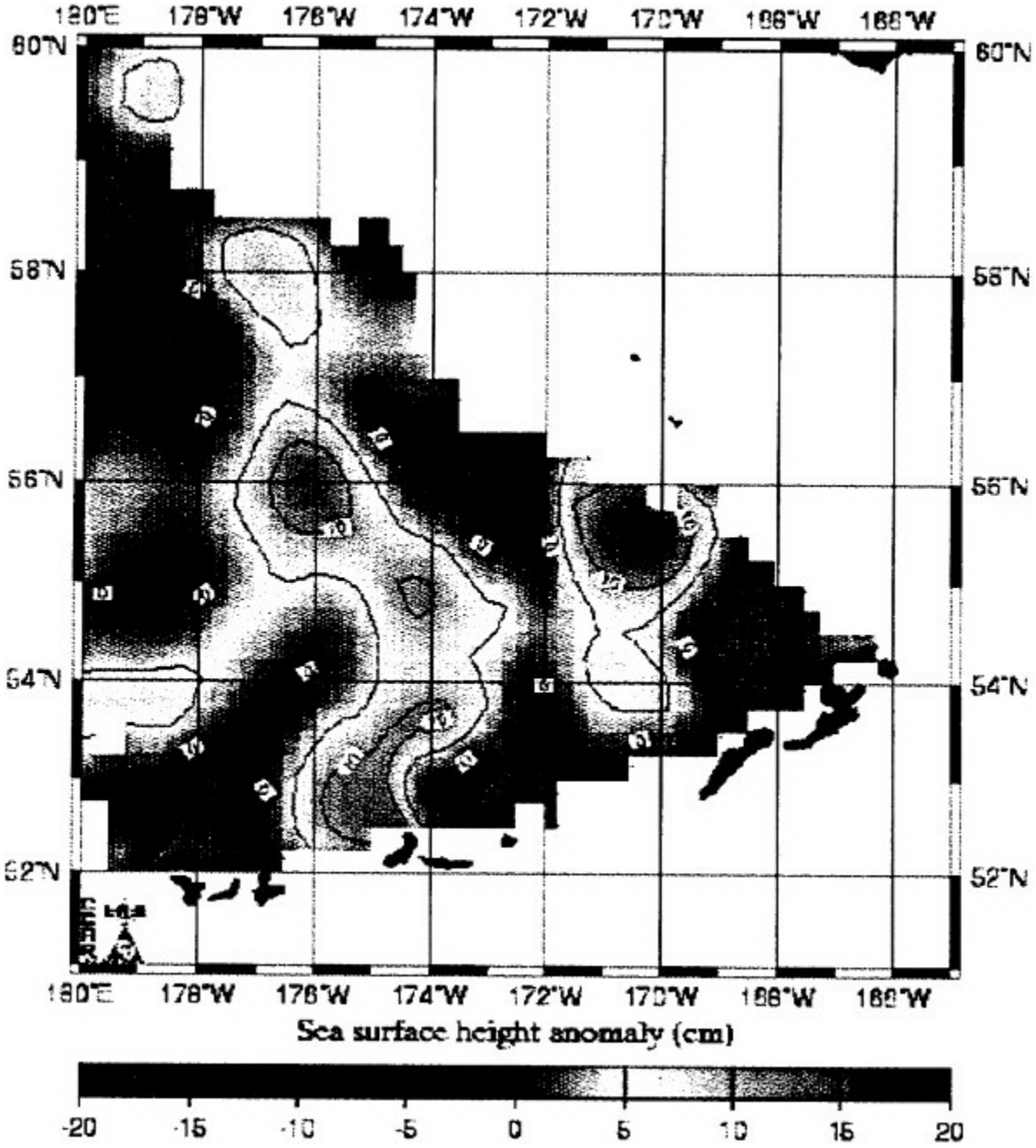

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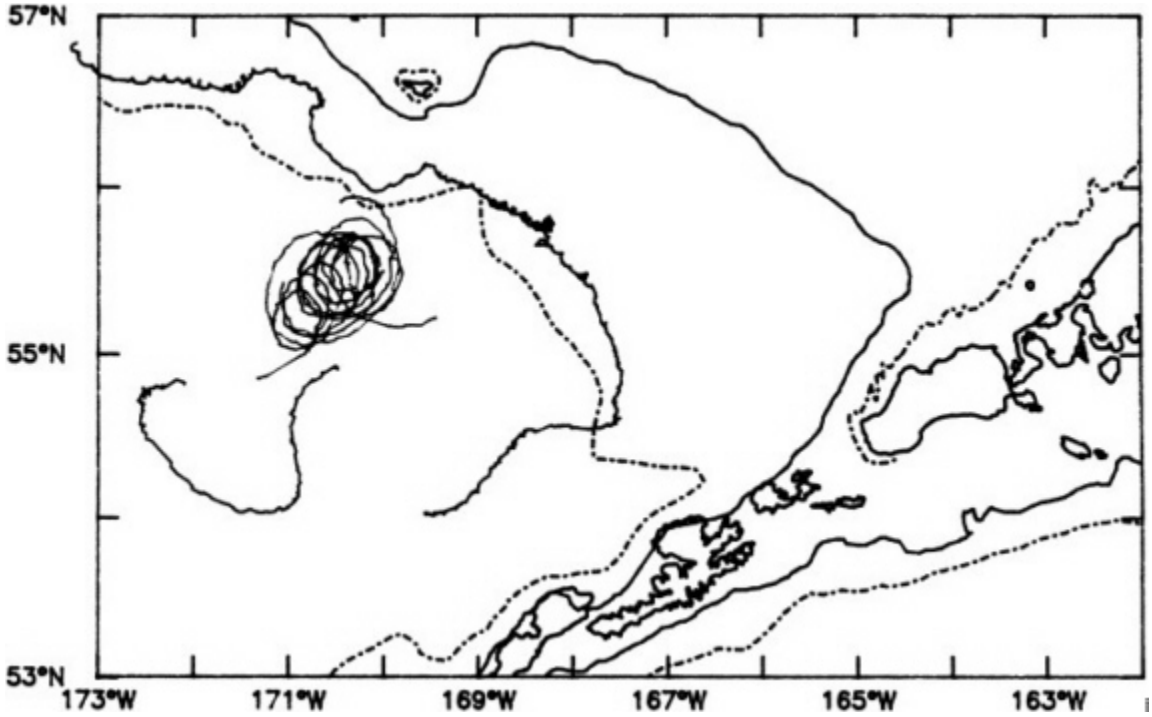

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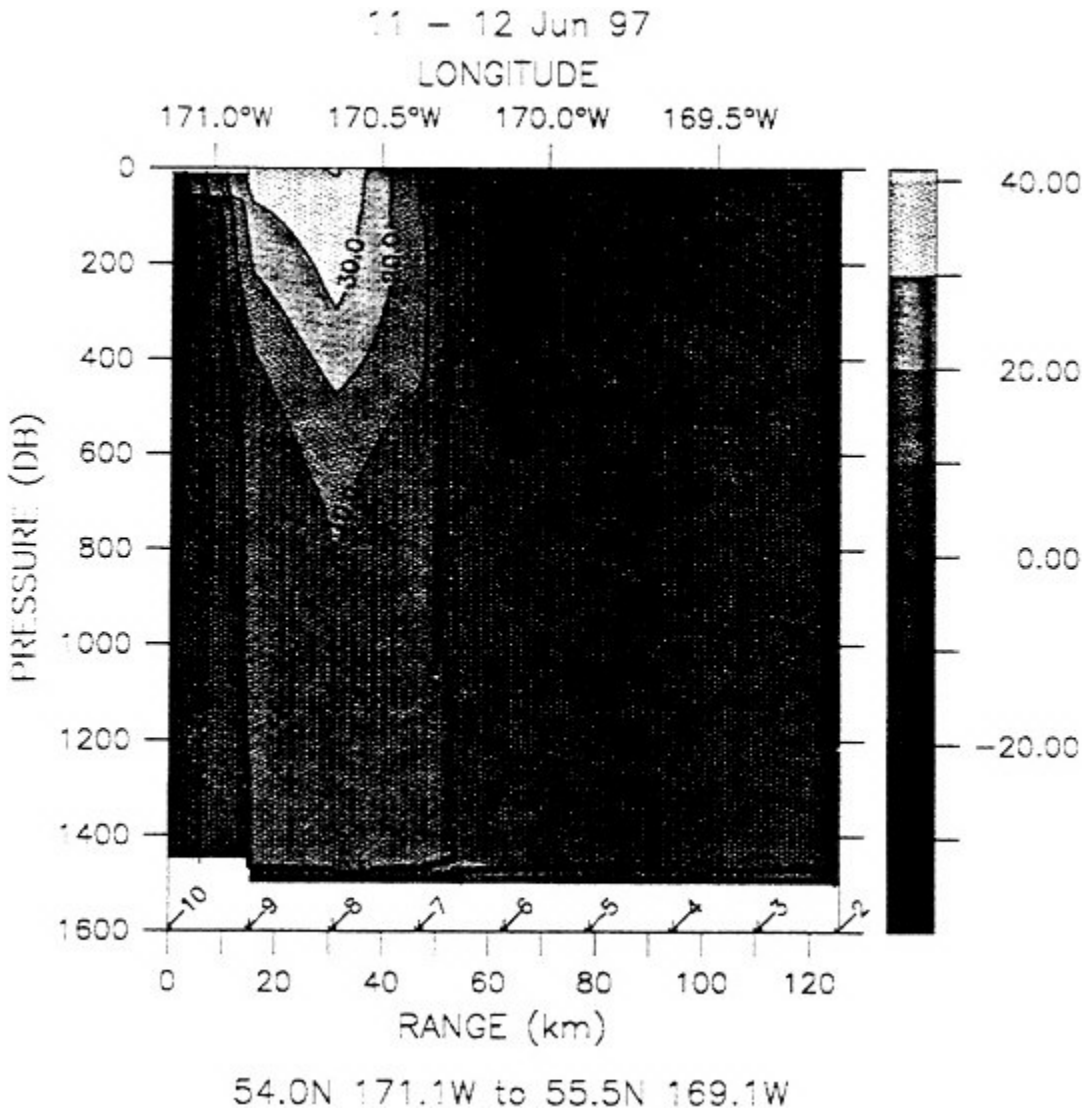

GEOSTROPHIC VELOCITY IN THE EDDY

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Other Perspectives

Bob Senseney, Department of State

Given the time constraints, there are just a few key messages that I want to get across. We have done an assessment at the U.S. level of our activities under the AMAP program. A copy of that is available on the table as well as a copy of the most recent declaration from the Arctic Environmental Protection Strategy at ALTA. One of the main messages of the AMAP program was that there were areas where U.S. participation was not at the level that we had hoped. We did, however, find that there were areas where our information was combined with Canada, and so the perspective that came out was a North American perspective. So, the U.S. contribution was not always entirely known. There were other instances where there was data, and information available, but it was not provided to AMAP.

We will be now focusing on the Phase II of AMAP, and as you will see from the declaration at ALTA the areas of inquiry for AMAP Phase II are even broader than AMAP. The areas of inquiry fall into three areas. One is contaminants. One is ozone depletion; and the other is climate change.

Now, what is the challenge for the U.S.? I think the challenge for us is to look at what are our U.S. programs fight now and our future program efforts in these areas and how can we ensure that this information is shared with the broader international community?

I think that is the challenge. I feel this is important not just because I am at the Department of State and I believe in the importance of exchanging international information but because I do firmly believe that there is a lot of information out there being collected from the other governments, the other researchers, the other universities, and that we have to give in order to receive (and who knows which is more blessed to do?)

So, I do think that it is beholden upon us to look at what are our current programs and what can we provide to the international community and see what we can obtain from them.

Another major effort is the fact that the Arctic environmental protection strategy is now being melded into the Arctic Council, which has a broader mandate than the Arctic environmental protection strategy. There is an increased focus on sustainable development by whatever definition you wish to apply, and there is a greater emphasis on human health. That also is reflected in the ALTA declaration. I go to various Arctic science meetings and hear these same themes is repeated over and over again. The challenge is how do we ensure that our U.S. programs are funneled into international efforts and to our international neighbors so that we get credit for that contribution, and are making a valid contribution.

U.S. programs can be leveraged with programs that are going on in other governments and other countries. This will encourage others to contribute to our

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programs, and it will increase, the body of understanding of the Arctic, which I suspect and I hope is the main goal of all of these meetings.

My third message today is that in hearing the discussions here of looking at recruitment and at the various species I think this is important and a noble effort, but there is something that seemed to be lacking in some of the discussions. Maybe someone mentioned it, but one very important issue is permafrost, and the stability of permafrost in the Arctic. It is my understanding that some 80 percent of Alaska is built on permafrost and close to 50 percent of all of Russia is built on permafrost.

Now, not being a scientist myself I don't understand all of the various processes that may be at play here, whether or not they are cyclical or endemic, but I do think it is important that we look at this particular issue not only because of its domestic implications but because of its international implications.

If there is a problem of permafrost stability we will be propping up more than just the economy of the former Soviet Union. It really is beholden upon us to look at these issues because they will have a major dramatic impact on the United States, U.S. foreign policy, and strategic interests.

Questions/Discussion:

DR. COX: I am not sure whether or not this is an appropriate time to bring up the AMAP program but since we are talking about international efforts, I went through the executive summary of the AMAP program and was happy to see that they identified pollution threats or potential threats, gaps in understanding and recommendations for future work, but what I didn't see were what are the priorities. You know, oftentimes we get a lot of issues that need to be addressed; what came out of AMAP with respect to what are the priorities? What is the No. 1 priority, the No. 2 priority, where we should be focusing our efforts and money?

DR. SENSENEY: I am not sure that I am the best person to address that.

DR. WEATHERHEAD: Ed or I could address that.

PARTICIPANT: I think that depends upon the nation, but I think there are definite priorities. UVB is one. POPs (the persistent organic compounds) is another. There are local problems in Finland and Greenland associated with heavy metals and in Finland there is acid rain or acidification. It really depends on the area, but there are definitely priorities.

DR. COX: Have they been ranked?

DR. WEATHERHEAD: That is the whole point of Phase II of AMAP, which is what we are just starting. Phase I was really a gathering stage: Let us get together all the information and see if we can merge it into a global picture. Let us see if we can get a consensus. Now Phase II is going to let us boil it down. We threw in everything we could think of as a possible problem. Now, let us start evaluating them and decide what has to be dealt with internationally and what are the local priorities.

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DR. COX: What I am looking for are drivers for the NOAA programs: are there some clear messages coming out of AMAP that we could hang our hats on.

DR. WEATHERHEAD: AMAP hasn't set priorities yet. That is what AMAP Phase II is about to do. If the U.S. wants to be involved in the setting of those priorities, if the U.S. wants to be involved with AMAP, the U.S. should start some real involvement at this point. But as far as setting priorities now, we can look to some other groups that have proposed priorities. IASC has set two priorities for international research: climate change and ozone/UV. And we have a couple of other reports that have set priorities. But if you want something as comprehensive as AMAP you are going to have to let it go through its course and really take the proper time to look at everything.

PARTICIPANT: The AMAP Phase I report does indicate priorities through the sections, because it identifies gaps. Clearly POPs come out as a priority. The whole report doesn't directly state the priorities, but I think they are very clear.

Other Perspectives

Garry Brass, Arctic Research Commission

My first experience in addressing groups came when I went through the most rigorous training I ever had in my life called the Fourth Armored Division NonCommissioned Officer's School, and I was told that you should always start a talk with a joke. So, I want to tell you a little story that I first heard actually from Bob Graham, the Senator from Florida, back when he was just a state senator in the State of Florida.

It is about a little Russian bird born far up on the Arctic slope of Russia who was so young he had never been through a winter, and when all his friends left he decided he would stay for the winter. He soon learned the error of his ways as it got colder and colder. So he started to fly south, but the cold overcame him. He was no longer able to fly and he fell to earth in a farmer's yard in Central Russia, and there he lay on the ground freezing. And it just so happened that the farmer came out of his house to check his cows, and on his way to the barn he saw the little bird. He thought for a moment about what to do for him, saw next to him a large and still fresh road apple deposited by the farm's horse, kicked it up, stuck the little bird in, and covered him up.

The little bird began to warm as a result of this comforting environment and soon thawed out and began to feel pretty good and started to sing. At which point the farmer's cat, hearing him sing, came and dug him out of the road apple and ate him. Now, the morals to this story are multiple. First, it is not always our enemies that put you in it. Second, it is not always your friends that take you out of it, and sometimes when things are going good, you ought to just shut up and enjoy it.

I don't know whether NOAA feels that they were put in it with the Arctic Research Initiative or not. I hope that they feel that a friend did it to them, but be that as it may, you are in, and you can sing or you can shut up.

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There are some things that perhaps the Board ought to consider when they talk about this. The first is that we are engaged, and I wake up at night in the middle of the night in the dark and shudder thinking about this, in just about the dumbest exercise I can think a federal government has engaged in, and that is to try to build a regional program that is organized across agency mandates and that occasionally does a cross-cut like CENR on topical themes but has no provision for looking at an Arctic or a tropic or any other kind of geographical mandate. This is a really hard thing we are doing, and the amount of success shows how hard everybody is working at it. I, for one, on the Arctic Research Commission really appreciate everybody's efforts.

That is one point. The second point is that we should remember and be tolerant of the fact that a happy child has many aunts and uncles, and many, many people who support him.

There are a number of programs we are talking about, including this one, that we can give many names to. The work in the Bering Sea is under the Arctic Research Initiative of NOAA but related work is being done under IASC's BESIS program. It probably has many aspects of an important sustainable development program for the Arctic Council. So, let us not be exclusive about these programs. The important thing is that the work is getting done, and in fact, you can look at this as a plus, as an amplifier. If we can find programs that we think are worth doing under whatever mandate they are being done, and we can use them in other venues as responses to AMAP and the Arctic Council or as collaboration with the Japanese or you name it, we should attempt to do that.

Let me make another point, and this is an important issue that I would hope the PRB's report would respond to. The last year's ARI money was allocated in what I think can be called mostly a bottom-up program. Priority areas were identified, but then there was an open call for proposals. The proposals came in. The best proposals were picked and funded. The actual program was put together with only a modicum of direction about research priorities.

There is another way to run programs like this, and I have been associated with at least two of them. The GEOSECs program, probably most of you don't remember now, 25 years ago had a central steering committee which decided what needed to be done and then went out and actually ran a competition saying, "Who is the best phosphate and nitrate measurer in the oceanographic community? They get to be the GEOSEC nutrient people. Who are the best carbon 14 people? They get to be the GEOSEC carbon people." This kind of top-down management program is not the style I was used to when I was at the National Science Foundation, but it may very well be the style that breeds success in the Arctic Research Inititative. Maybe this question of the program management and style, how to actually produce a program when you start with $2 million and a broad mandate, is one the Board could consider.

The next point that I want to mention is the need of our AMAP and Arctic Council Program for infrastructural reporting. It is actually pretty easy, believe it or not, to get funding for the research efforts. It is practically impossible to get funding for

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secretariat functions. Who gathers the data together? One of the things that we are learning as a result of our poor showing in AMAP is that research has been going on like crazy. There is page after page. In the briefing book for this workshop you put together pages of different programs that NOAA is doing in the Arctic, but they are not getting pulled together as our response to AMAP or the Arctic Council. That kind of synthesis work is not done for free. Somebody has to grit their teeth, cover one eye and say, "Okay, we will give some money to the structure. We will support secretariat functions to make the thing happen out of the parts."

Finally, someone asked an interesting question about the original $10 million NOAA initiative request, and I thought I would briefly give you a little history of how the whole thing happened, so people understand where we started and how we got to where we are.

The thing began with an agreement that the U.S. would participate in the AEPS and a response by Chuck's committee, the Interagency Arctic Research and Policy Committee, which is 12 agencies in the Federal Government that have interest in the Arctic, called the Arctic Contaminant Research and Assessment Program, ACRAP. I have always loved that acronym. I don't think Chuck ever called it that, but I love the name. I was not there at the birth of ACRAP, but I was there at its death, and that was the July 1994, meeting of the IARPC seniors where the folks from OSTP and OMB said, "No new money," and they said it just like that.

With that the program crumbled, folded completely. NOAA did a clever thing, and I give them credit because they deserve it, and that is they took their part of that initiative and pulled it together into the paper that you were discussing before about the $10 million a year initiative. That paper had a number of very important and useful sections in it. Although that paper was never submitted to Congress for reasons that we don't have to go into, I took it up on the Hill and told some people that this was worth doing. The result was the $1 million last year and the authorizing committee will authorize $2 million for the coming fiscal year and $2 million for the year after that for this initiative. It is a far cry from the $32.5 million in the IARPC plan. It is a far cry from the $10 million of the original NOAA request, but it is a far cry from zero. As Mr. Dirkson was fond of saying, "A million here, a million there, and pretty soon you are talking about real money." At $2 million a year for 2 years we are talking some real money now.

Questions/Discussion:

DR. HILD: Garry, you mentioned this issue that someone needs to pull these pieces together. I see that IARPC is there trying to pull together the federal agencies, but there is the State of Alaska, and a whole bunch of other stakeholders at the university, at the communities, and the state. Is there some mechanism to pull together really everybody who is concerned about the Arctic and an opportunity to put some planning into this? I think IARPC can get the agencies talking together, which is a nice big chunk,

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but it is certainly not everyone who is involved. If we are going to have a good U.S. policy, we are going to get involved with the Arctic Council, and we are going to be looking at fishery issues or looking at international politics in the Bering Sea, then we have a whole bunch of other players who have to be at the table.

DR. BRASS: You are absolutely right, Carl, and I meant to extend my discussion of the infrastructure to cover that aspect. A number of things are going on. Carl sends me e-mail all the time about things going on in the states. So, I do have some idea about what is going on. The people at the Prince William Sound Research Center in their Exxon-Valdez response monies are interested in doing some participation.

The Alaskan Native Science Commission is, in fact, the place to go for the involvement of the native communities. They are set up to perform exactly that function. There is a whole lot of infrastructure other than within the feds that has to be built, but I believe if it is not led by the feds it won't get done.

DR. COX: Regarding top-down management and a small budget, I know what top-down management is all about. I live by it every day, but it is very important still to get input from the bottom in formulating the program, and you are talking about IARPC as well.

DR. BRASS: I did not mean top-down management to imply that there was no input from every level. In fact, the style that I have participated in in these two big programs always had science steering committees of one sort or another that were community scientists, usually senior community scientists with the broadest view and the most experience to bring exactly that perspective. I don't expect Washington bureaucrats to know what needs to be done next without talking to the community.

Other Perspectives

Ted Delaca, University Of Alaska, Fairbanks

I am the Director of the Office of Arctic Research at the University of Alaska Fairbanks (UAF). I will give you my perspective and the perspectives of a number of other people who have been involved in the NOAA Arctic Research Initiative (ARI) and the NOAA/UAF Cooperative Institute for Arctic Research (CIFAR) since their beginnings but who unfortunately couldn't come to this meeting today. The primary focus of my presentation will be on DIFAR and on the developing UAF/Japan International Arctic Research Center (IARC). Organizationally, CIFAR reports directly to the Provost's Office at UAF. It is actually housed within the Center for Global Change and Arctic System Research, which facilitates and promotes interactions across all of UAF's organized research units. The Director of the CIFAR and the UAF Center for Global, Gunter Weller, who is currently in Australia sends his regrets as does his deputy Director, Patricia Anderson, for not being able to attend this meeting.

I have also been involved in these programs and the ARI, both in promoting and encouraging their development and as part of the review process that dealt with the first

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competition that you have been hearing about today. I will provide some additional background information about the process and some of the issues that influenced the review process.

The Cooperative Institute for Arctic Research was formed in 1993 and therefore existed prior to the establishment of the Arctic Research Initiative. The establishing MOU between MOAA and the University of Alaska has been in place for four years and many of its initial taskings are under way. The realization of the ARI and its research funding has provided a great deal of excitement and enthusiasm among arctic researchers at UAF, NOAA's Pacific Marine Environmental Laboratory and elsewhere in academia, judging from the response to the call for proposals and follow-on communications.

Interestingly, the first money that came into the CIFAR was contributed from ONR's Arctic Nuclear Waste Assessment Program (ANWAP). While those funds were used for the arctic nuclear waste assessment, they also allowed greater breadth an depth to an early evaluation of existing data sets and promoted activities in data-base engineering. CIFAR, therefore, began with a contaminants orientation and continues to promote studies related to the health of the arctic environment.

The ARI announcement of opportunity (AO) and competition have been discussed by several previous speakers. I wish to bring a couple of additional points to your attention about the review process. First, it is important to remember that the ARI funds appeared somewhat late in the fiscal year and posed a few organizational and procedural difficulties. In my opinion, the response by NOAA, CIFAR and various science communities was amazingly fast and efficient. The AO was derived from a workshop held in November 1996 that involved scientists and administrators from NOAA and UAF. At that workshop pointed out some attractive logistical opportunities were identified that would allow the relatively limited funding of the ARI to be much more effectively used. Those logistical opportunities and the rapid approach of the summer reason in the Arctic dictated an extremely short period of time to announce and compete the funds. It was written and approved advertised within two weeks. The science community was only allowed five weeks to respond to it. The panel meeting was held within two weeks of the proposal deadline and notification to proposers immediately followed.

These extreme time constraints posed a few problems. There was insufficient time to obtain written ad hoc reviews of the 56 proposals received and several of the panelists that were approached to take part in the review were unavailable. We, therefore, proceeded with the expertise that we could draw together given the circumstances. All of the proposals received panel review. I was one of the reviewers of the contaminant proposals. The list in your notebook contains the titles and authors of approximately 15 proposals were categorized as contaminant related. My impression of these proposals were quite favorable. Given the short period of time imposed on the research community, the proposals were generally of very high quality. While many of them seemed worthy of funding, they posed some very difficult issues for the panel. For example, our instructions were that the ARI should be considered available for FY97 only. We were compelled,

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therefore, to restrict awards to projects that were highly focused and that could be accomplished with a one-year budget. Additionally, research proposals that had benefited from previous or concurrent funding from other sources and research that could be coupled with existing supported logistical support were looked on favorably. In other words, we were looking to "leverage" funding from other sources wherever possible and were looking for early successes to promote the continuance and enhancement of the ARI.

What we felt we could not do with the ARI was to let it become a bank of last resort for funding all possible arctic contamination research. With the recent discontinuation of the ONR ANWAP program, and the apparent lack of enthusiasm by EPA for funding arctic contaminant research, there is a large vacuum for this type of research support in the U.S. My appeal to this workshop and the PRB is for you to think of themes and priorities that would provide guidance to the AIR. If we recreate another general program for arctic contamination with too broad of an announcement, we will wind up with another scattered response to the AO, uncoordinated research efforts and, in my opinion, a lackluster program. It could be decades before we develop an understanding of the health of the Alaska Arctic.

As I have said, given the difficult circumstances of the first year's effort on the Arctic Research Initiative, I think it was extremely successful that we were able to scope, advertise, select and award high quality proposals in such a low cost expedient fashion. There were two thematic areas identified by the workshop and carded through this process: natural variability and anthropogenic influences on the Bering Sea ecosystem. Within the anthropogenic influences theme, contaminants, arctic haze, and ozone issues were funded. Although Eddie Bernard provided impressive early results from ARI funded research, no results from the contaminants proposals are expected until the principal investigator meeting planned for this coming October.

We expect NOAA's Arctic Research Initiative to make contributions to high visibility developing programs such as the Bering Sea Impacts Study (BESIS). BESIS, a core project of the International Arctic Science committee, examines the impacts of global change on the western Arctic/Bering Sea region. It has gained both national and international recognition. While the 'green belt' investigations described here earlier by Eddie Bernard and others are not officially an element of BESIS, there is wide recognition of its relevance and importance to the developing BESIS program.

The extent of Native involvement in research projects funded through ARI was questioned earlier this morning but not answered very completely. In fact, Native involvement was an evaluation criterion for all of the proposals evaluated and many of the contamination related proposals included Native involvement. One of the funded projects focused on a retrospective evaluation of 30 years of environmental information derived from Native observations.

I also want to take a few minutes to tell you about a very exciting opportunity that we have to collaborate with Japanese investigators in arctic research through the International Arctic Research Center (ARC). The Japanese government has already made

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significant investments in infrastructure development towards this collaboration. There is a present a 100,000 square foot building under construction at UAF. The science community has undertaken a research planning effort that will be published soon for general comment on the internet. The contents of that developing science plan will be important to the deliberations of this committee. The Japanese are prepared to invest significant sums of money into their Frontier Research Program for Global Change which will collaborate with the SUGCRP. The State of Alaska, the University of Alaska and the U.S. government have already contributed significantly to this developing collaboration and the Japanese government is preparing to contribute resources to a vigorous binatinal and international program to study the arctic environment. Global change research has been the principal research area considered in science planning efforts. Within those discussions anthropogenic change, green house gases as contaminants, arctic haze, ozone depletion and UVB influx have figured prominently. Contamination studies could be an integral part of the IARPC research effort. The NOAA ARI has already been discussed as a U.S. contribution to the U.S./Japan collaboration by agency administrators. NOAA's involvement in the IARPC was very positively viewed by the Japanese representatives of the Frontier Program and seem likely to encourage further Japanese investments in arctic environmental research.

Finally, as mentioned earlier in my presentation, the first effort funded through CIFAR was an ONR ANWAP award. A portion of that award will be used for an arctic contamination synthesis scoping workshop this fall. One of the principal purposes of that workshop will be to design future U.S./International research projects that will be presented at the next Arctic Environmental Protection Strategy meeting as a contribution to the next phase of the Arctic Monitoring and Assessment Program.

Questions/Discussion:

DR. OECHEL: I promised in my introduction that we would hear a bit about the contaminants meeting in Fairbanks last August. Could you give the high points of that?

DR. DELACA: You have the results of that meeting in your binders. There were organizational and management difficulties with the meeting that complicated the final production of a proceedings for the meeting. The meeting was supported through ONR funding. My last conversation with Cmdr. Robert Edson, program manager for ONR's AMAP program, directed me to not spend any more time on the proceedings but to look for a mechanism to include the summary sheets from the August meeting included in some other relevant document. The proceedings from this meeting may provide the appropriate format.

DR. COX: What lessons can you give us in terms of now moving forward and trying to do this again?

DR. DELACA: For another effort?

DR. COX: Right now we are looking at what are we going to do for year two, and you have tried the planning for year one. You said that there were some shortcomings.

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DR. DELACA: More lead time is needed. That need is already recognized and planned for. The second competition would allow three months between the next announcement and the proposal deadline. I recommend ad hoc reviews for some of the proposals in addition to panel evaluation. We need to have more clear guidance for the review committee regarding the program priorities. That is the challenge for this PRB workshop. The ARI is an environmental initiative with a contaminants component. I think that balance needs to be kept in mind when providing guidance to the review committee. I agree with the comments of Garry Brass regarding the need to invest in coordinating and trying to draw data sets which we know exist into future evaluation processes. There was a very interesting and productive effort funded by EPA Region 10 through the University of Alaska Anchorage Institute for Social and Economic Research that evaluated the Canadian research program published in 1996 that included summaries of environmental and human health impacts of contaminants in the Canadian arctic. I encourage this committee to include those published results in their deliberations as they were very well presented. The two-day EPA sponsored meeting evaluated the Canadian publication and tried to answer the question: "Does similar information exist for the State of Alaska and its adjacent regions?" "Or, if it doesn't, from first principles would one imagine that the same data trends documented by the Canadians are likely to continue to the west (and therefore into Alaska)?" There are a number of people here at this meeting that were part of the EPA funded process and perhaps you should ask their opinion of this exercise. In many of those topics and in many geographic regions we simply do not have any data. It was generally agreed that, from first principles, the data trends should or could be extrapolated into Alaska which would imply significant contamination and impacts, but that the investigations need to be carded out in a systematic way.

DR. OECHEL: I don't know if it is happenstance or intentional but the bulk of the university funding from ARI went to UAF. Is it intended that it is protected UAF-NOAA program, and if not what is going to change in the future to open it up?

DR. DELACA: As you probably know, the people who attend planning workshops have a foot up on future funding opportunities that result from the workshop. This especially true with a competition with such a short lead time as this one. The people who attended the ARI workshop had knowledge about what was intended and had somewhat more of a chance to think about it. That gave them an advantage, but I think it was never intended to be a closed competition. Of course from a UAF perspective, we are trying to do as well as we can on these competitions, but we recognize we don't have sufficient research staff and expertise to respond to all aspects of the program. We have been encouraging collaborations from other institutions wherever possible and if a highly rated proposal comes from another institution it will be reacted to favorably.

PARTICIPANT: I am going to ask you about priorities. It wasn't clear to me in the write-up in the work book whether you have come to grips with the priorities at Fairbanks.

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DR. DELACA: This is absolutely essential: One of the primary failures of that meeting was the lack of involvement of Native people from a very early date. This oversight created insurmountable problems during the meeting and, later, when the production of the proceedings were attempted. The agreement at the closure of that meeting was that we would not attempt prioritization without Native input and yet that Native input never materialized, nor will it. This has become the bottom line for the August 1996 meeting.

DR. WEATHERHEAD: To follow up on that, you took a lot of flak, and you have all of our sympathy on it. But Patricia Kaufman called it one of the most useful meetings she has been to. It was a starting point, a very good starting point. We went to school on what the Canadians have done. We realized how much we benefit from the Canadians' failures and successes. We identified some real key areas where we don't have the knowledge. Not all of them are under the NOAA auspices or for NOAA to address but, for instance, scientist after scientist pointed out that dietary information is completely lacking for Alaska, and until we have that we cannot set priorities on the different pollutants. We can talk about their concentrations, but we cannot talk about it in terms of risk assessment until that piece of information is provided, and the Canadians have done great on that. So, I view it in a very positive light.

DR. DELACA: If one takes a look at the summary sheets that are in your handout, you will see that each of the so-called "stressors," because the meeting went beyond contaminants, had listed those things that showed the greatest area of interest and need. Any particular issue identified was prioritized into either a level one or level two column on the spread sheet or was placed into a category that could be generalized across all stressors considered. There is very good information there, but it needs to be expanded and qualified. The results of the August 96 meeting will be valuable to the planned November 97 contaminants meeting as well as other AMAP planning.

DR. COX: Just to follow up on what you were saying if my memory serves me correct, Patricia was designated the responsibility to get Alaskan Native input.

DR. WEATHERHEAD: She was asked to take on that role, yes.

DR. COX: Did she accept that?

DR. WEATHERHEAD: At the meeting her statement was, I cannot speak for anyone other than myself, which was a little discouraging, but I think she was trying to educate us as to how communication with the native populations has to proceed.

DR. COX: Do we have any progress on that since last November?

DR. DELACA: She sent a letter, I believe, to Dr. Huggett (AD of EPA's ORD). Dr. Huggett and his staff at EPA were the organizers provided the leadership of the August 1996 meeting. I think that Patricia Cochran's bottom line was that there would be no any follow-on responses from the Native community to that meeting.

DR. BRASS: I want to make a brief comment about that because I spoke with the person from EPA who was organizing early on and suggested that they needed native people's participation, and I was told they were avoiding that at the time. Somewhere along the line they saw the light but by the time Patricia was invited it was too late.

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DR. WEATHERHEAD: There was also the conflict that the meeting was, unfortunately, during the whaling season. Even though we were told it was held specifically in Alaska to try to have Native involvement. But it is a learning process to try to mesh different groups of people together, and I think it is going forward.

DR. HALLET: Some of these are useful lessons from the past. There is a need for guidance for the future.

The agenda calls now for more participation from all of you here, and before I open it up to remarks from any of you, in view of NOAA's interest in forming collaborations and leveraging resources, it seems like a bit more discussion of this major Japanese initiative would be suitable and Garry perhaps I could ask you to say a couple of words about what is the level of the U.S. interest in this at this point.

Other Perspectives

Gary Brass, Regarding Collaborative Work With The Japanese

The Japanese Government has agreed in this fiscal year, and their fiscal year begins on the first of April, to begin a program called the Frontier Program in Global Change Prediction. This program is to be funded over 5 years at the level of 50 billion yen which is $500 million more or less. Of this, eventually maybe $10 million a year would be spent at the International Arctic Research Center. Don't hold to those numbers because first of all the Japanese start programs in a peculiar way. They start them halfway through the fiscal year. So, it is only getting half a year's money in this first year. Their money will start to flow on October 1.

The proposition that the Japanese Government had made to itself and activated in this program was that global change is important to them and they have no satisfactory program in it. What they want to do is collaborate with the United States, which is probably the leader in the global change community, in order to learn from our example, collaborate with our program, and generally bring themselves up to speed in global change research.

The program is going to have five centers of research. Three will be in Japan. One of them will be a modeling center. Those of you who know Suki Manabe at Princeton's GFDL, probably one of the best climate modelers, ocean climate modelers, in the country is leaving to go to one of the Tokyo centers. And two will be in the U.S., one in Hawaii, the International Pacific Research Center (IPRC) which is going to study tropical climate, such as the Asian-West Pacific monsoon system, hydrology in Southeast Asia and things like that. The other will be at the University of Alaska, or at least the home of it is at the University of Alaska, and it is going to study a broad array of Arctic problems from ocean circulation to river hydrology.

The science planning effort is under way. I am chairing the last of the meetings of the science planners on the twenty-ninth and thirtieth of this month in Seattle. Bernard Hallet is part of the process and will be the leader of the U.S. delegation, the equivalent

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of More Ikeda from Hokkaido University who is leading the planning effort for the Japanese. As soon as that meeting is over we will be putting together the plan. It will be posted on the web and open for public comment, and we will probably use the ARCUS mailing list to at least notify people to look at the home page and look at the final result of the plan.

I didn't bring the long list of topics, I cannot read them to you just to see what everybody is interested in. Ted, is the outline on a publicly available home page yet?

DR. DELACA: Yes, it is, and the rudiments of the developing plan are available but under a sort of security system.

DR. BRASS: Do you know the URL?

DR. DELACA: I cannot recall it, but I will get the mailing list and get it out.

DR. BRASS: I would tell you to contact my office by e-mail for that, but I am going away for about 40 days on a variety of trips.

DR. DELACA: Right now it is an independent home page under the Office of Arctic Research I think. Maybe it has its own title.

DR. BRASS: Maybe you can talk to Wendy when you get back and ask if they can put a hot link on the ARCUS home page which is www.arcus.com, isn't it?

By the way I ought to mention one other thing that the Commission and ARCUS have been working on together. It is a subsidiary project, but the Arctic logistics report is at the printer's and should be out in another couple of weeks and start to be circulated. It is a science-driven plan for logistics in the Arctic. How are we going to get there to do the things that we all think are scientifically important? Keep your eyes open for that document. Research in the Arctic is so facilities and logistics limited that no matter what you think ought to be done you may not be able to do it because you just cannot get there. This is a plan to work towards being able to get there to do it. We think it is important.

DR. HALLET: Garry, one thing I would like to ask you, what is the level of commitment from other U.S. organizations?

DR. BRASS: This is a matter of continuing discussion. That means we haven't decided yet. But let me tell you two things about it. First of all, the United States spends about, I think the number is $140 million annually on global change research applicable to the Arctic. The Japanese are going to be spending $10. So, the likelihood that the Japanese program will set the agenda for U.S. global change research is relatively slim. What that means is the monies already committed to important programs aren't going to be pulled from those programs and committed to the center, and what I have been encouraging the Japanese about, all along, is to join these existing programs, for instance to join the Land, Atmosphere, Ice Interaction Program to get aboard SHEBA to work in the Bering Sea program to do the things that we are already doing. There is a perfect place for them to come in, learn, get their sea-legs, and find out how to do this process. I don't know that I am getting through to them, but I preach the sermon.

Hopefully proposals will have collaboration with Japanese scientists, and be applicable to the goals in the science plan. This will not require you moving to Fairbanks. Some may want to. Some may not want to, but the idea is that we will be working on the

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goals of the plan. We have not identified those sources of funding yet. In the parts that are applicable, remember what I said about the happy child having many relatives, we might be able to put some of this money in there with the proviso that it deals with AMAP topics like say, global changes and its effects as a stressor in the Arctic.

I believe NASA is contemplating putting a money into this announcement as well, and their programs will be focused probably in other ways, things like satellite measurements of ozone and looking at the dates of snow melt with satellites and ice models and all the things that they do. It is not going to be a magnet that pulls the U.S. global change program around to it, but it is a place where the U.S. and Japan programs can make contact. Is that sufficiently non-definitive that I am not in trouble with any agency?

Other Perspectives

Charles Myers Regarding The U.S. Arctic Research Plan

I would like to briefly mention the U.S. Arctic Research Plan. The Arctic Research Plan is now at the White House awaiting final approval. What you have in your book at Tab 7 is Section 2.1, which is the section that we have titled "*Assessment of Risks to Environments and People in the Arctic*." We deliberately chose this terminology rather than arctic contamination because we felt the Plan needed a broader focus that would draw in more of the basic research as well as the applied and other work.

The components of this section of the Plan are listed. The Plan includes: data and information management coupled with data rescue; observation; process research; model development; and risk assessment and risk management.

There was a comment about top-down management. None of us who were involved in developing the Plan feel that this was a top-down process. Most of the Plan is based on the Interagency Committee's Workshop in Anchorage. That workshop involved about 300 people and it had broad community involvement, including native people.

Again, the question I asked before is key: how do we match the Plan to the resources?

PARTICIPANT: I would like to see that sort of thing addressed. I, too, feel the same way although I didn't attend any of those meetings. Part of it, we have to get all the U.S. historical data in one place, one format, the AMAP format. I defy anybody now to try to pull it out the way it is now.

There are at least six groups who are collecting contaminant data, and then we have the problem with Russia. You have to get all the Russian data in.

I think that is something that needs to be funded, and it is a very likely candidate to be funded, in my opinion, under the NOAA initiative. It is the sort of thing that we should be doing. The interagency group is recommending it, and I would hope there would be a subgroup here who could address this. We are talking about a contaminant program within NOAA, not so much transport, but we have got to have our basic data

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first which we don't really have. And if we are going to monitor, where are we going to monitor; who is going to run it, some of the nitty-gritty problems.

DR. HILD: Chuck, did you want to mention anything about the process?

MR. MYERS: Carl, I am going to defer to you because you had asked about that.

DR. HALLET: Carl, would you like to come up and address the group from up here?

Other Perspectives

Carl Hild Regarding "People In The Arctic" Prospectus

I will be happy to. I knew this was coming from the National Science Foundation. So, I thought maybe Chuck would want to do this presentation. I am not sure how many people have even seen this document yet (shows "People in the Arctic: A Prospectus for Research on the Human Dimensions of the Arctic System.".)

Two years ago under the Arctic System Science Program of the National Science Foundation a group of people were brought together and asked, "How can we start to integrate a large component that would involve the communities?" This is something that is coming from many different directions, partly out of the Rio declaration that indigenous people need to be involved, and indigenous knowledge needs to be involved at all levels of science. One of the questions within the National Science Foundation within the Arctic program was how to blend this into programs that are physical sciences, looking at the ice sheet in Greenland; how does that apply to the people who live in Alaska? Somebody asked earlier about permafrost issues, and the need to talk about that, and there is a lot of concern in Alaska from the people who are saying, "We are seeing some significant changes." People of Kipnuk have contacted me saying, "We think our community is sinking. Can you get us help? Can you tell us? Can you confirm that our community is actually sinking?" They know it because when they dig in the ground they used to hit permafrost or used to hit gravel, and now they dig down, and they hit water, and they are saying, "The ocean is coming up further on our beaches."

So, there is a lot of concern about how to take those local observations and get some interface with science. This document here, People in the Arctic: A Prospectus for Research of Human Dimensions of the Arctic System has just recently come off the press in the past week or so, and I would highly recommend it as these programs are being developed. I mentioned this morning about the Department of Commerce policy on American Indians and Alaskan Natives, I bring that up, and I brought it up this morning specifically because I have gone to Department of Commerce staff in Alaska, and they didn't even know the policy existed, let alone had read it. Here is a department policy on how to deal with Alaskan Natives, and they didn't know that they were supposed to have these interchanges and try to get local information and incorporate this.

This prospectus gives a number of suggestions on how that can be done. We are not saying that physical scientists need to do social science. We are saying that you need

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to engage the community. There are lots of observations out there. There is a lot of good information, and there is a real desire to participate. One example that I will give is a person who went up to a community and set up an air monitor and suddenly realized he was getting all these hydrocarbons. He just didn't understand why he had these high readings until he found out that everybody in town wondered what this machine was out on the tundra, and they were going out with their snowmobiles to go see what was. Had the person sat down, taken some time with the community, saying, "We are doing this research at this remote site. This is what it is about," explained it to the community, people may have actually given him a better location to put it, and at least everybody in the community wouldn't have had to go out with their snowmobiles to find out what was going on. I recommend if you haven't got a copy of this report, please get one. Consider the stakeholders, the people who live in the Arctic.

Other Perspectives

David Hofmann Regarding The Atmospheric Radiation Measurement Program

I didn't get a chance to mention that the Department of Energy has a research program called the Atmospheric Radiation Measurement Program. They are collocating with the NOAA CMDL station at Barrow Alaska, and just last week there was a dedication of this facility. Of course, when the natives heard "atmospheric radiation measurement," they got very concerned. We had meetings in the local high school gymnasium with all the local people invited, and there was a little lunch and people got up and explained what we were doing. We explained that the radiation is coming from the sun and that we are concerned about climate change. We explained that it is not dangerous radiation, and we had visits out to the NOAA and DOE site. I think that was the right way to do it, like you said, so that they know what is happening out there. It was very successful.

Other Perspectives Leslie King Regarding ARCUS

Leslie King Regarding ARCUS

I am Leslie King from the University of Northern British Columbia, and I am here representing ARCUS, the Arctic Research Consortium of the United States. I worked with Carl and a east of thousands on the prospectus and one of the things that we had to think quite hard about was getting contaminants into the prospectus. You will find when you read it that they definitely are there, and I always loved that cover photo, Joe Philips and seal and I keep looking at the seal and wondering whether their are contaminants in that seal. I am going to do is spill over a little bit into our next section, where we will talk about the right questions for our small breakout groups, I have a personal interest in contaminants and I also have a strong interest in seeing some coordination because I

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greatly fear that a lot of contaminant issues have fallen through the cracks and that we really need to address that before we can really identify the priorities. We need to ask: what are the gaps? I think there are several issues related to coordination and integration, but I am hoping that we can address these in the small groups. I think we should address them in each of the groups. There is the mechanics of coordination or integration that Garry had talked about, and the infrastructure issue of how we are actually going to do it. We need to think about what are the niches that each of us and our agencies can fall into and how can we get value-added leverage. There are other aspects of coordination, also, that we need to attend to, and one of them is funding. These are piddling amounts and how are we going to encourage interdisciplinary teams, which is what is needed if we are going to incorporate human and other dimensions into this. The other issue that has been raised quite a bit is what kinds of linkages are we going to create internationally with the Alaskan Native Science Commission, with the State of Alaska, etc., and there are all kinds of other issues like data integration and logistics that are extremely important. These are issues that we should address in each of our groups.

Questions/Discussion

DR. COX: Getting back to priorities and drivers, I am very results oriented. So, bear with me. When I went through all the material I was asking myself what should be driving the decision-making process for deciding where we are going to spend this money, and I came up with a number of things. I will throw these out for thought to the various breakout groups.

No. 1 was impact on human health as being a primary thing, particularly how it impacts Alaskan Natives. The obvious thing is we need to focus on traditional foods. Second, what are the U.S. responsibilities with regard to legislative and regulatory needs? We need to meet those commitments, and I was thinking of intergovernmental treaties, protocols, conventions and so on.

Third was the establishment of baselines, particularly in areas of commercial activity, whether it be fisheries or oil and gas. So, what drives the selection of research priorities are those three areas: things with impacts on human health, things that are required by regulation or legislation, and things necessary to give us a baseline understanding especially where it comes to commercially valuable resources.

PARTICIPANT: I would like to make a very short comment. I will start out with what Carl and Leslie have said and that is that the meeting just a few weeks ago in Tromso where I had an opportunity to go up and listen to the Arctic problems firsthand. I am not an Arctic specialist, but I was struck very much by a comment made by one of the representative indigenous people who said, "We have to tell our children we cannot eat our reindeer anymore because of the contamination, and about the fish. We have to tell them they cannot eat their fish." And then he said, "Now, I have to tell them we cannot let them go out and play in the sun." This leads to a poignant point and that is the reason we cannot advise them right now is because we don't have the data to make the risk

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assessment. If we had that data, if we had been collecting that data over the years, we could begin to say something useful. Maybe some of these problems may not turn out to be as bad as we have to say they may potentially be. I know the available money is not great, but as Garry says, it is better than zero. We need to focus on effects. I am personally interested in UV but of course there are so many other effects, it is going to be so difficult to partition this money. But if we can begin to understand the effects, particularly at the human level, then I think we will have made a great leap forward and maybe eventually over time we will begin to focus in with a coordinated federal program.

DR. HOFMANN: I would just like to make a couple of comments about two of the handouts. My name is Bob Hofmann. I am the Scientific Program Director for the Marine Mammal Commission. Many of you probably don't know what the Marine Mammal Commission is. It is one of the, if not the, smallest independent agency. Our job is to advise the Federal Government on anything that in any way affects marine mammals.

The two handouts, one is a letter to the Department of States dated January 31, 1996, and the relevant part of that is an attachment in which the Commission tried to look at a broad range of Arctic issues mostly from the foreign policy perspective. That attachment might be useful to some of the breakout groups.

The other document is a contract report by Henry Huntington that talks about the general role of the U.S. in involvement in the Arctic environmental protection strategy and the negotiation that led to formation of the Arctic Council. There is a whole host of interrelating issues, many of them dealing with foreign policy because we are dealing with multiple nations, not just the eight Arctic countries but others as well. To the extent that there are foreign policy issues, the Department of State has the lead, as Bob Senseney explains, and there is an interagency working group that Garry sits on. Looking at the organization and implementation of the AEPS, and the various working groups that were formed, it was clear that there was some duplication and some things falling between the cracks and some cases of people seeming to represent the United States when they in fact didn't and we ended up with egg on our face. So, what the Commission recommended is that the Arctic Working Group hold a meeting of the various agencies to try to identify what the critical issues are and how the four or five international working groups might be tasked to work more efficiently. This is explained in the attachment, which may be of use to this group. The other material is for information.

DR. BRASS: Bernard, I did want to comment, once again, about whether $2 million is a lot of money or not very much money. I hope everybody will bear in mind that NOAA has missions that they are required to take on, but there are other very worthy missions that are not in their responsibility. For example, at the planning workshop last year we talked about $1 million, and we frankly did not expect them to take up direct health issues. We have the National Institute of Environmental Health Studies, and that is their job. This is the place to talk about how within NOAA's mission requirements they can help accomplish what we need to accomplish. It would be lovely to throw all responsibility onto them, but then you divide $2 million by such a large number that

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everybody gets a dollar and one-half. So, bear in mind the relevance to NOAA's mission at all times.

SMALL GROUP WORK SESSIONS

Charge To The Small Groups

***NOTE**: The participants broke into three small groups during a working lunch. They were asked to decide if the themes used in the first year of Arctic Research Institute continue to be an adequate way of categorizing the issues. Those themes are:(1) natural variability and (2) anthropogenic influences, with the subtheme of (a) contaminants sources, transport/dispersion, and effects and (b) arctic haze, ozone, and UV flux. After lunch, they returned to the main room, had the following discussion about the tasks for the small groups, and returned to their small groups.*

DR. OECHEL: What we want to do is briefly hear from each of the groups, to hear what you discussed over lunch and any observations. Then we'll break back out into the groups and do the hard work of this workshop—brainstorming the key issues we think should be the focus of the Arctic Research Institute.

First, a couple of suggestions have come up that are cross cutting and so before we break apart we will have a presentation by Ed Myers and maybe of comments from Len and others of things we should consider across the groups. So, let us hear the group reports first and then we will look at some of these cross-cutting issues.

DR. KING: First of all our group decided that yes, indeed, contaminant sources, transport, and effects was an appropriate question. We had a fairly lengthy discussion on whether NOAA should be involved with effects, especially vis-a-vis human health effects and risk assessment, but we haven't resolved that question except to say that when we reconvene we should look at the big picture, look at the priorities and the gaps and then decide where NOAA fits. Because otherwise if you are talking about fate and transport and pathways, you cannot ignore where those pathways end up. We also talked briefly about coordination: once we decide where NOAA fits in to that big picture we should talk about how NOAA is going to link to the other niches.

PARTICIPANT: Our group thought that the coupling together of the anthropogenic influences of arctic haze, ozone, and UV flux with natural variability was a good one, and that it is in the right direction. The difficulties which arose last year were ones concerning natural variability and this is, in fact, an incredibly complex issue and

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problem. Nevertheless, given the trends of the last few years vis-a-vis the ozone depletion story it certainly does warrant continued and more focused investigation.

In terms of the UV flux our group had a very heady and strong or discussion about the fact that indeed there is a scarcity of information. UV flux measurements are absolutely necessary.

We agreed that there could be and should be an Arctic-wide consortium of UV monitoring stations, interrelated and integrated measuring and monitoring UV flux across the entire Arctic, and IASC has a plan for that. We agreed that the information in terms of UV flux and the effects of the UV flux on the biological systems is very scarce indeed and represents an area that needs a lot more focus and attention and research.

DR. OECHEL: Does the IASC plan have a plan for standardizing or making simultaneous measurements at sites to make sure the sensors are calibrated?

MR. MYERS: To make sure that the sensors are calibrated is a high priority, perhaps the highest priority of the entire plan. But to have simultaneous measurements means that all of the Arctic countries have to agree, first of all to have these monitoring stations and second that they would be all willing to share this information in real time.

The other point that I didn't mention is that these monitoring stations which are currently existing would be very good candidates for the rest of the plan, which is to modify these stations in such a way that the effects biologists could go there and actually do their measurements on site or away from the site. Their effects measurements could then be linked directly to the well-calibrated UV measurements and these might be opportunities for terrestrial biologists, aquatic biologists, and physicians, for example, interested in skin and eye effects, and social scientists. It is kind of pie in the sky at this moment, but the concept is something which is needed.

DR. WEATHERHEAD: I think the calibration of the UV instruments was proposed as a WMO Class B UV spectral instrument which is a very high-level spectral instrument that would be calibrated through NIST. So, I think we could have a high level of confidence if we could get support for such an idea.

DR. OECHEL: That is a lab calibration procedure?

DR. WEATHERHEAD: Yes, but NIST is currently developing a traveling standard lab type setup which shouldn't add too much to the uncertainty and still has a direct link to NIST standards. So, we think we can tackle that one pretty well if we ever get the green light.

DR. BRASS: I have spoken to Effie about this beforehand. She indicated to me that the cost of some of these instruments is coming down to the point where it might be worthwhile considering talking to the Arctic Buoy Program about putting them on the buoys.

DR. WEATHERHEAD: And it is the same type of instrument Garry is referring to that Dave Hofmann has from the last $1 million and is testing out up in the Arctic right now. There is already a network of them in Norway, and they seem to work very, very well in arctic conditions.

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DR. COX: Our small group talked about natural variability. There was some question as to what that actually means. We could certainly go by how it is defined in the NOAA ARI, but if you look beyond that even when you say, "Natural," it is not often clear is the variability due to natural processes or is it man made. So, maybe it should just be variability.

A number of other things were mentioned.

DR. OECHEL: Is this intra and inter-annual variability?

DR. COX: Yes, short term, long term and so on. It was, also, recognized that there is a lot of overlap between these three different groups, and one is transport. Natural variability or variability includes the physical processes as it is set up in the ARI. It can include ICE, the eddies and all that kind of stuff, and there needs to be communication between the different subgroups as to what the priorities are.

Before you can really do talk about variability intelligently we need to know what the baselines are. The dilemma that we are faced with fight now is that for many things we don't have good long-term baselines to compare current conditions to. But certainly one thing that is clear is that air and water temperatures are on the increase. Permafrost is degrading and so on. So, that is what we have learned so far.

DR. BRASS: I want to make a quick comment about natural variability. We are engaged in systems now that have very long time scales and because we are only just now starting to look, there is an important opportunity to go back and reconstruct whatever records we can so that we know what is going on. I hear people talking about monitoring and other people saying, "We don't do monitoring," but to me they are just longer term experiments than you are used to. In a phenomenon that has a period of 50 or 100 or 1000 years, a 10-year experiment is like yesterday.

DR. OECHEL: Yes, I think that it is important to couch the language more in understanding interannual and interdecadal variation variability than monitoring. Monitoring I think still is pretty much the kiss of death, but if you want to understand variability then that is okay.

DR. HALLET: You know, decadal variability is obviously very important, and we have seen very large variations in this, two or three decades for which there are good instrumental records. But there are others approaches that are proxy records that permit you to go much further back and allow you to look at large-scale variations. It seems like many time series are such that if you increase the length of a series you start to increase, also, the amplitude of the variations. We need to understand the variability based on our excellent observational record in some cases but, also, use to a much greater advantage the sort of retrospective look. In that way, the records would be very useful. I don't think that NOAA, of course, wants to head in this direction in a major way, but on the other hand, it is at the interface between sort of the instrumental records and the failure records that give you a chance to really develop some new insights and greatly extrapolate from observations.

DR. OECHEL: One thing that our group discussed is the idea that once the research needs are listed we can then go back and look at the ones that seem particularly

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appropriate for NOAA to do. But at least with those identified even if some fell outside of NOAA's bailiwick, it would still be identified as important and it would indicate a place for cooperation between NOAA and possibly some other agency.

DR. BRASS: That there are some programs that are worth paying attention to. One is the ice coring program, but the other is the PAYO program that the National Science Foundation runs, which concentrates on the last few thousand years and has some excellent records from lake sediments that can be used to study what the long-term variability is to make sure you are not just looking at the noise figure.

DR. HILD: I was going to build on the same idea that we don't even have to go that far back. If we go look at maybe 100 years ago or 500 years ago at mummified remains from Canada, Greenland and Alaska, where hair has been preserved, and it has been compared for certain contaminants or natural elements. That can be looked at in further detail, also. The historic record of ice that the whalers left back from the turn of the century provide excellent records of ice conditions and weather conditions as they explored into the North, particularly in the Chukchi Sea. That has to my knowledge not been investigated thoroughly. Then there is the whole issue of traditional knowledge with local communities being able to tell you many things about what levels are.

We talked a little about cadmium earlier. There has been one attempt to extract cadmium from walrus teeth, and if you can do a comparison between the levels in the kidneys and teeth and then look at teeth that have been around for several hundred years in collections, then you can have a different type of record to go back and see what the biological availability of cadmium was.

DR. BURCH: First, there are historical records in some parts of the Arctic that go back 100, 200 years. The Hudson Bay Company archives go back to 1717 at Churchill. Between Iceland and Norway there are records that go back farther than that. There is also archeological research, some of which is getting pretty sophisticated. For example, a couple of people have reconstructed not only paleo whale population size and movements but, also, ice conditions and everything for over 1000 years. I gathered from a recent Polar Research Board meeting that the archeologists on the one hand and the paleoclimatologists on the other aren't talking to each other and that is too bad.

DR. HILD: Yes, some of those examples are in the HARC document.

DR. OECHEL: I think the CO2 record is a nice example of what can be done matching the geologic record to the ice core data to current, contemporary records.

I think the consensus is that the original grouping of questions that NOAA came up with is free. We can move ahead in our working groups based on those themes. What I would want to do is have the groups look at their theme in detail and come up with possibly 12 research areas that are significant. Then out of that distill maybe six or so that are high priority and appropriate for NOAA.

DR. BRASS: May I make an operational note? In the long run we should do a fairly careful analytical job of what we need to do with regard to the Arctic Council and our future participation in AMAP and things like that. We have a fairly short string between now and the first meeting at the Arctic Council at which the AMAP decisions

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will be made. I think we have to proceed on a dual track, a careful analytical track but find our top three or four hot buttons and make sure we are ready for them soon. We are going to have to be able to talk in the spring about what our national priorities are for AMAP.

DR. WEATHERHEAD: It seems to me we are setting up the outline for an RFP or a notice of opportunity, which really bypasses the idea that I think Garry has proposed that we at least set aside some real chunk of money to do AMAP and do it right or to be involved in this Japanese joint venture. It seems like we are heading along a single track right now, setting up the specific research ideas instead of addressing do we want to be involved with AMAP and if so what does it take to be involved with AMAP?

MS. ELFRING: I can comment on that, and Renee, you should feel free to also. When we started on this planning exercise it indeed was to help for the next announcement of opportunity, but our goal was to make sure that it is designed in a way that you leverage what is done so that it fits into AMAP.

So, one of the things we are hoping will come out of this workshop is, indeed, a better sense of where AMAP is going and can we set the priorities for the ARI in a way that we are then getting that added benefit of feeding into AMAP. That is why I tried so hard to make sure there were people here who really knew AMAP because we are counting on you to steer your groups.

DR. WEATHERHEAD: But I think what has been pointed out is that NOAA has been doing AMAP-type activities all along. That doesn't mean that it has ended up making an assessment. That doesn't mean that it has ended up sort of on the global level and up there with the other measurements.

DR. OECHEL: Maybe we should broaden that list and it should be more than a research area but, also, activities. If we see NOAA interfacing with AMAP as our priority, then that should be in the list.

DR. SENSENEY: I think that we are at a point right now in terms of AMAP where we could actually help guide and steer the AMAP Phase II agenda. Perhaps one of the things we want to look at is how these activities we are outlining here can support AMAP. Can we say: "this is what AMAP Phase II should look like." Our contribution to AMAP becomes this $1 or $10 or however millions of dollars are being put into arctic haze, climate change, ozone contaminants all the way down the line.

DR. WEATHERHEAD: This is just sounding like the same old story to me. Unless it gets specifically into the process, that the ARI projects should directly contribute to AMAP, it won't happen. It is not a trivial thing to add to each of 15 proposals to get the scientists together at these international meetings, to get the information written up. This is not something that you can just tack onto everyone's proposal.

DR. OECHEL: No, but you can have supporting AMAP identified as one of the high-priority tasks for NOAA.

DR. WEATHERHEAD: Yes, but I think that requires a real budget set aside for AMAP.

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DR. OECHEL: Yes, but I don't think anyone is arguing against that.

DR. BRASS: Maybe this is the proposition to bring up, that this opportunity for supporting research is not everything that NOAA is going to do to help AMAP. There really should also be some contribution to a secretariat function to organize the data and bring it forward.

DR. WEATHERHEAD: And that is not a small contribution.

DR. BRASS: I want to make another point about this announcement of opportunity. The question becomes how detailed and how preplanned the announcement of opportunity is, and this brings me back to my question about top-down management versus bottom-up management. If we identify a high-priority topic, but we don't get a good proposal or we get a proposal that doesn't review very well, it is not going to be selected even though the topics was a high priority.

The question is: would we like to see NOAA have a sufficiently directed scientific agenda that they can go out and find the participants? This is a different way of doing business than just relying on over-the-transom proposals. You pick out some topics that you must do and others that you are prepared to do. You don't have to run a little NSF here.

MS. ELFRING: We want your best ideas, and if your best idea is, for instance, that NOAA should be considering some other ways of supporting AMAP in a more general sense, tell us. Just make sure it gets into the record because remember this workshop is a quick snapshot of discussions at one moment in time. We will not be making recommendations because that is too formal for what we can do in this quick snapshot. But this is guidance to people who are going to be making decisions, and anything that gets into that record, hopefully, will help that decision process. So, make sure it comes up in your group. Make sure it gets down on a flip chart and that gets it into the record as an idea that needs to be considered.

DR. WEATHERHEAD: Is it possible to add a separate little group that could meet for just half an hour and brainstorm what we think is appropriate to support AMAP?

PARTICIPANT: Yes, I think it is. I am very concerned about this issue, too, and it really overrides over the three groups.

DR. OECHEL: Ed has a nice overhead that he worked up, and I asked Ed if he would share it with the group.

MR. MYERS: Yesterday I went through my AMAP notes and there is a lot of history that precedes AMAP and the Arctic Research Initiative, but between Garry Brass and Chuck Myers and some others today this history has all either directly or indirectly been covered. When I think about the Arctic Research Initiative, year two, I think what constraints or boundary conditions might I put on it? First of all, I think that whatever we put together must meet the intent of Congress.

The individual efforts must integrate into greater than or equal to a whole. What I am talking about is that we cannot just have a big wish list. We have to tell a story in the end through our cost sharing, our partnering, involvement of the Alaskan Indigenous

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Natives, and the like. I strongly feel that we must honor our international commitments, and the first one that comes to my mind is AMAP.

MR. MYERS: I think the study designs or design must be based on certain paradigms, and those paradigms will govern which locations we study, the spatial and temporal resolutions we look at, the incorporation of risk assessment and the like.

I think the evaluation of the RFP must be a fair and open process, and must involve, must be driven by, high-quality science as judged by a peer review of national and international experts. And last but not least somehow we must get the ARI built into the NOAA base budget.

We cannot depend add ons year after year after year. Eventually 2 to 3 years down the pike we are going to run out, and so, we have to build it into the NOAA budget. I think that can be done, but it is not an easy task.

PARTICIPANT: I have heard it many times since we have been here, climate changes, and yet when I look at these I don't see it here. Where does it fit into this picture?

DR. OECHEL: I assume that it is in natural variability, natural and unnatural variability.

DR. JOHNSON: As a supplement to what Ed said, and I regret I don't have a vugraph, but from my perspective I think the first thing that should be in this RFP is to assemble all the historical data from Alaskan water, land and air into a common database. This does not exist. A lot of it is in the gray literature. I defy anyone to try to find it all. It is not in any format we can use, and it should go into the AMAP format.

Also, I feel that a companion joint program with Russian colleagues should start looking at the other side of the Bering Sea. It is one system. We cannot just look at one side. I realize the problems with getting Russian data and quality control and all the rest of it. But I think it is worth the effort, and it is quite cheap to work with them once you get the fight people.

After we have the data in hand and properly calibrated we need to do a risk assessment using the APS matrix such as the one that PAME uses. There are matrices around that are not hard to use.

Then I would see as a component of this to convene a workshop in Alaska with the idea of supporting AMAP II. Would an Alaskan Arctic site fit the requirements? Should we use the CMDL lab up at Barrow? Is that the fight site? Scientists need to think about that, or would it be better to be down in Juneau and Kodiak where there are monitoring aspects? And what parameters do we really want to measure? I don't think we can answer that until we get our data in hand. What equipment; who would run it within NOAA? Where would support come from; how much would it cost, and how do you use the indigenous population as an asset for any sort of monitoring activity? I realize monitoring is not popular among funding agencies, but it is something that has to be done so we have a baseline.

My last thought was, which hasn't come up at all, is that in case of a spill of any sort of contaminant in the water or on the land we need a circumarctic regional

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information system on a computer with real time information on nature of problems, methods, techniques and means for appropriate response for somebody who spills something. If Russia blows up and all that stuff is starting to float toward Alaska, who do we talk to; what do we do? It would be very useful to have that all on one circumarctic databank which can be pulled right off the web.

Plenary Discussions

***NOTE**: The participants returned to the main meeting room after spending about two hours having focused discussions in four small groups.*

MS. ELFRING: We have tried to stress that this workshop is an exercise to give the science community a voice in NOAA's thinking about the ARI. We will produce proceedings from this workshop. The proceedings will be composed of various of the background materials that were in the meeting book. It will also include the talks and any of you who did talk, we are going to send you a transcript, which you can edit some. And the report will say clearly, "This is from a talk," because obviously you speak differently than you write.

DR. OECHEL: It may be what I said, but it is not what I meant, and you know, if you said anything really impolitic you can probably convince us to edit a bit, but you obviously cannot add new material.

MS. ELFRING: We will also include these flipcharts. We may run them by the people in the work groups to be sure they reflect what you discussed. The proceedings will also include an overview from the PRB that summarizes the meeting, and the main messages. We will stress the point that these are thoughts from one small meeting; these are not community consensus on the top five research priorities. We want to avoid that kind of thinking from this kind of an exercise.

We are going to try to make the proceedings happen fairly fast. So, I would ask that when you get a request from me, a quick request about please send in your overheads or here is your talk, it will always have a statement in there that if I do not hear back from you in a certain number of days I will assume you approve.

My deadlines are very strict, as PRB members know, but I ask for your cooperation because NOAA is trying to get the second year of this up and running in September, and we want to try to get them useful guidance. This is an Academy document, so not only do we have to prepare it, but we have to put it through outside review between now and then. A proceedings has a different level of outside review because it isn't recommending actual steps to be taken, but it still needs to be looked at by a selected group of experts who say, "Does this make sense?" So, there is quite a lot to be done, in a relatively short period of time this summer.

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Summary Of Breakout Group #1: Arctic Haze, Ozone, and UV Flux

DR. HALLET: We addressed three issues, arctic haze, ozone and UV flux. Let me put up the flipcharts so that you can see some of the major issues that were discussed. What we tried to do is establish priorities based on what we thought was important and, also, what was within the aims of NOAA. The first topic is ozone. Here the focus was on stratospheric ozone, and the two primary areas we identified for research were to characterize the variations in ozone, with a stress on looking for anomalies and trends and, of course, there is a strong interest in losses in the system.

Then there is a strong interest in understanding temperature trends in the stratosphere now and its effects on the formation of polar stratospheric clouds. That is very important from a number of points of view, and so, this was thought to be not only critical for the ozone but also for other areas of climate change.

We talked about a couple of other items, one being the wintertime stability of the arctic stratosphere, the polar vortex. Volcanic perturbations were discussed, and we did not assign priorities, and then, also, interests of commercial transport, both current and anticipated were discussed. But in terms of priorities, these are the ones that were highlighted.

In terms of UV flux, which was the other major area of consideration, we have several bullet we took from an IASC document on the effects of increased UV radiation on the Arctic biosphere; we thought these were very relevant. The major items were this first one, surface and satellite monitoring and modeling of the UV radiation field and then there was a little laundry list. But the basic concern is effects of UVB on terrestrial ecosystems, aquatic ecosystems and human health. Then finally there was the final issue which was social impacts of UVB. We thought these last two items were outside the boundaries of the NOAA mission as far as we understood it.

The one issue that we wanted to highlight out of these was the effects of UVB on aquatic ecosystems. In particular, we think a priority area is the distribution, composition and biogeochemical cycling of particulates in organic matter in diverse aquatic ecosystems. That seems to be within the purview of NOAA.

Questions/Discussion:

PARTICIPANT: In terms of the effects of UVB on human health, I know that this is really probably not a part of the purview of NOAA. However, over the years it has been increasingly frustrating that every agency retreats saying this is NIH's purview. This is where these experiments and support belong, but NIH doesn't have an organized program for UV effects.

So my suggestion is that when you write up your report perhaps you can suggest that NOAA recognize the impacts of these other effects ultimately on overall human health and make a recommendation that perhaps other agencies responsible for this might

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wish to take this up because we don't have a formal coordinated program for looking at UV effects on health in the NIH directly.

DR. FRIDAY: There is one aspect of the health effects where NOAA is concerned. For the last couple of years you may have noticed that there are UV indexes routinely associated with the weather forecast around the country. That is a product of NOAA.

We worked on that issue with the American Academy of Dermatology and with the Center for Disease Control and Prevention. We see it as educational outreach to try to explain the significance of UV exposure on humans. But you are right that in general the actual health mechanisms are not our mission.

DR. HALLET: One thing that is closely related to this: the international research centers have an interest in participating in UV, and apparently a set of stations is being discussed it is partly in place around the Arctic. This would be a natural focus for scientists coming in to study the causes of UV. The idea would be that NOAA could participate in an international program that is fairly well established.

The third item was arctic haze. Here we discussed atmospheric circulation variations, understanding sources and regions of aerosols, and intercomparisons of databases in the U.S., Russia and other parts of the world. Perhaps the two contenders for most of the attention, according to our group, were understanding and defining long-term trends and then understanding the characteristics of the aerosols and so understanding chemical and physical characteristics of arctic haze. Those were seen as the primary areas of need.

Now, one thing that was common to all themes was a need to really understand what to document and understand variability in atmospheric circulation as a driver for all of these components. Here we discussed some subcategories. One is to take advantage of the instrumental and the paleo records and to focus on stability issues and mixing dynamics. And, of course, the use of models to better understand and develop insights and, also, to work on the models and use the data to validate the models so that they can be better predictive tools.

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FLIPCHART NOTE—GROUP #1

Research Needed to Address Arctic Haze, Ozone, and UV Flux

General Areas of Significance:

- **Define variability in atmospheric Circulation as a driver for all 3 areas, plus**:

- **take advantage of instrumental and paleo records**,
- **focus on stability/mixing dynamics, and**
- **improve modeling and validation**.
- **Effects of UVB of biosphere (e.g., Aleutian low dynamics**).

UV Flux

(Note: The Working group Used the IASC document, "Effects of Increased UV Radiation" as the basis for its discussion and selecting the following key issues.)

- **UV International Research Centers (UVIRCs): using the research stations that already exist in the Arctic to measure UV changes, we should incorporate a biological component so we can begin to develop a coordinated Understanding of UV flux and its effects**.
- **Surface and Satellite monitoring and modeling of the UV radiation field**.
- **Effects of UVB on aquatic ecosystem (e.g., abundance, distribution, composition, and biogeochemical cycling of particulate and dissolved organic matter in diverse aquatic ecosystems**).
- Effects of UVB on terrestrial ecosystems. UV-induced changes in plant chemical composition.
- Effects of UVB on human health.
- Social impacts of UVB radiation, e.g., perturbation of food Chain and impact to indigenous populations.
- Effects of arctic haze and clouds on UV radiation.

Ozone: Stratosphere

- **Characterize ozone anomalies, loss, and trends**.
- **Understand temperature trends for formation of polar stratospheric clouds (PSCs**).
- Win me stability of Arctic strata, sphere vortex.
- Volcanic perturbations to stratospheric aerosol and effects on ozone.
- Impact of current commercial transpolar subsonic aviation (current and projected) on Arctic stratosphere.

Arctic Haze

- **Understanding and defining long-term trends**.
- **Understanding chemical and physical characteristics of Arctic haze** .
- Atmospheric circulation variations.
- Understanding source regions of aerosols.
- Comparisons, of databases in U.S. and Russia.

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Summary of Breakout Group #2: Natural Variability

DR. COX: What you see in front of you are the results of our group's brainstorming exercise. After we did some brainstorming we made an effort to prioritize or identify which of these issues are more critical than others. Those issues that are most important are identified by a circle around the issue number.

I am going to only highlight those issues that we have identified as being the most important. These are quality assurance, control, how data are collected and analyzed (I think this applies to everything we are talking about today), and common calibration procedures, whether it be satellite instruments or other equipment. We are looking for standards to employ in our regular business.

As far as the more important research issues, we discussed the need to coordinate, share, and pull together information from different databases; there are a number of different arctic databases. There may be some advancements that we can make by pulling together information from some, say, physical databases and biological databases.

What is the spectrum of variability and time scales for important environmental parameters? Define what the important parameters are and develop models to describe the variability.

This was an interesting outcome from our discussion and that is the use of manmade or anthropogenic contaminants as tracers to better understand natural variability. These could include things like better understanding transport.

It was also suggested that maybe there are some manmade non-toxic tracers that we could introduce into the environment to better understand transport and other mechanisms.

Another issue we discussed was sensitivity studies, and models to obtain parameters of variability. Let me expand on that a bit. If we run the models that we currently have, we may identify some variables that people wouldn't necessarily think as being important but in fact could be good indicators of change.

We discussed environmental monitoring of critical areas; Barrow is a good example. There may be other areas that should be designated as critical areas. Essentially what we want to do is look for areas that would be good locations to test the health of the environment.

Last but not least, we discussed advancing our ability to predict fishery stock. Here is a very important commercial issue, and what we are looking at are natural versus manmade effects. It can include things like impact on pollock or other important species in the environment.

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FLIPCHART NOTES—GROUP #2

Research Needed to Address Natural Variability

- **Coordinate, share, combine information from different databases. Need to establish baseline understanding so We Can understand variability**.
- **Better understand the spectrum of the variability amplitude and time scales of important environmental parameters. Define important parameters; develop models to describe variability**.
- **Environmental monitoring of critical areas (e.g., Barrow, Alaska.**)
- **Improved ability to predict fisheries stock trends, to determine what is "natural" versus "man-made" effects; to understand regime shifts**.
- **Improved capabilities to use of anthropogenic contaminants as tracers to better understand natural variability and contaminant transport; these must be nontoxic**.
- **More sensitivity studies and models to identify parameters of variability**.
- Better quality assurance, quality control, and attention to how data is collected and analyzed.
- Better understanding of interannual variability of greenbelt processes, including shelf/slope exchange processes.
- Address ice dynamics/thermodynamics, including historical records and trends.
- Address variability of stratosphere (ozone depletion, cooling), long-term trends, effect of cloud, and driving forces for stratospheric stability.
- Better understanding of coupled physical-biological models/processes including beyond the boundaries of the Bering Sea.
- Consider long-term records (1000s of years) through ice and sediment cores to put current variability into perspective.
- Improved comparative studies in the Arctic, including comparisons of similar environments with different human usage.
- Better understanding of multi-stressor problem-existing and possible future stressors.
- Better understanding of "predictability." How far out into the future do we need to predict?
- Increased emphasis on habitat change (e.g., migratory changes, permafrost, vegetation changes).
- Better understanding of the role of long-term variability in atmospheric transport on temperature, cloud cover, and arctic haze variations (as opposed to greenhouse gas forcing).
- Increased use of common calibration procedures.

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Summary of Breakout Group #3: Contaminant Sources, Transport, and Dispersion Effects

DR. BURCH: Our report is divided into three sections, and depending on our time I may or may not make it through all of them. So, I will start with the most important one which was substantive issues. (These, by the way, are not prioritized.)

The general opinion was that the effects of contaminants on people was the key issue now and in the future. We also felt that a lot of that was not NOAA's problem but certain aspects of it were.

For example, ecological risk assessment, exposure estimates, the study of sentinel species and so on—all of which relate to impact on humans—those things are certainly within the realm of NOAA's operations.

A second consideration was that whatever is done should be science driven. That means that it should be guided by hypotheses that relate to a larger body of knowledge. It should relate to the general body of science, not isolated theories.

A third consideration is that, there should be special attention paid to multiple stressors and synergy.

Fourth, an ecosystem approach should be used, with special emphasis on the food web and biomagnification. I thought that the need to take a systems approach was obvious, but my colleagues tell me not everybody thinks this way. I don't know how you could do this without a systems approach.

Fifth, we talked about why people contaminate in the first place, particularly when they are pretty sure they are going to contaminate. We agreed, however, that that was really not NOAA's problem.

Then our group had a series of general areas that we thought should be investigated. One of them is the interactions of sources and sinks especially land atmosphere exchanges. Another one is the large-scale pattern of and controls around contaminant transport. Third, large-scale patterns of and controls on atmospheric CO_2 and methane concentrations.

Another subject we thought would be appropriate for NOAA investigation was attention to local sources of contamination and their effects. Most of the time we are talking about Arctic or global but sometimes you build a dam or do something locally that has pretty serious effects. Many times NOAA has some business in studying them.

Another area was the interaction between arctic and sub-arctic transport processes. We shouldn't keep the rest of the world out of this. We have to plug the arctic studies into the rest of the world.

Finally, under substantive studies it was recommended that baseline studies of newly introduced chemicals should be carded out. An enormous number of new chemicals is introduced every year and nobody knows what effect these are going to have. Since you know when they are being introduced you can get on it fight away and make some sense out of it fairly quickly.

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The second general area was what I called administrative issues. I don't know if my colleagues agreed with that, but you will understand what I mean in a minute. One of them is that there needs to be an analytical protocol, an intercalibration of results, so that the results of the various studies can be compared and perhaps integrated with one another.

There should be the archiving of data, and whether this is central or decentralized doesn't matter so much as that there be a plan. If it is decentralized the various laboratories have to be able to communicate with each other.

We are also told that Antarctic specialists may have more experience in this than the Arctic people, and we might check out what they have done before we try it ourselves.

Another recommendation is that we establish index sites and study index species. This will give us a series of comparisons over time so we can see trends.

In addition, looking at the effects of contamination or contaminants should be encouraged. In other words, you may be studying contaminants themselves, but try to go a little bit beyond that and see what the next step is.

Sixth, there is the environmental impact of the research itself. The scientists in Antarctica were forced to pay attention to this because of our Treaty obligations. Arctic scientists probably should do the same thing. And finally there should be communication with the local people. I emphasize the word "with" because it does not mean communicate to. It means that you listen as well as talk, and this is best done before, during, and after the study.

The final general subject we talked about was criteria to be used by NOAA in evaluating proposals. We didn't resolve all these thoughts, but I will mention them anyway. One of them was that funded studies should be relevant to societal needs. We started to get into the old argument about basic research versus societal needs and we never finished.

PARTICIPANT: That is too bad. We have been waiting for that answer for 100 years.

DR. BURCH: Secondly, we should contribute to the understanding of systems as opposed to isolated phenomena. Again, I am embarrassed to tell you it has to be mentioned. But people forget about it.

The third factor in evaluating proposals is that they should involve partnerships. To the extent possible, new proposals should be built on existing proposals or programs. I suppose the new buzz word is "leveraging."

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FLIPCHART NOTES—GROUP#3

Research Needed to Address Contaminant Sources, Transport, and Effects

- **Effects of contaminants on people, both now and in the future. Specific areas of concern include individual health, community health, subsistence, risk assessment, and risk communications. These areas are generally outside the scope of NOAA's mandate. However, related areas that do fall within the Scope of NOAA's mandate include ecological risk assessment, the long-term study of possible sentinel species, and exposure estimates**.
- **Contaminants research should use an ecosystems approach, focusing on the food web and biomagnification**
- The interaction between Arctic and subarctic transport processes.
- The interactions of sources and sinks, especially land-atmosphere exchanges.
- Large scale patterns of and controls on contaminant transport.
- Large scale patterns of and controls on atmospheric CO_2 and methane concentrations.
- Studies of local sources of contamination and their effects.
- Baseline studies of local sources and effects of newly introduced chemicals should be conducted.
- Am important area that has received little or no scientific attention is the decision-making processes used by and the motivations of the people Who institute policies leading to serious environmental damage. Of particular interest are policy makers in the former Soviet Union. However, these issues fall within the domain of the social sciences and not NOAA.
- Contaminant research should be science-driven. This means that it Should not be ad hoc, but guided by careful assessment of research needs so what results over time is an integrated view of the problem.
- Special attention Should be paid to multiple stressors and synergy.

ADMINISTRATIVE ISSUES

- Continued efforts to improve and standardize analytical protocols so there can be calibration of the results of different studies.
- Systematic efforts to archive data on contaminants (origin, transport, effects). If data are stored in dispersed locations, a network of communications between the several archives, and between the archives and researchers. needs to be created. A general policy governing proprietary fights to data must be agreed on before such a network will be able to function effectively. (To do this, the advice of scientists working on similar issues in the Antarctic should be sought.)
- A set of index sites should be established and monitored.
- A set of index species populations should be agreed upon and monitored.
- Documenting the effects of contaminants should be encouraged.
- There is a need for greatly improved communication between the members of the scientific community and Arctic residents with respect to contaminants. In this exchange, scientists should listen as Well as speak.

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Summary of Breakout Group #4: Amap

DR. BRASS: be clear that what I am about to say that this is not a statement from the Arctic Research Commission. This is the statement from the group that discussed AMAP. I am going to read it:

The Arctic Research Initiative has been designated in part to satisfy the U.S. involvement in AMAP Phase II. Funding arctic contaminant research is not sufficient to meet the U.S. responsibility to AMAP. NOAA should do a good and complete job with respect to AMAP or withdraw from AMAP involvement. There is a bold statement.

There are great scientific benefits to be gained from NOAA's involvement in AMAP. Furthermore, should the U.S. want a role in Phase II of AMAP and in setting priorities for contaminant research and response in the Arctic, adequate U.S. involvement in Phase II is essential.

This group agrees that one FTE and a budget of around $300,000 are necessary to satisfy minimum U.S. involvement in AMAP. The FTE will serve as the U.S. AMAP manager and will be responsible for coordinating involvement from other agencies assuring that appropriate U.S. data are fed into the AMAP data center, continue native involvement and information exchange. The budget will be used to support travel, printing, data formatting and transfer and ad hoc research costs.

Furthermore, all scientific results produced under the ARI must be reported to AMAP. NOAA should establish at least one long-term study site in the U.S. Arctic to conduct baseline studies of environmental stressors and provide supporting data for other focused AMAP research projects.

FLIPCHART NOTES—GROUP #4

Working Group Statement on Suggested U.S. Role in AMAP

The Arctic Research Initiative has been designed, in part, to satisfy the U.S. involvement in AMAP Phase II. But funding for this one, relatively small research program is not sufficient to meet the U.S. responsibility to AMAP. The United States should do a good and complete job with respect to AMAP or withdraw from AMAP involvement. There are great scientific benefits to be gained from U.S. involvement in AMAP. Furthermore, if the United States want a role in Phase II of AMAP and in setting priorities for contaminants research and response in the Arctic, adequate U.S. involvement is essential. This group believes that one full-time employee is necessary to adequately coordinate federal and state agency involvement in the program, assure that appropriate U.S. data are fed into the AMAP data center, and promote continued involvement and data exchange with Alaskan Natives. A budget sufficient to support travel, printing, data formatting and transfer, and ad hoe analytical costs is essential, perhaps around $300,000 per year to satisfy minimum U.S. involvement. Although many federal and state agencies should contribute (including financially) to a U.S. AMAP effort, NOAA should play a leadership role. All scientific results produced under the ARI could be reported to AMAP. It would be in NOAA's interest to establish at least one long-term study site in the U.S. Arctic to conduct baseline and trend studies of environmental stressors and provide supporting data for other focused AMAP research programs.

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Questions/Discussion:

DR. THOMAS: I just want to be sure I understand. What I am hearing is that you say that NOAA should be the one who picks up the responsibility for Phase II of AMAP, administrative responsibility versus passing the hat interagency-wise. Is that what you are saying?

DR. BRASS: I think you can be creative about how you get the funding, if you can find some partners and fellow collaborators for that. It would reduce the financial burden on the ARI and free up more money for science. I encourage all of us to try to find some partners for you. I have been working on one called the Environmental Protection Agency. We know that they are at least interested.

So, yes, remember I said that there were infrastructural costs involved in AMAP that we just cannot avoid. It is much more fun to put all the money for science, but if that science is not pulled together and reported back and put into a coherent U.S. position, we just haven't done our job.

DR. OECHEL: So, the recommendation of your subcommittee group was that there be the secretariat established and that NOAA would take the lead on it.

DR. BRASS: Now, I want to reiterate the qualification that I just made. If there is a way to add some contributors, even if it means distributing a little control, I think that is an important thing.

PARTICIPANT: Also, we were using the term "AMAP manager" as opposed to secretariat because there is already an international secretariat.

FINAL THOUGHTS

DR. OECHEL: I would like to thank everyone for the high-quality presentations and the excellent contributions in the working groups. I, personally, feel quite good, the extent to which everyone jumped into it and what people came up with. So, from my perspective it was quite successful.

DR. THOMAS: May I have a minute? I just want to add my thanks particularly to Chris for her organization and to the Board. I found it an interesting day, and I think it will take us a while to digest the findings.

DR. FRIDAY: And I just wanted to point out that we shouldn't apologize for identifying the fact that we need to study systems as opposed to individual events because we have never been able to really study systems effectively. I think we need to constantly remind ourselves of that.

DR. CLARK: You all have stolen my thunder. I want to thank each and every one of you. You are all busy people. Some of you have traveled thousands of miles and you all had something else you could have been doing. So we appreciate your input. We appreciate the effort. We approached this with some apprehension because we were

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initially convinced we couldn't do much of value inside of 2 days, yet I think we have made some progress.

I hope this workshop and its proceedings will be useful to NOAA, and that we have helped make the 1997-98 funding year even more successful than the previous one.

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3

Background Information

The National Research Council is the principal operating agency of the National Academy of Sciences and the National Academy of Engineering to serve government and other organizations. The Polar Research Board is responsible to the National Research Council through the Commission on Geosciences, Environment, and Resources.

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Revised Workshop Agenda
NOAA's Arctic Contaminants Research[1]
Friday, July 11, 1997
Polar Research Board
NOAA Building 2, Room 2358
1325 East-West Highway
Silver Spring, MD

Closed Session:	
8:00 a.m.	Review workshop tasks and strategy; PRB members and staff only.
Open Session:	
8:30 a.m.	**Introduction** • Welcome, David Clark, PRB chair • Workshop structure and goals, Walter Oechel, PRB workshop chair • Questions to guide workshop discussions, Walter Oechel
8:45 a.m.	**Welcome**, Joe Friday, OAR
8:50 a.m.	**NOAA and Arctic Contaminants Research**, Alan Thomas, OAR • NOAA's role and potential • The Arctic Research Initiative • Expectations for this workshop
9:15 a.m.	**The Big Picture: A CENR Perspective on Contaminant Research Priorities** , Dr. James Baker
9:35 a.m.	**The View from the Line and Program Offices** Walter Oechel, moderator (5 minutes each) • Jawed Hameedi, National Ocean Service • Robert Reeves, National Weather Service • Teri Rowles, National Marine Fisheries Service • Walter Planet, National Environmental Satellite, Data, and Information Service • David Johnson, Coastal Ocean Program

[1] Most Academy activities are conducted in open sessions and information about all meetings is available on the NAS World Wide Web site. Closed sessions can be held to enable study groups to work free from external influences and protect the integrity and independence of the study or where classified or proprietary information is involved. Discussions of personal information, personnel matters, and deliberations on the contents of reports are conducted in closed sessions. The chair is responsible for the conduct of all activities and may close a meeting, if necessary, to remove disruptive persons.

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10:15 a.m.	Break
10:30 a.m.	**Other Perspectives** Bernard Hallet, moderator • Bob Senseney, Department of State • Garry Brass, Arctic Research Commission • Ted DeLaca, University of Alaska-Fairbanks • Other participants Discussion
11:15 a.m.	**Key Research Issues (brainstorming)** Walter Oechel, moderator • natural variability of the western Arctic ecosystem • anthropogenic influences on the western Arctic ecosystem - contaminant sources, transport and dispersion, effects on humans and ecosystems - arctic haze, ozone, UV flux
12:00 noon	**Charge to the Small Groups**
12:15 p.m.	Working Lunch (buffet, take food to break-out rooms. Introductions and informal discussions will begin over lunch) Group 1: Room 2358 (Oechel and Elfring) Group 2: Room 3208 (Hallet and Burch) Group 3: Room 2222 (Clark and Cox)
1:15 p.m.	**Small Group Assignments**
2:30 p.m.	Break
2:45 p.m.	**Plenary Discussion**, Walter Oechel • Reports from the small groups • Questions and discussion • Strategies for reorienting the Arctic Research Initiative
3:55 p.m.	**Summary**, David Clark
4:00 p.m.	Open session adjourns
Closed Session	
4:00 p.m.	PRB members remain for closing discussions
5:00 p.m.	Closed session adjourns

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NATIONAL ACADEMY OF SCIENCES/NATIONAL RESEARCH COUNCIL COMMISSION ON GEOSCIENCES, ENVIRONMENT, AND RESOURCES POLAR RESEARCH BOARD WORKSHOP ON NOAA'S ARCTIC CONTAMINANTS RESEARCH

The Purpose Of This Workshop

At the request of NOAA's Office of Oceanic & Atmospheric Research, the Polar Research Board has planned this workshop to help NOAA develop a vision to guide the Arctic Research Initiative (ARI). The ARI focuses on the health of the Western Arctic and Bering Sea Ecosystem, and within that geographic scope the research focus is on two themes: (1) natural variability and (2) anthropogenic influences. The anthropogenic influences theme contains two categories: (a) arctic haze, ozone, and UV flux and (b) contaminant inputs, fate, and effects. While this workshop will address natural variability to some extent, emphasis will be given to anthropogenic influences, and in particular activities related to Arctic contaminant inputs, fate, and ecosystem effects. Through presentations, brainstorming, and small group discussions we hope to develop a broad list of key research issues, propose a range of more specific research questions, and identify some subset of those as potential priority research questions. This input will help NOAA reorient the ARI so that it better supports the NOAA mission while at the same contributes to a coordinated national and international strategy for addressing the health of the Arctic environment.

This workshop follows a number of contaminant-related activities, including for instance a multi-agency activity, "U.S. Arctic Contaminant Research Planning Workshop," held August 10-13, 1996 in Fairbanks, Alaska, which examined the state of the art of U.S. agency research on arctic contamination issues and suggested overall national research priorities. Today's more focused workshop is designed as a follow-up activity to look specifically on how NOAA — given its mission, capabilities, staff, and resources — could be an effective component of a coordinated national research effort on Arctic contaminants and help NOAA managers ensure that such work supports NOAA's overall mission. In particular, this workshop seeks to identify key research issues to be addressed with funds granted by the Arctic Research Initiative and, if possible, suggest how to reorient that program so it better targets unmet needs.

Participants include members of the Polar Research Board, appropriate NOAA staff, representatives of other key federal agencies, and selected other guests. We expect active participation from all present, especially during the brainstorming and small group assignments. The workshop participants will:

- explore the range of Arctic contaminants research being conducted under the auspices of current NOAA programs and how such research can contribute to NOAA's mission and goals;
- discuss other contaminant-related research activities such as the August 1996 workshop and the priorities developed there as well as the recently released report of the Arctic Monitoring and Assessment Program and plans for AMAP phase two, and how the Arctic Research Initiative might build on and contribute to other federal and international activities;
- suggest key research areas and research questions to better understand natural variability and anthropogenic influences, with emphasis on contaminant sources, transport and dispersion, effects and arctic haze, ozone, and UV flux; and
- discuss the relative strengths of NOAA's research capabilities and partnerships and suggest how NOAA should orient its Arctic Research Initiative in the future.

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THE ARCTIC RESEARCH INITIATIVE: SCOPE, DESCRIPTION, AND FUNDED PROPOSALS

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The Arctic Research Initiative

The scope of the Arctic Research Initiative program is broad. The initial focus will be on Health of the Western Arctic/Bering Sea Ecosystem, in particular, on two major scientific areas:

1. Study of the natural variability of the Western Arctic/Bering Sea Ecosystem.
2. Study of anthropogenic influences on the Western Arctic/Bering Sea Ecosystem.

The Arctic Research Initiative includes five major sub-topics:

Natural variability of the Western Arctic/Bering Sea ecosystem

1. The Bering Sea Qreen Belt: processes and ecosystem production.
2. Atmosphere-ice processes that influence ecosystem variability.
3. Atmospheric, cloud and boundary layer processes.

- Anthropogenic influences on the Western Arctic/Bering Sea ecosystem

1. Arctic haze, ozone and UV flux.
2. Contaminant inputs, fate and effects on the ecosystem.

1. The Bering Sea Green Belt: Processes And Ecosystem Production

The Green Belt is a region of sustained high primary production located over the outer shelf and slope of the Bering Sea. Ecosystem production is also focused here as evidenced by large numbers of fish, marine mammals, and birds. This abundance must be the result of primary production. The physical and biological processes accounting for this abundance, however, are poorly defined or unknown. The goal of this research component is to define and understand the physical and biological processes that lead to sustained ecosystem production.

Objectives:

1. Determine the distribution of nutrients and production in the Green Belt region.
2. Determine the biological and physical processes that result in the distributions observed in (1).
3. Ascertain the potential impacts of fishing practices and climate change on distributions and processes and how these changes will likely affect humans.

2. Atmosphere-Ice Processes That Influence Ecosystem Variability

Climate-scale atmospheric phenomena and attendant changes in ice cover are critical elements of the regional ecosystem. It has been determined that the variations in the Northwest Pacific atmosphere influence intra-annual, inter-annual and decadal shifts in wind patterns over the Bering Sea. The impact of these shifts can be enhanced and transferred to the biological domain. Sea ice plays a prominent role in the Bering Sea ecosystem; its variability influences the physical mechanisms of advection and stratification, as well as the extent and timing of biological processes.

Objectives:

1. Quantify the influence of the atmospheric arctic front on basin-scale climate variability.
2. Determine the influence of sea ice on local and large scale oceanographic processes.
3. Ascertain the potential impacts of climate change on atmosphere-ice processes that are critical to ecosystem health.

3. Atmospheric, Cloud And Boundary Layer Processes

An understanding of atmospheric processes in the Arctic, including both large-scale circulations as well

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An understanding of atmospheric processes in the Arctic, including both large-scale circulations as well as boundary layer dynamics, will be important to developing integrated models of both horizontal and vertical contaminant transport and exposure pathways. In addition, it is generally accepted that there is a poleward amplification of climate change effects and that the Arctic is likely to be a sensitive indicator region of global change processes. Atmospheric processes constitute important a biotic controls on arctic sea ecosystems and their evolution.

Objectives:

1. Develop and deploy instrumentation suitable for measuring atmospheric processes in the Arctic.
2. Analyze existing data sets to identify the essential physical indicator of climate change.
3. Apply scientific techniques of satellite remote sensing to the region.
4. Advance modeling arctic boundary layer processes (sea-land-ice interface) for numerical model predictions of contaminant transport.

Coordinate this work with NOAA, NSF (SHEBA), NASA, and DOE (ARM) activities.

4. Arctic Haze, Ozone And Uv Flux

Key components of climate and global change in the Arctic include the observed changes in arctic haze, stratospheric ozone and UV flux. These are important to climate forcing, human health and the arctic ecosystem.

Objectives:

1. Arctic Haze:

Assess the meaning of the long-term trends, for example downward trends as observed at Barrow through the following:

1. Establish a climatology and chemical fingerprinting of aerosols in the Western Arctic.
2. Enhance NOAA/University of Alaska collaboration within existing chemical sampling networks.
3. Assess transport from source regions such as Eurasia and the Orient and general changes in meteorological patterns.
4. Expand measurements of chemical and physical properties of aerosols and their precursors at the NOAA Barrow Baseline Observatory to augment present aerosol climate-forcing studies.
5. Investigate residence times and gas-to-particle conversion rates of Arctic aerosols.
6. Determine arctic pollution source attribution g. Determine the ultimate fate of arctic haze

2. Stratospheric Ozone and UV Flux

1. Expand chemical and meteorological stratospheric ozone-related measurements obtained in the POLARIS program.
2. Improve ozone-measuring capabilities by augmenting the data retrieval of the NOAA/University of Alaska Dobson spectrophotometer.
3. Utilize spectral UV data being collected at the NOAA Barrow Observatory and upgrade broadband measurements of UV in order to study the relationship of UV, ozone, and arctic aerosols.

5. Contaminant Inputs, Fate And Effects On The Ecosystem

The Arctic is not a pristine environment. Various contaminants have been and continue to be introduced into the region by a variety of pathways. One essential step in understanding the fate and effects of contaminants is measuring contaminant levels in subsistence or commercial species eaten by top consumers (i.e., humans, marine mammals, birds) that are most likely to be adversely affected by food web biomagnification of contaminants. Contaminants include: radionuclides, metals, organochlorine compounds, and petroleum hydrocarbons.

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Objectives:

1. Determine pathways of contaminant accumulation in species that are consumed by top predators, including humans, and determine sub-regional differences in contaminant levels.
2. Assess the biological effects of exposure to contaminants in food and top predator species.
3. Where needed, develop methods and protocols for measuring contaminants or effects.
4. Involve local communities in planning and implementing food sampling strategies.

An overall objective of the Arctic Research Initiative is to provide opportunities for arctic residents to participate in the evaluation and dissemination of research results.

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Background and Geographical Area

There are several reasons why this initiative focuses on the Western Arctic/Bering Sea region, including the importance of the fisheries and marine mammals, the presence of coastal communities, the cultural and economic value of this area, and the need to address issues of sustainable use of resources. In addition, this initiative is in support of the CIFAR research theme of Environmental Monitoring, Assessment, and Numerical Modeling.

The Bering Sea contains a tremendous variety of biological resources, including at least 450 species of fish, crustaceans, and mollusks; 50 species of seabirds; and 25 species of marine mammals. High primary production supporting this ecosystem is found at the retreating ice edge in spring, and along the frontal areas along the shelf. Primary production in the Bering Sea is highly variable seasonally and spatially. The physical environment is dominated through much of the year by sea ice, which is a prominent feature over the Bering Sea shelf during the winter months. The ice edge in the Eastern Bering Sea advances and retreats seasonally over a distance as great as 1,000 km, and there is extraordinary interannual variability in ice cover as well as a trend towards less ice in recent years. The Bering Sea region is of great international interest and attention since it is one of the largest remaining fisheries in the world, heavily utilized by many nations. While the Arctic Research Initiative focuses on the Bering Sea, the surrounding regions of the Western Arctic, which are connected to the Bering Sea through various processes and interactions, are also targets of this initiative. These connections include the large-scale circulation of the atmosphere and the ocean which transport heat, momentum, moisture, sea ice and contaminants into and out of the region. Areas along the Chukchi Sea coast, such as Barrow where there is already a major NOAA research facility, are therefore included in the initiative.

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THE NOAA ARCTIC RESEARCH INITIATIVE: HEALTH OF THE WESTERN ARCTIC/ BERING SEA ECOSYSTEM

BACKGROUND: OAR received $1 million in FY97 for Arctic research
On November 13-14, 1996:

- A workshop was held at the University of Alaska Cooperative Institute for Arctic Research (CIFAR) in Fairbanks to determine a programmatic thrust within the NOAA Arctic Research Initiative
- Participants at the workshop included representative from the University of Alaska Fairbanks, State of Alaska, and NOAA OAR (ERL, Sea Grant, and NURP), NMFS, NOS, and NWS

This Research Initiative focuses on two major scientific themes and five subproject areas:

- Natural Variability of the Bering Sea/Western Arctic Ecosystem

(1) The Bering Sea green belt: shelf-edge processes and ecosystem production
(2) Physical processes that control green belt variability
(3) Atmospheric, cloud, and boundary-layer processes

- Anthropogenic influences on the Bering Sea/Western Arctic Ecosystem

(4) Arctic haze, ozone, and UV flux
(5) Contaminant sources, transport and dispersion, and effects on humans and ecosystems

On December 3, 1996:

- An Announcement of Opportunity (AO) was advertised through the Arctic Research Consortium of the United States (ARCUS) and the CIFAR Home Page to solicit proposals
- 57 proposals were received by CIFAR with a request for support totaling over $3.5 million

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During the week of January 21, 1997:

- A technical peer review panel took place in Seattle, WA, with members from the University of Washington, University of Alaska, CIFAR, NOAA, and NSF
- 15 proposals were selected for support as follows (see table for more details):

(1) 6 under green belt biology
(2) 2 under air-ice-ocean interactions in Bering Sea
(3) 1 under boundary layer
(4) 4 under Arctic haze and UV flux
(5) 2 under contaminants

- 13 proposals have direct connections between NOAA and the University of Alaska Awards for $900K will be made in March 1997, broken down as follows:
- $250K will go to NOAA laboratories
- $550K will go to the University of Alaska
- $100K will go to other institutions

The remaining $100K will be used for a special study on Arctic contaminants by the Polar Research Board (PRB), NOAA support of the Arctic Monitoring and Assessment Program (AMAP), CIFAR planning of this Arctic Research Initiative, and administrative expenses

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Pro. #	1st PI	1st PI	Address	CO-PI	CO-PI	ADDRESS	Title	Theme	Request
1	Bengtson	John	National Marine Mammal Laboratory Alaska Fisheries Science Center National Marine Fisheries Service/NOAA 7600 Sand Point Way NE Seattle, WA 98115	Boveng	Peter	National Marine Mammal Laboratory Alaska Fisheries Science Center National Marine Fisheries Service/NOAA 7600 Sand Point Way NE Seattle, WA 98115	Life history of spotted seals: do apex predators reflect inter-decadal changes in the Bering Sea Ecosystem	1	$29,957
2	Finney	Bruce	School of Fisheries & Ocean Science Institute of Marine Science PO 7220 University of Alaska Fairbanks Fairbanks, AK 99775-7220	Naidu	Sathy	School of Fisheries & Ocean Science Institute of Marine Science PO 7220 University of Alaska Fairbanks Fairbanks, AK 99775-7220	Variability of Primary Production in the Green Belt: The Paleoceanographic Record	1	$74,046
3	Frost	Kathryn	State of Alaska Dept. of Fish and Game 1255 W. 8th Street Juneau, AK 99802	Springer	Alan	Institute of Marine Science University of AK Fairbanks Fairbanks, AK 99775	Winter Distribution of Spotted Seals, *Phoca Largha*, Relative to the Bering Sea Shelf Edge, Green Belt, and the Seasonal Sea Ice Front	1	$36,882 *
4	Gearing	John	School of Fisheries & Ocean Science Institute of Marine Science PO 7220 University of Alaska Fairbanks Fairbanks, AK 99775-7220				Measurements of Total, 'New' Export and Regenerated Production in the Southeast Bering Sea Using 13C Labeled Bicarbonate and 15N Labeled Nitrate, Ammonium and Urea	1	$22,875 *
5	Huntington	Henry	ICC-Alaska 401 E. Northern Lights Blvd SU 203 Anchorage, AK 99503	Raygorodetsky	Gleb	PO Box 1231 Inuvik, NWT, X0E 0T0, Canada	Traditional Ecological Knowledge in the Bering Sea Region: Pilot Project	1	$94,609
6	Krupnik	Igor	Arctic Studies Center, Department of Anthropology MRC-112 Smithsonian Institution Washington, DC 20560	Bogoslovskaya	Lyudmila	Russian Institute of Natural and Cultural Heritage Moscow, Russia	Ecosystem Variability and Anthropogenic Hunting Pressure in ah Bering Strait Area	1	$71,576 *
7	McRoy	Peter	School of Fisheries & Ocean Science Institute of Marine Science PO 7220 University of Alaska Fairbanks Fairbanks, AK 99775-7220	Schumacher	James	NOAA/Alaska Fisheries Science Ctr 7600 Sand Point Way NE Seattle, WA 98115	Ecosystem Foundation for the Green Belt: Observations of Velocity, Water Properties and Nutrients in the Green Belt	1	$158,769 *
8	Murphy	Edward	Institute of Arctic Biology University of Alaska Fairbanks Fairbanks, AK 99775-0180				Population status of cliff-nesting seabirds in the Bering Sea in relation to variability and changes in atmospheric and sea ice conditions	1	$71,541

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Pro. #	1st PI	1st PI	Address	CO-PI	CO-PI	ADDRESS	Title	Theme	Request
9	Napp	Jeffrey	NOAA/Alaska Fisheries Science Ctr 7600 Sand Point Way NE Seattle, WA 98115	Springer	Alan	Institute of Marine Science University of Alaska Fairbanks	Is Green Belt Production Advected Onto the Southeast Bering Sea Continental Shelf?	1	$46,693
10	Schamel	Doug	Institute of Arctic Biology University of Alaska Fairbanks	Tracy	Diane	Institute of Arctic Biology University of Alaska Fairbanks	Monitoring waterbird populations at Cape Espenberg, Alaska: are we witnessing a long-term decline?	1	$17,879
11	Schell	Donald	School of Fisheries & Ocean Science Institute of Marine Science PO 7220 University of Alaska Fairbanks Fairbanks, AK 99775-7220				A Regional and Retrospective Assessment of Primary Productivity in the Bering Sea	1	$61,344
12	Severin	Ken	Institute of Northern Engineering University of Alaska Fairbanks PO Box 755910 Fairbanks, AK 99775-5910	Bailey	Keven	AK Fisheries Science Ctr Seattle, WA	Development of Microchemical Techniques for Analysis of Walleye Pollock Otoliths: A Tool for Tracing Fish Stock Structure	1	$75,306
13	Springer	Alan	School of Fisheries & Ocean Science Institute of Marine Science PO 7220 University of Alaska Fairbanks Fairbanks, AK 99775-7220	Schumacher	James	NOAA/PMEL Seattle, WA 98115	Seascape Ecology of the Bering Sea: Time Scales of Variability	1	$56,070
14	Megrey	Bernard	National Marine Fisheries Service AK Fisheries Center 7600 Sand Point Way NE Seattle, WA 98115	Springer	Alan	School of Fisheries & Ocean Science Institute of Marine Science PO 7220 University of Alaska Fairbanks Fairbanks, AK 99775-7220	Creation of a Browsable Bio-physical Meta-data for Research on the Western Arctic and Bering Sea Ecosystem	1	$11,661
15	Stamnes	Knut	Geophysical Institute University of Alaska Fairbanks PO Box 7320 Fairbanks, AK 99775-7320 E-Mail:	Napp	Jeff	AK Fisheries Science Ctr Seattle, WA	Light and Life in Alaska Coastal Waters: Satellite Remote Sensing of Phytoplankton and the Light Environment in the Bering Sea, Including Comparisons with In Situ Data	1	$94,407
16	Duffy	Philip	Climate System Modeling Group University of California Livermore National Laboratory L-256 Livermore, CA 94550				Mixing due to Salt Rejection During Sea-ice Formation: a Modeling Study of an Ice/Ocean Interaction	2	$53,000

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Pro. #	1st PI	1st PI	Address	CO-PI	CO-PI	ADDRESS	Title	Theme	Request
17	Henrichs	Susan	School of Fisheries & Ocean Science Institute of Marine Science PO 7220 University of Alaska Fairbanks Fairbanks, AK 99775-7220				Composition of Sinking Organic Matter at the Ice Edge of the Southeast Bering Sea	2	$38,581
18	Holland	David	Oceans and Climate Division Lamont-Doherty Earth Observatory PO Box 1000 Rt 9W Palisades, NY 10964-8000				A Study of Atmosphere - Ice - Ocean - Land Processes that Influence Natural Variability of the Ecosystem in the Western Arctic/Bering Sea using a nested version of the NCAR Climate System Model	2	$39,720
19**	Jacoby	Gordon	Tree-Ring Laboratory Lamont-Doherty Earth Observatory Route 9W Palisades, New York 10964 E-Mail: druid@ldeo.columbia.edu	Lovelius	Nikolai	Botanic Institute RAS Popova 2 197022 S. Petersburg Russia	Long-Term Climatic Information from Arctic and Subarctic Tree-Ring by Circumpolar Studies	2	$40,000
**	This proposal was submitted to the CRDF competion and not directly submitted to this RFP								
20	Kowalik	Zygmunt	School of Fisheries & Ocean Science Institute of Marine Science PO 7220 University of Alaska Fairbanks Fairbanks, AK 99775-7220				Dynamical Processes Determining Ecosystem Production at the Pribilof Canyon and Islands	2	$104,569
21	Li	Shusun	Geophysical Institute University of Alaska Fairbanks PO Box 7320 Fairbanks, AK 99775-7320 E-Mail:	Tilley	Jeffrey	Geophysical Institute University of Alaska Fairbanks PO Box 7320 Fairbanks, AK 99775-7320 E-Mail:	Improving Understanding of Sea Ice Behavior in the Bering Sea	2	$83,609
22	McNutt	Lynn	Geophysical Institute University of Alaska Fairbanks PO Box 7320 Fairbanks, AK 99775-7320 E-Mail:	Overland	James	National Marine Mammal Laboratory Alaska Fisheries Science Center National Marine Fisheries Service/NOAA 7600 Sand Point Way NE Seattle, WA 98115	Defining Biophysical Domains in the Bering Sea Based on Analysis of Synthetic Aperture Radar (SAR) and Advanced Very High Resolution Radiometer (AVHRR) Data	2	$58,262
23	Overland	James	NOAA Pacific Marine Environmental Laboratory 7600 Sand Point Way NE Seattle, WA 98115 E-Mail: overland@pmel.noaa.gov	Niebauer	Joe	School of Fisheries & Ocean Science Institute of Marine Science PO 7220 University of Alaska Fairbanks Fairbanks, AK 99775-7220	Causes of Variability in the Aleutian Low	2	$89,000
24	Proshutinsky	Andrey	School of Fisheries & Ocean Science Institute of Marine Science PO 7220 University of Alaska Fairbanks Fairbanks, AK 99775-7220	Overland	James	NOAA/PMEL Seattle, WA 98115	Large-Scale Ice and Oceanographic Changes in the Bering Sea During the Last 50 Years	2	$88,127

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25**	Seelye	Martin	University of Washington School of Oceanography Box 357940 Seattle, WA 98195-7940 E-Mail: seelye@ocean.washington.edu	Rogachev	Konstantin	Pacific Oceanological Institute 43Baltiskaya Street Vladivostok, 690041 Russia	A Process Study of Recent Climate Change in the Subarctic Pacific	2	$4,250
**	This proposal was submitted to the CRDF competion and not directly submitted to this RFP								
26	Stabeno	P.J.	NOAA/Alaska Fisheries Science Ctr 7600 Sand Point Way NE Seattle, WA 98115	Kowalik	Zygmunt	Geophysical Institute University of Alaska Fairbanks PO Box 7320 Fairbanks, AK 99775-7320 E-Mail:	Transfer Processes between Shelf and Slope Waters: A Lagrangian Perspective	2	$98,419
27	Weingartner	Tom	School of Fisheries & Ocean Science Institute of Marine Science PO 7220 University of Alaska Fairbanks Fairbanks, AK 99775-7220	Schumacher	James	NOAA/PMEL Seattle, WA 98115	Estimating Tidal Holograph Parameters on the Bering Sea Shelf from Shipboard Acoustic Doppler Profiler Data	2	$91,221
28	Brooks	Steven	NOAA Atmospheric Turbulence and Diffusion Division 456 S. Illinois Ave. BOX 2456 Oak Ridge, TN 37831	Crawford	Timothy	NOAA Atmospheric Turbulence and Diffusion Division 456 S. Illinois Ave. BOX 2456 Oak Ridge, TN 37831	Instrumentation for NOAA ATDD Dedicated Arctic Research Aircraft	3	$56,420
29	Flanders	Nicholas	Institute of Arctic Studies Dartmouth College 324 Murdough Center Hanover, NH 03755				Assessing and Compiling Historical Atmospheric and Ice Data for the Bering Sea Region	3	$29,339
30	Uttal	Taneil	NOAA/ERL/ETL Radar Meteorology & Oceanography	Bowling	Sue Ann	Geophysical Institute University of Alaska Fairbanks PO Box 7320 Fairbanks, AK 99775-7320 E-Mail:	Utilization of an Unattended 35 Ghz Doppler Radar to Study Vertical Mass Fluxes in Clouds: A Precursor to a Study of the Removal of Arctic Haze Particles by Clouds	3	$50,520
31	Wendler	Gerd	Geophysical Institute University of Alaska Fairbanks Fairbanks, AK 99775-0800 E-Mail:	Dutton	Ellsworth	Climate MOnitoring and Diagnostics Lab ERL/NOAA Boulder, CO	On the Climate Change in the Western Arctic, with Special Emphasis on Barrow, Alaska	3	$46,000

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32	Bonner	Richard	Geophysical Institute University of Alaska Fairbanks Fairbanks, AK 99775-0800 E-Mail: fifrb@aurora.alaska.edu	Holmann	David	NOAA/CMDL 325 Broadway Boulder, CO	Upgrade of Dobson Ozone Spectrometer in Fairbanks, Alaska	4	$17,214 *
33	Bonner	Rich	Geophysical Institute University of Alaska Fairbanks PO Box 7320 Fairbanks, AK 99775-7320 E-Mail:	Shaw	Glenn	Geophysical Institute University of Alaska Fairbanks PO Box 7320 Fairbanks, AK 99775-7320 E-Mail:	Integrated Improvement to Year-Round Arctic Environment Research Sites	4	$66,540
34	Bodhaine	Barry	NOAA/CMDL R/E/CG1 325 Broadway Boulder, CO 80303	Stamnes	Knut	Geophysical Institute University of Alaska Fairbanks PO Box 7320 Fairbanks, AK 99775-7320	Establishment of accurate yet reliable, portable and inexpensive measurements of the UV radiation environment in the Arctic	4	$75,000 *
35	Disselkamp	Robert	Geophysical Institute University of Alaska Fairbanks PO Box 7320 Fairbanks, AK 99775-7320 E-Mail:	Fahey	David	Aeronomy Laboratory NOAA	Stratospheric Ozone Changes in the Bering Sea Region in Summer	4	$73,475
36	Jaffe	Daniel	Geophysical Institute University of Alaska Fairbanks PO Box 7320 Fairbanks, AK 99775-7320 E-Mail:	Harris	Joyce	NOAA/CMDL Barrow, AK	Identification of Sources and Long Term Trends for Pollutants in the Arctic using Clustered Trajectory Analysis	4	$88,527 *
37	Lowenthal	Douglas	Desert Research Institute Atmospheric Sciences Center University & CC System of Nevada PO Box 60220 Reno, NV 89506-0220				Elemental and Organic Carbon in Arctic Haze at Barrow, Alaska	4	$79,091
38	Rahn	Kenneth	The Research Office The University of Rhode Island 70 Lower College Road Kingston, RI 02881				Sources and Transport of Anthropogenic Aerosol to the Western Arctic/Bering Sea Ecosystem	4	$79,713
39	Shaw	Glenn	Geophysical Institute University of Alaska Fairbanks PO Box 7320 Fairbanks, AK 99775-7320 E-Mail:				Long-term Trends in Arctic Haze in Alaska -- A contribution to the FY 97 NOAA Arctic Initiative	4	$64,204 *

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40	Shaw	Glenn	Geophysical Institute University of Alaska Fairbanks PO Box 7320 Fairbanks, AK 99775-7320 E-Mail:	Hameedi	Jawed	Texas A&M University Dept. of Oceanography Galveston, TX 77651	Sources and Residence Times of Arctic Haze Using Concentrations and Activity Ratios of 7Be, 210Po, and 210Pb in Arctic Aerosol-Implications to the Fate of Arctic Atmospheric Pollutants	4	$50,000
41	Tsay	Si-Chee	NASA Goddard Space Flight Center Laboratory for Atmospheres, Code 913 Greenbelt, MD 20771 E-Mail: tsay@climate.gsfc.nasa.gov				Detection and Assessment of Biomass Burning Aerosols over the Western Arctic/Bering Sea Ecosystem	4	$56,000
42	Beckmen	Kimberlee	Institute of Arctic Biology University of Alaska Fairbanks Fairbanks, AK 99775-0180	Krahn	Margaret	Environmental Conservation Division Northwest Fisheries Science Center National Marine Fisheries NOAA Seattle, WA 98112	Immonotoxicology of Organochlorine Contaminants	5	$70,717
43	Bradley	W. Guy	Biology Department Eckerd College 4200 54th Avenue, South St. Petersburg, FL 33711 E-Mail: bradlewg@eckerd.edu	Reynolds	John	Marine Science Department Eckerd College 4200 54th Ave. S St. Petersburg, FL 33711	Immunological Expression in Selected Arctic marine Mammals	5	$36,175
44	Castellini	Michael	School of Fisheries & Ocean Science Institute of Marine Science PO 7220 University of Alaska Fairbanks Fairbanks, AK 99775-7220				Biomedical Responses of Alaskan Marine Mammals to Environment Contaminants	5	$98,636
45	Duffy	Lawrence	Institute of Arctic Biology University of Alaska Fairbanks Fairbanks, AK 99775-0180	Paul	Senka	Y-K Delta Health Corp Bethel, AK	Development of contaminant biomarkers in nearshore subsistence species appropriate western Arctic and subarctic sentinel species: marine mammals and river otters	5	$84,801
46	Foster	Gregory	George Mason University Department of Chemistry Fairfax, Virginia 22030-4444	McConnell	Laura	US Dept. Agriculture Beltsville, MD	Atmospheric Transport and Deposition of Pesticides and PCBs in the Arctic	5	$87,885
47	Gibson	Margie	Arctic Network PO Box 102252 Anchorage, AK 99510 E-Mail: arcnet@igc.org				Community Awareness Project Concerning the Health of the Western Arctic/Bering Sea Ecosystem	5	$10,000

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48	Kelley	John	School of Fisheries & Ocean Science Institute of Marine Science PO 7220 University of Alaska Fairbanks Fairbanks, AK 99775-7220	Naidu	Sathy	School of Fisheries & Ocean Science Institute of Marine Science PO 7220 University of Alaska Fairbanks Fairbanks, AK 99775-7220	Heavy Metal and Hydrocarbon Contaminants in Sediments of the Nearshore Beaufort Sea	5	$67,946
49	Kelley	John	School of Fisheries & Ocean Science Institute of Marine Science PO 7220 University of Alaska Fairbanks Fairbanks, AK 99775-7220	Alexander	Vera	School of Fisheries & Ocean Science Institute of Marine Science PO 7220 University of Alaska Fairbanks Fairbanks, AK 99775-7220	Monitoring the Arctic Marine and Aquatic Environment: A Workshop	5	$51,068
50	Naidu	A. Sathy	School of Fisheries & Ocean Science Institute of Marine Science PO 7220 University of Alaska Fairbanks Fairbanks, AK 99775-7220	Kelley	John	School of Fisheries & Ocean Science Institute of Marine Science PO 7220 University of Alaska Fairbanks Fairbanks, AK 99775-7220	Impact of Heavy Metal Contaminants in Sediments on the Marine Food Chain Organisms of Subsistence Animals off Kivalina-Point Hope, Eastern Chukchi Sea	5	$78,682
51	O'Hara	Todd	North Slope Borough Dept. of Wildlife Management Box 69 Barrow, AK 99723	Bandiera	Stelvio	Dept. of Pharmaceutical Sciences University of British Columbia Canada V6T 1Z3	A Determination of Heavy Metal and Select Organochlorine and Methylsulfone Metabolite Levels and Assessment of Histopathologic and Ultrastructural Changes in Blubber, Liver and Kidney of Subsistence Harvested Polar Bear and Beluga Whale from Arctic Alaska	5	$97,260
52	Philemonof	Dimitri	Aleutian/Pribilof Islands Association 401 E. Fireweed Lane, Suite 201 Anchorage, AK 99503-2111				Aleutian/Pribilof Islands Association, Inc.	5	$43,801
53	Sinlff	Donald	Department of Ecology, Evolution and Behavior University of Minnesota St. Paul, Minnesota	Estes	James	Institute of Marine Science University of California Santa Cruz, California	Sea Otters (Enhydra Lutris) as Indicators of Contaminant Cycling in the Nearshore Community of Amchitka Island and Other Islands of the Aleutian Archipelago	5	$89,347
54	Stegeman	John	Woods Hole Oceanographic Institution Woods Hole, Massachusetts 02543	Moore	Michael	Woods Hole Oceanographic Institution Woods Hole, Massachusetts 02543	Organic Contaminant Fate and Effects in Subsistence Hunted Western Arctic Beluga and Bowhead Whales	5	$89,443
55	Ford	M.S. Jesse	Department of Fisheries and Wildlife Oregon State University Corvallis, Oregon 97331-3803				Airborne contributions of organochlorine contaminants to arctic Alaskan ecosystems	5	$51,864

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56	Bischof	Jens	Department of Oceanography Old Dominion University PO Box 6369 Norfolk, VA 23508-0369	Darby	Dennis	Department of Oceanography Old Dominion University PO Box 6369 Norfolk, VA 23508-0369	The Sources of Contaminated Sea Ice in the Chukchi and Bering Seas	5	$45,285
57	Bonzongo	Jean-Claude	University of Alabama Department of Geology Box 870338 Tuscaloosa, AL 35487-0104	Lyons	W. Berry	University of Alabama Department of Geology Box 870338 Tuscaloosa, AL 35487-0104	Determination of Levels and Speciation of Mercury in Waters and Biota of the Bering Sea Ecosystem	5	$57,024
									$3,581,839

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DESCRIPTIONS OF NOAA PROGRAMS WITH RELEVANCE TO ARCTIC CONTAMINANTS

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SUMMARY OF NOAA/OFFICE OF OCEANIC AND ATMOSPHERIC RESEARCH PROGRAMS RELATED TO ARCTIC CONTAMINANTS

(1) The NOAA Arctic Research Initiative:

NOAA's Office of Oceanic and Atmospheric Research (OAR) provides management for the NOAA Arctic Research Initiative, which received initial funding in FY97. The NOAA Arctic Research Initiative (ARI) focuses on research in natural variability of and anthropogenic influences of the Western Arctic/Bering Sea ecosystem, including the importance of fisheries and marine mammals, the presence of coastal communities, the cultural and economic value of this area, and the need to address issues of sustainable use of resources. There are five major goals of the initiative: (1) to define and understand the physical and biological processes that lead to sustained ecosystem production of the Bering Sea Green Belt; (2) to define and understand atmosphere-ice processes that influence ecosystem variability; (3) to understand atmospheric processes in the Arctic, including both large-scale circulations as well as boundary-layer dynamics, in order to develop integrated models of both horizontal and vertical contaminant transport and exposure pathways; (4) to assess observed changes in Arctic haze, ozone, and UV flux, which are important to climate forcing, human health, and the Arctic ecosystem; and (5) to understand contaminant inputs, fate, and effects on the ecosystem, including radionuclides, metals, organochlorine compounds, and petroleum hydrocarbons.

(2) OAR/Environmental Research Laboratory (ERL):

See attached summaries provided by the Environmental Technology Laboratory (ETL), Air Resources Laboratory (ARL), Pacific Marine Environmental Laboratory (PMEL), Aeronomy Laboratory (AL), and Climate Monitoring and Diagnostics Laboratory (CMDL).

(3) OAR/National Undersea Research Program (NURP)

NURP capabilities could be very useful in studying contaminants under ice or on the seafloor. For the latter, the advantage of a submersible or ROV is that the investigator can collect sediment or benthos from a specific spot with little disturbance to the sample. In the case of sediment, contaminants may be in layers and the most recent evidence would be in the surface layer which is always disturbed when collected from a surface vessel. Also, one can make sure that your sample is collected from an undisturbed site. This is important because much of the Arctic shelf is very shallow and frequently disturbed by gray whales, walruses, and ice keels. If a time series is of interest, subs and ROVs can return

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ERL/ENVIRONMENTAL TECHNOLOGY LABORATORY (ETL) SUMMARY

The four major sources of pollution in the Arctic Ocean Basin are inflow from rivers, direct dumping by ships, dry deposition of atmospheric aerosols, and wet removal of atmospheric aerosols by precipitation. The relative contributions of these processes depend on season and location and at present are largely unknown. NOAA/ETL is a world leader in the development of ground-based remote sensors and recently has developed state-of-the-art radars and lidars for monitoring cloud and aerosol properties in the Arctic. These instruments can be used in combination with micrometeorological techniques (sonic anemometers and fast particle/chemical sensors) and cloud-aerosol/ensemble trajectory models to significantly advance our understanding of the transfer of contaminants from the atmosphere to the ocean (i.e. wet and dry deposition processes). The following pages summarize NOAA/ETL activities that relate to Arctic haze, ozone, and contaminant inputs to the Western Arctic/ Bering Sea ecosystem. In addition, the objectives of the Implementing Arrangement which exists between ETL and the Communications Research Laboratory of the Ministry of Posts and Telecommunications of Japan (MPT/ CRL) are outlined and highlighted. This Implementing Arrangement is a powerful mechanism for facilitating collaborative efforts between NOAA and Japanese researchers in the Polar regions..

Radar Studies of Wet Deposition

NOAA/ETL has recently deployed a vertically pointing Doppler millimeter-wave radar in Barrow, Alaska and collected data in the winter and spring of 1997. This radar has been designed to be largely unattended and unlike longer wavelength radars is designed to collect detailed microphysical information on non-precipitating clouds, diamond dust and ice fogs which axe ubiquitous in the Arctic. The 1997 NOAA Arctic Initiative is presently supporting a study which will utilize the Doppler and cloud retrieval capabilities of this cloud radar to study vertical transports of water mass in Arctic clouds. In future work this information can be combined with measurements of the concentration of pollutants in the condensed water to obtain a total vertical transport budget for contaminants. Present research efforts are concentrated during the spring transition period during which an dramatic decrease in atmospheric Arctic haze occurs on an annual basis. This study will be a part of a more comprehensive evaluation of the relative effects of chemical reactions, horizontal transports to lower latitudes, and wet/dry deposition of pollutants in removing pollutants from the Arctic atmosphere and depositing them into the Arctic Basin Oceans. This study is being conducted in collaboration with GI/UAF.

Micrometeorological Measurements of Dry Deposition

For dry deposition processes, the simplest method is to use the measured concentration of the contaminant and multiply it by the "deposition velocity" to obtain the rate at which either solid or gaseous pollutants are transferred to the surface. The surface can be foliage, snow, ice, bare soil, lakes or open ocean. For example, known atmospheric concentrations of Arctic haze aerosols could be converted to rates of deposition of the chemical constituents to each surface type in the Arctic if the deposition velocities were known. the deposition velocity is a strong function of the surface characteristics and the properties of the pollutants; it must be

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determined by direct measurement using micrometeorological techniques (sonic anemometers and fast/particle/chemical sensors). Such direct measurements have not been done in the Arctic although at least one very limited study has been done over snow. ETL, ARL, and the GI/UAF have scientists working in this area who have collaborated in the past.

Lidar Measurements of Arctic Haze

ETL has developed the Depolarization and Backscatter Unattended Lidar (DABUL) which provided research-grade measurements of aerosol particles in an automated all-weather mode. The system is designed to run continuously for periods of months to years with minimal operator intervention. The system was successfully deployed in Barrow, AK in March of 1997. The lidar reveals the vertical structure of the haze particle concentration and sizes which are essential in defining the transports, the details of trajectories and the context of in-situ chemical and particle size measurements. An optional scanning capability improves quantitative accuracy in the vertical structure in deriving the optical characteristics of haze. Scanning also reveals horizontal gradients that can help distinguish between regional and local sources of aerosol at monitoring stations like those in Barrow, AK.

Modeling Studies of Aerosol-Cloud Interactions and Wet Deposition

NOAA/ETL has been investigating aerosol-cloud interactions in the Arctic for a number of years using a coupled dynamical/microphysical/radiative transfer model. the model is a large eddy simulation (LES) model based on the Colorado State University Regional Atmospheric Modeling System (RAMS). It has ben modified to include detailed calculations of aerosol-cloud interactions and ice-phase clouds. It included solute tracking capabilities that enable investigation of wet deposition of contaminants. More recently microphysical models have been coupled to aqueous chemistry models to investigate aqueous-phase production of sulfate and the resultant modification of the aerosol distribution. instead of doing these studies for simple parcel trajectories, an ensemble of trajectories that are produced by the LES model. In this manner realistic in-cloud residence times and liquid water content histories are obtained that are far more representative than those from single parcel runs. Using these tools, we can study 1) incorporation of contaminants into cloud droplets and subsequent wet deposition to the surface (land or sea) by precipitation, 2) the impact of Arctic stratus cloud on trace gases (SO_2 and O_3), 3) Arctic haze and impacts of visibility, and 4) Cloud processing of aerosol through heterogeneous chemistry and impacts on the optimal properties of these clouds in subsequent cloud cycles.

Lidar Measurements of Ozone, Polar Stratospheric Aerosol and Volcanic Ash

NOAA/ETL has also developed lidar capabilities that pertain to the study of stratospheric ozone and its controlling factors. ETL has conducted long-term lidar studies of volcanic aerosol, especially the El Chicon and Pinatubo eruptions. These transportable lidars could be used for intensive studies of polar stratospheric clouds and their role in ozone depletion. The DABUL lidar described above would be ideal for monitoring, and in the event of a major Alaskan volcanic eruption, the volcanic ash cloud could be studied in the downwind region. ETL also has a transportable ozone lidar tailored to urban air quality research. With appropriate modification, it would be possible to use this instrument to monitor stratospheric ozone in the Arctic, perhaps in cooperation with CMDL or AL.

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ETL-GI/UAF-CRL Collaboration Efforts

In January of 1995 NOAA/ETL and the Communication Research Laboratory of the Ministry of Posts and Telecommunications of Japan (MPT/CRL) agreed on an Implementing Arrangement in accordance with the Agreement between the Government of the United States of America and the Government of Japan on Cooperation in Research and Development in Science and Technology. The objective of this agreement is to facilitate the development of new radio and optical methods for research on the polar region, and it was specified that activates would be carried out with the cooperation of the Geophysical Institute-University of Alaska-Fairbanks (GI/UAF). Additionally, in February 1996 NOAA/ETL, MPT/CRL and GI/UAF signed a joint communiqué which recognized the importance of the Arctic atmosphere and agreed to combine their respective and unique expertise in conducting and promoting Arctic research. An present example of this cooperative agreement is NOAA/ETL's role in pursuing a frequency license for MPT/CRL to operate an MST radar in Alaska.

Summary

NOAA/ETL has developed measurement capabilities which have the potential to comprehensively examine the issue of Arctic haze and the transport of contaminants from the atmosphere to the ocean. Both the lidar and the radar described above have been containerized for deployment on ships and have the potential of opening new cost-effective techniques for addressing the problem of transfer of contaminants from the atmosphere to the ocean. The measurement techniques are especially powerful when used in conjunction with the modified CSU/RAMS model. The NOAA/ARI will be able to utilize NOAA/ETL experience in combining state-of-art measurements with models to take full advantage of the observation and theoretical tools that are now available for addressing Arctic contaminant issues in a manner that has not been technologically feasible until recently. The NOAA/ETL focus will be on Arctic haze and the transfer of contaminants from the atmosphere into the Western Arctic/Bering Sea. NOAA/ARI activates can also be leveraged off the existing Implementing Arrangement between NOAA/ETL, MPT/CRL and GI/UAF to entrain powerful University and Japanese research partners for Arctic research issues.

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ERL/AIR RESOURCES LABORATORY (ARL) SUMMARY

(1) ARL/Surface Radiation Research Branch: Ozone Depletion Impact on Arctic Surface UV

Rationale:

Biologically active, and potentially damaging, UV radiation in the Arctic is directly connected to the amount of column ozone amount. The "predicted" rate of UV biologically active UV increase due to a decrease in ozone is about 1.3% increase to a 1% decrease in ozone. Therefore, UV increases can be on the order of 50% to 100% for "ozone hole" events the occur during the Arctic springtime.

However, measurements alone are not enough. The various moderating or enhancing effects of clouds, aerosols, and snow cover need to be taken into account if a clear understanding of the ozone-decrease/UV-increase is to be accurately quantified. Before this can be done, accurate measurements are mandatory. The important interagency mission of the ARL U.S. Central UV Calibration Facility (CUCF) is specifically focused on assuring accurate UV measurements in the U.S. Interagency UV Monitoring Network. This network is composed of several institutions (Re: interagency MOU). The NIST is collaborating with the ARL CUCF laboratory to certify that it is conducting its work at the level of NIST's stringent state-of-the-art standards.

What Can ARL Contribute to Arctic Research?

Measurements:

The ARL UV monitoring network in the continental U.S. with its quality assurance overseen by the CUCF and the U.V. field measurement expertise of the ARL Surface Radiation Research Branch located in Boulder, can be extended to the Arctic at stations collocated with either the DOE ARM site or the CMDL site in Barrow, Alaska, and a few other stations in the vicinity of the Bering Sea.

The coverage of the Bering sea can be expanded with the use of satellite observations when it is free of sea ice. The SRRB is currently conducting a study with NASA Goddard on the relationship between surface and satellite observations of UV. Snow cover is a major problem that needs further investigation.

Research:

The ARL SRRB UV scientific investigators already working on the U.S. network data can assess the UV climatology of the Arctic including the impact of ozone depletion, and furthermore, assess the modifying effects of clouds, aerosols, and surface reflectance on increased UV caused by ozone depletion.

(2) ARL/Atmospheric Turbulence and Diffusion Division (ATDD):

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ARL/ATDD is currently involved in three major Arctic research efforts and one near-future effort:

(i) Land-Atmosphere-Ice Interaction (LAII) Alaskan Landscape Flux Survey (ALFS) Summertime aircraft measurements of the Alaskan north slope tundra (collaborating with San Diego State University)
(ii) Year-round unmanned research towers/sites on the Alaskan north slope (collaborating with San Diego State University)
(iii) Surface Heat Budget of the Arctic (SHEBA) in-situ light aircraft measurement program (collaborating with the University of Colorado)
(iv) ATDD has proposed operating a research aircraft as part of the International Geosphere Biosphere Program Northern Eurasian Study (IGBP/NES) in the Siberian Arctic.

Unique aspects of ATDD's Arctic research include:

(i) ATDD operates the only year-round eddy-correlation flux tower sites in the Arctic.
(ii) ATDD will operate the only shipboard eddy-correlation research aircraft from onboard a research icebreaker within the Arctic ice pack.
(iii) ATDD is the only group to combine isotopic carbon analysis with concurrent eddy-flux measurements in the Arctic tundra.

RESEARCH PROGRAMS:

Alaskan Landscape Flux Survey (ALFS:)

For the past three years, NOAA/ATDD and San Diego State University (SDSU) have collaborated on this program with summertime operation of an instrumented NOAA/ATDD light aircraft. The aircraft has been used in the investigation of energy balance and trace gas fluxes along one latitudinal and two longitudinal 160 km transects on the North Slope of Alaska. The experiment has consisted of over 150 flights, occurring over a range of weather conditions during both daytime and evening hours (Brooks et all., 1996).

Overall, the east-west and north-south transect carbon dioxide fluxes show uniformity throughout the coastal plain despite north-south gradients in temperatures and vegetation. Significant daytime carbon dioxide sources are the major rivers (Sagavanirktok and Colville) crossed by the east-west transect. This was a clear example where the aircraft measurements have been particularly successful in resolving landscape-level patterns of flux. The overall uniformity and similarities between the three years of flux measurements makes extrapolation to the circumpolar arctic a real possibility.

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The results also show that the summertime tundra can be both a sink and a source for atmospheric carbon dioxide depending on location and time of day. While the tundra historically is a sink for carbon dioxide, recent climatic trends may have changed the tundra into an overall source of carbon dioxide. After three years of study we can conclude that there exists a significant possibility that arctic tundra may now be an overall source of carbon dioxide providing a positive feedback to global warming.

Year-round Eddy-Correlation Flux Tower, Current:

In collaboration with San Diego State University Researchers a winter-time flux tower has been assembled in the Prudhoe Bay area. The tower is powered by propane thermo-electric generators and auxiliary wind generators. Extensive design work went into the adaptation of the tower to very cold winter conditions. The tower has been operational since mid-October 1996.

The year-round tower/instrumentation site will be used to determine the following:

1. Surface/atmosphere fluxes
2. Long-term greenhouse gas measurements
3. Soil active layer properties
4. Long-term permafrost change
5. Snow/ice distribution, scouring, and depths
6. Long-term meteorological data
7. Carbon cycle dynamics

Surface HEat Budget of the Arctic (SHEBA), Current:

The SHEBA study will involve low altitude aircraft measurements of surface cover and radiation parameters in the vicinity of the frozen-in SHEBA ship during two daylight periods (Apr. 20-June. 5 and Aug. 20-Sept. 10, 1998). NOAA ATDD Aircraft operations will consist of low and mid-altitude flights with flux, remote sensing and video equipment in box grid patterns over approximately 400 square km of sea ice around the ship. Additional measurement of fluxes downwind of leads will also be conducted.

International Geosphere Biosphere Program Northern Eurasian Study IGBP/NES) Program, Near-future:

The IGBP/NES study will use a NOAA ATDD aircraft to study two north-south transects in Siberia along longitudes 90 and 135 degrees. These transects have been selected to take advantage of intense temperature gradients and the transition between tundra and boreal forest. The study approach will be similar to that of the LAII program. The goal of IGBP/NES is to determine how the terrestrial carbon cycle in Siberia will be affected by global change and what feedbacks might exist. The field campaign is scheduled to begin in 1999.

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ERL/AERONOMY LABORATORY (AL) SUMMARY

The Aeronomy Laboratory's (AL) research would primarily be focused with the "Arctic haze, ozone, and UV flux" category of the Arctic Research Initiative.

The next ten years are a vulnerable time for the Arctic ozone layer. The amount of ozone-destroying chlorine and bromine in the stratosphere will be at its peak during the coming decade. The variability of the Arctic says that there is a potential for significant ozone loss occurring sometime during this period. AL research continues to focus on advancing the capability to "forecast" ozone over the coming vulnerable decade. The AL will do this in two primary ways:

- through theoretical modeling research that targets specific research issues and questions
- in 1998 and 2002, by leading efforts to provide the United Nations with international "state-of-understanding" scientific assessments of the ozone layer, emphasizing the Arctic region

Aspects of the Arctic region that are highly relevant to the Arctic Research Initiative include:

- the high variability of temperature and dynamics of the Arctic stratosphere,
- the role of temperature extremes in the formation of particles that accelerate the chlorine and bromine chemistry that destroys stratospheric ozone
- the possible influence of future volcanic activity on accelerating the chlorine/bromine chemistry that depletes Arctic ozone
- the impact of current commercial transpolar subsonic aviation on the Arctic stratosphere, and the potential for impacts from any future expansion of supersonic air travel

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ERL/PACIFIC MARINE ENVIRONMENTAL LABORATORY (PMEL) SUMMARY

The Bering Sea ecosystem is among the most productive of high-latitude seas and, as such, produces large biomasses of fish, birds, and mammals. Fish and shellfish constitute almost 10% of the world and 40% of the U.S. fisheries harvest, including pollock, salmon, halibut, and crab. Some Bering Sea fisheries, such as pollock, appear not to be over-exploited, although there have been major changes in abundance over the last 30 years. At present, the biomass of pelagic fish, consisting mostly of pollock, is 7 million metric tons (mmt) down from an early 1980s peak of 13 mmt, but above the 6 mmt level throughout most of the 1970s. Decadal variability in stocks is associated with the influence of a few strong year classes, such as 1978, 1982, and 1989. Populations of several species, however, are at near historical lows, such as king crab and Greenland turbot. We do not know the fragility of the present ecosystem in which abundance of many important species have historically varied over a wide range. Thus, the major resource of Bering Sea ecosystem is subject to both natural variability on decadal and interannual scales and vulnerability to contaminants.

NOAA's Fisheries Oceanography Coordinated Investigations (FOCI), a cooperative effort of the PMEL, the National Marine Fisheries Service (NMFS)/Alaska Fisheries Center (AFSC), and the Coastal Ocean Program (COP), is conducting research on the causes of high productivity in the Bering Sea Greenbelt, located in a region along the continental slope associated with the Bering Slope current (Figure 1). This Greenbelt has shown sustained productivity in the spring and summer and provides a clue for the location of the major pollock spawning area of the Bering Sea. The Greenbelt is fed by waters which flow along the north side of the Aleutian Islands which originate, in part, by flow from the Pacific Ocean through Amchitka Pass. Unfortunately, a quarter century after an underground nuclear blast by the United States, small amounts of radiation contaminants may be leaking into Amchitka Pass (Washington Post, October 31, 1996). As part of the NOAA Arctic Research Initiative, the University of Alaska and PMEL conducted the first major reconnaissance of the accompanying velocity, salinity and temperature fields. This data, along with satellite measurements of ocean color and sea-surface height, will elucidate mechanisms for the prolonged production. Also in 1997, PMEL and COP began a measurement program in the north Aleutian slope current to monitor the flow of water from Amchitka Pass into the Greenbelt region.

The Bering Sea ecosystem, both physical and biological, displays major natural variability. A major driver of the variability is atmospheric forcing. The Western Arctic appears particularly prone to decadal shifts. Figure 2 shows the change in sea level pressure for the period 1989-1996 minus the sea level pressure for the period 1978-1988. There was a 6 mb decrease in pressure of the Beaufort high pressure region over the Arctic in the 1990s compared to the 1980s and a 6 mb increase in pressure of the Aleutian low pressure region over the southern Bering Sea and north Pacific Ocean. A 6 mb change represents over a 1/3 weakening in these two climatological features. Winds associated with pressure gradients advect sea ice and warm and cold temperatures and effect primary productivity through changes in ocean mixed-layer depths. The weak pressure gradients between the Beaufort high and Aleutian low in the 1990s have brought colder temperatures to Alaska, greater sea-ice extent in the Bering Sea and less sea-ice extent in

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the Sea of Okhotsk, similar to the decadal period prior to 1977. It is intriguing that many biological shifts tend to occur with the changes in atmospheric regimes. The NOAA Arctic Research Initiative is pursuing the causality of such connections, which also provides a background for interpreting contaminant effects.

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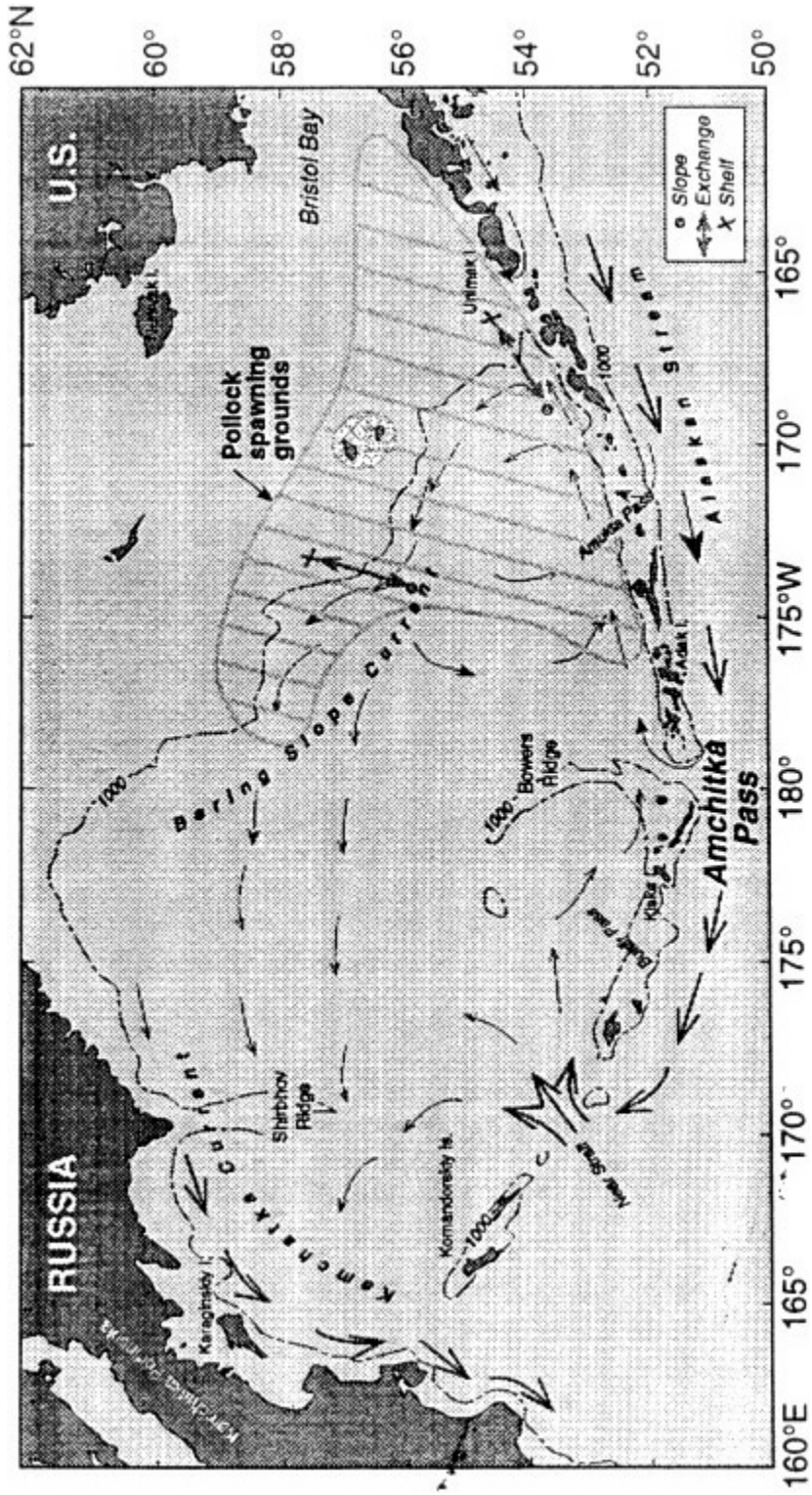

Bering Sea Circulation

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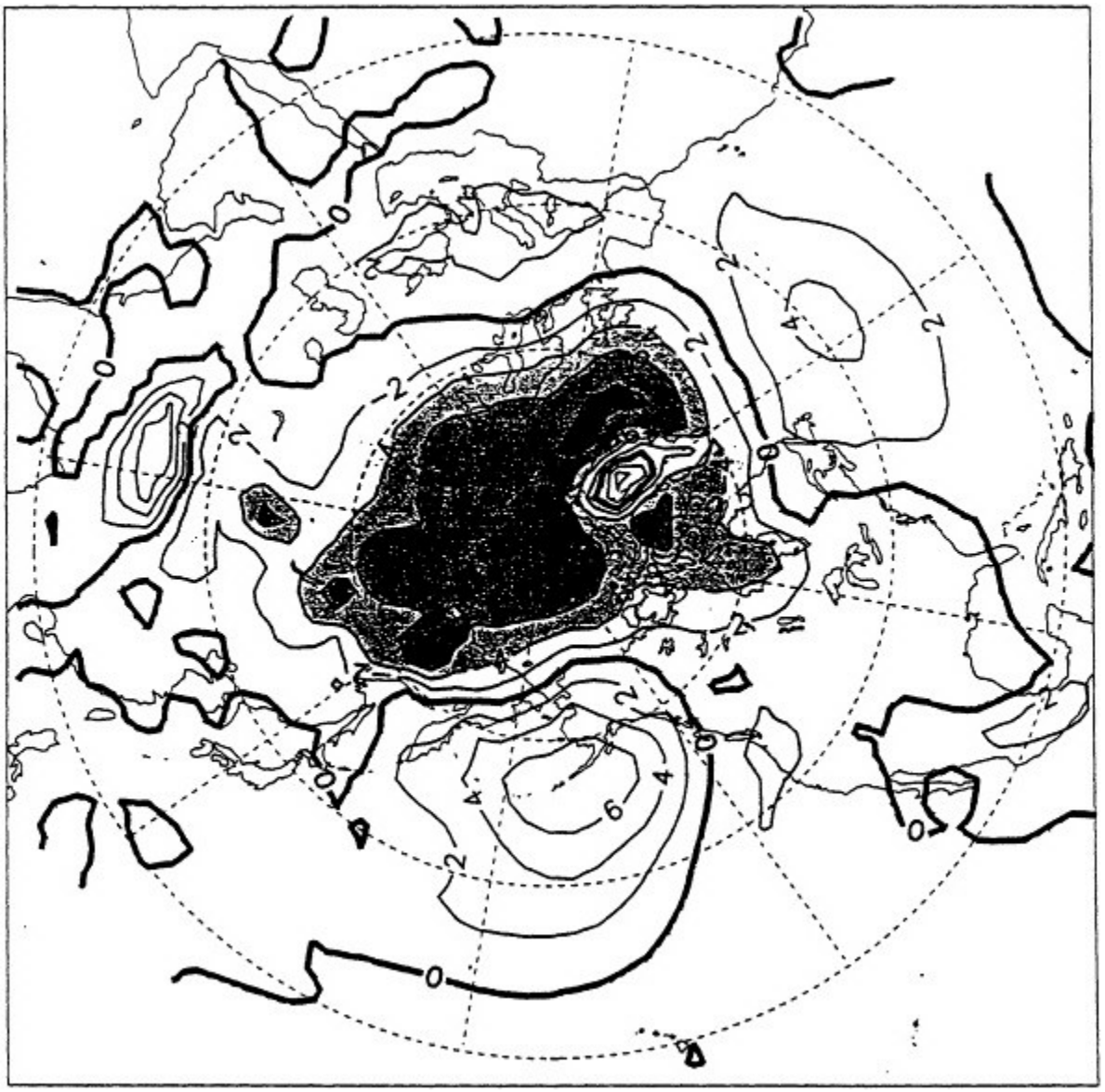

CHANGE IN MEAN JANUARY-FEBRUARY SEA LEVEL PRESSURE FOR THE YEARS (1989-1996) MINUS (1977-1988)

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ERL/CLIMATE MONITORING AND DIAGNOSTICS LABORATORY (CMDL) SUMMARY

BARROW OBSERVATORY:

The NOAA/CMDL operates one of its Baseline Observatories at Barrow, Alaska (71.3°N). Records of greenhouse gases, ozone, aerosols and solar radiation extend back to the early seventies, including continuous data on the Arctic haze phenomenon and recent episodes of Arctic ozone depletion. Recently, CMDL has linked with the DOE Atmospheric Radiation Measurement (ARM) program with the North Slope ARM site contiguous with the CMDL site and with collaboration in solar and terrestrial radiation and atmospheric aerosol research. CMDL also measures ozone from the surface and with balloons at Fairbanks in collaboration with UAF Geophysical Institute scientists.

NOAA ARCTIC RESEARCH INITIATIVE:

The NOAA/CMDL is collaborating with University of Alaska investigators (through CIFAR) in three FY1997 research programs:

(I) LONG-TERM TRENDS IN ARCTIC HAZE IN ALASKA:

Aerosol measurements at the NOAA Barrow Observatory, which are being upgraded through the ARM program, will be complemented with aerosol chemical measurements and air trajectory analyses to investigate the causes and track possible future changes in the long-term decrease in Arctic haze that has been observed at this site. In addition, by acquiring chemical information on the aerosol at three other sampling sites in Alaska, information will be derived on the geographic coverage of Arctic haze in the U.S. Arctic region; in particular, testing the working hypothesis that the Brooks Range represents a barrier to Arctic haze reaching into the central portion of Alaska. It is expected that pollution flowing into Alaska from the Orient represents a relatively small contribution in comparison to the Arctic haze transported from Eurasia. This will be investigated.

(ii) MEASUREMENTS OF THE UV RADIATION ENVIRONMENT IN THE ARCTIC

Rare and fragile life forms and the potential for excessive stratospheric ozone loss in the Arctic make the monitoring of actual variations in the biologically sensitive regions of the UV spectrum particularly important in the Alaskan Arctic. Biological effects depend on the spectral distribution, and different biological systems have markedly different action spectral responses. There is a great need to know more about the effects of UV on Arctic ecosystems. Although considerable progress has been made in predicting UV exposure for mid-latitudes, there are great limitations in predicting or modeling ground level UV in polar regions. Ground-based spectral UV measurements are, therefore, crucial for developing reliable algorithms for surface UV exposure in the Arctic from satellite data. In addition to simply measuring the integrated erythemal radiation, the UV exposure including the spectral dependence of the radiation field will

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be measured at the Barrow Observatory and correlated with ozone measurements.

(iii) CLIMATE CHANGE IN THE WESTERN ARCTIC:

In recent decades, the climate of the western Arctic has changed. This is indicated in both the temperature and the snow cover records from several high-latitude observatories in that region. At Barrow, for example, the annual accumulation of snow has diminished and the date of snow melt has apparently advanced, while temperatures have increased by about 1.4°C over the past 30 years. The goal of this study is to determine the underlying physical causes of these changes. Preliminary results show that Barrow's climate is being influenced by the transport of heat and moisture into the region from the north Pacific. Neither the decrease in snowfall, nor the non-uniform temperature trends are easily explained as the direct consequence of greenhouse warming predicted by climate models and are more likely a consequence of changing circulation.

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SUMMARY OF NOAA/NATIONAL OCEAN SERVICE PROGRAMS RELATED TO ARCTIC CONTAMINANTS

I. Environmental Quality Monitoring and Assessment Network

NOAA's National Status and Trends (NS&T) Program is designed to determine the current status of, and to detect changes in, the environmental quality of estuarine and coastal waters of the United States. The program consists of two primary components: Coastal Monitoring (includes Mussel Watch, Quality Assurance, Specimen Banking, and Historical Trends Analysis) and Bioeffects Assessment (includes Sediment Toxicity Assessment, Application of Biomarkers, Coastal Ecosystem Health Indicators, and Integrated Regional Assessments). The Mussel Watch component of the program monitors levels of contaminants at more than 240 sites nationwide. This activity has continued since 1986. Sediment toxicity assessment studies have been carried out in over 22 estuarine and coastal regions of the United States since 1991. The NS&T suite of chemical contaminants consists of chlorinated pesticides (22), polychlorinated biphenyl congeners (18), polycyclic aromatic hydrocarbons (30), trace elements (12), butyltins (3), and several ancillary parameters. In certain cases, planar PCBs, polychlorinated dibenzo-p-dioxins, and polychlorinated dibenzofurans are also analyzed. Eleven (11) Mussel Watch sites are located in Alaska along the Gulf of Alaska coast. All of them were sampled in 1995; five (5) core sites were sampled again in 1997. The core sites are near Ketchikan, Nahku Bay (near Skagway), Port Valdez (2), and Homer Spit (in lower Cook Inlet). There are no Mussel Watch sites in the Bering, Chukchi or Beaufort seas. Our current plans call for establishing five sites along the Beaufort Sea coast: Barrow, East Harrison Bay, Prodhoe Bay, off Canning Privet, and off Barter Island. Field sampling is scheduled for August 1997. No bioeffect assessment studies have been carried out in Alaska. Contingent upon the need and availability of resources, such studies may be carried out in the future.

II. Radionuclides in the Environment and Biota of the Arctic

With partial funding from the Office of Naval Research and very effective collaborative efforts with different state and Federal agencies, NOS/Office of Resources and Conservation Assessment (ORCA) has obtained and analyzed a large number of sediment and biological samples from the United States Arctic and Russian Far East. Field sampling was carried out during the 1993-95 and included collaborative work with Russian scientists. Particular emphasis was placed in collecting animals or tissues from animals that are used for subsistence, such as anadromous and marine fish, marine mammals, seabirds, and caribou. The samples were analyzed for a variety of alpha-, beta-, and gamma-ray emitting radionuclides that are long-lived and known to have environmental significance. All samples were analyzed by high-level gamma ray spectroscopy. Selected samples were also analyzed for cesium (low level beta counting and high resolution gamma ray spectroscopy) and strontium (low level beta counting of yttrium) after chemical separation purification. A number of samples were also analyzed for plutonium isotopes, americium, and polonium. Thermal Ionization Mass Spectrometry (TIMS) was used to determine the 239Pu and 240Pu atomic ratio in sediments. An important finding to date is that radionuclide activity in marine fauna has extremely low, often undetectable, 137Cs activity; only slightly higher

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values are noted for anadromous fish; relatively high values are found in caribou tissues; and 40K values are fairly uniform in all biological samples, except blubber. Even in the case of caribou tissues, measured radioactivity levels are much lower than the level of concern, or screening value for cesium in food items, 370 Bq/kg fresh weight. Assuming that all of the harvested caribou is consumed as food, a radiation dose of 0.0045 mSv per year can be calculated. This value is orders of magnitude lower than the worldwide average background radiation exposure, 2-3 mSv per year. Exposure to radionuclides in humans from consumption of marine foods should be viewed as negligible. Another important finding is that global fallout appears to be the predominant source of measured radionuclide activity in the sediment and biological samples. Seven (7) manuscripts have recently been prepared or are under preparation (as of June 1997) for publication in scientific journals.

III. Participation in the Arctic Monitoring and Assessment Programme (AMAP)

NOS/ORCA has participated in the development of various phases of the AMAP ranging from the conceptualization of the technical scope of the program in 1989 to preparation of "Arctic Pollution Issues: A State of the Arctic Environment Report" in 1997. ORCA staff had the lead role in preparing a chapter entitled "Petroleum Pollution" in the State of the Arctic Environment Report. This chapter was prepared in collaboration with Canadian, Russian, and Norwegian scientists. A 188-page summary of the report was distributed in June 1997; the full report will be published and distributed by the AMAP Secretariat at the end of summer 1997. Phase II of AMAP is to begin following a Sept-Oct, 1997 meeting when the scope of the program and priority of program elements will be discussed.

IV. Transportation and Deposition of Pesticides and Pcbs in the Arctic

NOS/ORCA scientists have been concerned about the transport and deposition of persistent organic pollutants, such as chlorinated pesticides and polychlorinated biphenyls (PCBs), in the Arctic since several such chemicals are nearly ubiquitous in the environment and some are found in biological tissues in concentrations that are orders of magnitude higher than in the surrounding media and lower trophic level animals. Scientists from Environment Canada have established a network of stations within the Arctic circle (Alert, northern Ellesmere Island; Tagish, Yukon; and Dunay, Russia) to monitor atmospheric levels of polycyclic aromatic hydrocarbons, organochlorine pesticides, and PCB congeners. Their results show that levels of these pollutants are appreciable and often comparable to levels in more populated and industrialized region of North America and Europe. No such measurements exist in the United States Arctic. Currently, the United States represents a void in the monitoring and assessment of POPs in the Arctic. Our previous proposals for such a study, which have also included measurements in sediment and biota, have not been successful primarily due to institutional constraints. However, this remains an important research element without which the occurrence of persistent organic pollutants in the Arctic ecosystem cannot be adequately explained. Successful implementation of this study will also address data requirements of the international AMAP working group and respond to the U.S.-Russia agreement on responsible stewardship of the Arctic (December 1994).

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V. Petroleum Hydrocarbons In The Arctic

Largely as a result of managing the Outer Continental Shelf Environmental Assessment Program (OCSEAP) during the 1974-92 period, and studying the Exxon Valdez oil spill, NOS/ORCA has accumulated an extensive information base and institutional capabilities that are unmatched in addressing environmental issues relating to petroleum hydrocarbons in the Arctic, including transport, fate and effects of spilled oil. Recently, we completed a review of polycyclic aromatic hydrocarbons (PAHs) in the United States Arctic with the purpose of describing their patterns of distribution and diagnosing their sources, i.e., crude oil, peat, wood or fossil fuel combustion.

VI. Scientific Review And Outreach

(a) NOS/ORCA has maintained effective liaison with the State of Alaska on matters relating to environmental contaminants for a number of years. Over the years, our field sampling in the Arctic has generally involved collaborative efforts with personnel from the North Slope Borough. Recently, ORCA provided funds to the North Slope Borough for preparing a review of data on environmental contamination in the Arctic region under the jurisdiction of the borough, providing assistance in the collection of biological tissue samples for contaminant analysis, and disseminating the resulting information to local communities.

(b) Responding to recent requests from the scientific community and residents of the US Arctic, we are proposing to convene a special session at the joint meeting of the American Society of Limnology and Oceanography and the Ecological Society of America in June 1998. This session, tentatively entitled "Arctic Contamination: An American Perspective," will focus on contaminant levels and sources, contaminant transport pathways and food chain transfers, and adverse biological effects due to environmental contamination, including assessment of ecological and human health risks, as appropriate. For comparative purposes, presentation of data from Canada, Russian Far East, and other Arctic regions will be strongly encouraged.

The above summary is for the NOAA, National Ocean Service activities that directly pertain to the study of environmental contaminants in the Arctic. It does not specifically include capabilities dealing with sea ice analyses and forecasting, data and imagery from high resolution remote sensing, and results of the United States Interagency Arctic Buoy Program that provide useful information on the meteorological conditions and patterns of contaminant transport as mediated by sea ice. Also not included are information management capabilities using desktop microcomputer systems that can produce a wide variety of products, ranging from distribution maps of different environmental parameters to CD-ROMs that can provide unified and integrated data information products derived from numerous widely dispersed sources.

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DRAFT SUMMARY OF NOAA/NATIONAL MARINE FISHERIES SERVICE PROGRAMS RELATED TO ARCTIC CONTAMINANTS

The National Marine Fisheries Service (NMFS) has several key programs contributing directed research on 1) contaminant inputs, fate and effects, and 2) the potential impacts of Arctic haze, ozone and UV flux in the Arctic ecosystem. The NMFS is developing a Centers of Expertise for Contaminants which will coordinate the contaminant programs within NMFS so that we can further our research capabilities. Recently, contaminant research in NMFS has largely focussed on fate and effects. The Alaska Fisheries Science Center research focuses on baseline data so that the impacts of atmospheric changes on ecosystem productivity. NMFS performs assessments of the current status of ecosystems as well as assessments of specific species. NMFS programs which are directly related to Arctic contaminants include the Marine Mammal Health and Stranding Response Program, programs in the Northwest Fisheries Science Center-Environmental Conservation Division, the National Marine Analytical Quality Assurance Program, and programs in the Alaska Fisheries Science Center.

These programs contribute to NMFS stewardship role for living marine resources through two of its major efforts, recovering protected species and sustaining healthy living marine resource habitat. A brief description of these programs follows.

The **Marine Mammal Health and Stranding Response Program** (MMHSRP) was established under Title IV of the Marine Mammal Protection Act as amended in 1992 in order to facilitate the collection and dissemination of reference data on health and health trends in marine mammal populations, to correlate the health of marine mammals with physical, chemical and biological environmental parameters (including contaminants), and to coordinate effective responses to unusual mortality events. The initial focus of the program has been establishing a better understanding of anthropogenic contaminant levels in marine mammals with a considerable emphasis on Alaskan species. The components of the MMHSRP are: The National Marine Mammal Tissue Bank (including the **Alaska Marine Mammal Tissue Archival Project**), the stranding network (including response to unusual mortality events), the contaminant and health biomonitoring component, the quality assurance component and a National database on strandings, health and contaminants relative to marine mammals.

The Alaska Marine Mammal Tissue Archival Project (AMMTAP) and the biomonitoring components of the MMHSRP have been active in contaminant research in the Arctic since 1987. The AMMTAP was initiated as part of the Outer Continental Shelf Environmental Assessment Program of NOAA and was funded by the Department of Interior's (DOI) Minerals Management Service. The AMMTAP was merged with the MMSHRP after 1992, and the two are managed together with funding from NMFS, the National Institute of Standards and Technology (NIST) and DOI, Biological Resources Division, US Geologic Service. In addition to this partnership, the MMHSRP has other federal, native, state and international partners. A Memorandum of Understanding regarding expansion of the contaminants program is being reviewed by the Departments of Interior and Commerce. AS of 1996, the NMMTB including AMMTAP contained tissues from 252 animals of 16 species. Of these, 192 animals are from the Arctic with the

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bowhead whale, ringed seal and beluga whale having the highest numbers. Many of these tissues have been analyzed for metals and chlorinated hydrocarbons. Analytical results from these samples have been published and are being used by management. Future activities will be focussed on understanding fate, transport and biomedical and population effects of marine contaminants and other human activities. The MMHSRP will continue to be a multi-disciplinary and integrated program.

The **National Marine Analytical Quality Assurance Program** was established in 1995 as an outgrowth of the MMHSRP, involving the collaboration of NMFS with the National Institute of Standards and Technology. The goals of the program are to assess and improve the quality of analytical measurements in the marine environment through interlaboratory comparisons and reference material development and to improve the capabilities to assess trends in marine environmental quality by expanding environmental specimen banking activities. The activities of this program are: 1) collaboration / consultation to identity quality assurance, reference materials and specimen banking related needs in marine environmental research, 2) establishment of cryogenic specimen bank facility in Charleston, 3) production of control material, proficiency testing materials and reference material that are representative of marine matrices for evaluation of the quality of analytical measurements, 4) cooperation in the preparation and certification of NIST standard reference materials for marine environmental measurements, and 5) education and training of scientists on quality assurance and specimen banking procedures. The specimen bank includes fish and sediment samples (National Status and Trends Program) and marine mammal samples (from AMMTAP-1987 and MMHSRP since 1992). Banking and quality assurance will continue to be an integral part of NMFS contaminant studies in the Arctic and nationwide.

The **Environmental Conservation Division (ECD) of the Northwest Fisheries Science Center** conducts research to define the nature and extent of chemical pollution and natural toxins (marine biotoxins) in the marine environment; their effects upon the health of living marine resources (LMRs), including protected species, and their implications for the safety and quality of seafood products. The ECD is the lead NMFS lab in the National Marine Analytical Quality Assurance Program and the MMHSRP. Because chemical pollution can affect the health and survival of LMRs as well as contaminate fisheries products, its potential impacts are of growing concern for NMFS. Studies undertaken within the ECD to address this complex problem typically follow an interdisciplinary approach. Among the scientific disciplines utilized are analytical chemistry, biochemistry, toxicology, reproductive biology, pathology, fisheries biology and immunology. One of the goals of the fishery contaminants program is to link effects observed in individual fish to potential changes at the population level. The ECD is also involved in long term studies of the effects of environmental contaminant on the survival and fecundity of protected species. Through association with the MMHSRP, the ECD has analyzed tissues from more than 20 marine mammal species for chlorinated hydrocarbons and toxic metals. These analyses are from bowhead whales, ringed seals, beluga whales, Northern fur seals, Steller sea lions and harbor seals of the Alaskan Arctic and Bering Sea. Other studies are focussed on evaluating the biological effects of contaminant exposures. For example, the ECD is collaborating with the University of Alaska, Fairbanks on the potential correlation of contaminants with health indices of Northern fur seals in the Bering Sea.

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The **Alaska Fisheries Science Center** has several programs which are either directly or indirectly involved in research related to contaminants and contaminant effects on ecosystems and special-species and in research evaluating pathways, food webs and productivity. This latter information is of importance as baseline data from which we can evaluate and model the potential impacts of Arctic haze, ozone and UV flux may have on ecosystem productivity. In addition, a better understanding of food webs and productivity will allow us to better evaluate and assess the transport and impacts of contaminants on the ecosystem. The Resource Ecology and Fisheries Management Division conducts research and data collection to support management of eastern Bering Sea fish and crab resources. The Resource Assessment and Conservation Engineering Division conducts fishery surveys to measure the distribution and abundance of important fish and crab stocks in the eastern Bering Sea and Gulf of Alaska. This research has expanded into the Fisheries Oceanography Coordinated Investigation (FOCI) program, a joint project between NMFS and the Pacific Marine Environmental Laboratory to study the biological and physical processes that control the survival and growth of fish in the Gulf of Alaska and the Bering Sea. Studies targeting groundfish, seabirds and marine mammals to understand the food chain links in production and trophic interactions are underway. Additionally, studies to understand primary production and the links to lower trophic levels and food chains are important to contaminant and arctic atmospheric research.

The **National Marine Mammal Laboratory** of the Alaska Fisheries Science Center has two programs which are related to the issues of contaminants and their impacts on populations. The Alaska Ecosystems Program is primarily responsible for advising managers on the status of Steller sea lions, northern fur seals and harbor seals. The program is charged with performing biological studies and assessments on seals and sea lions taken incidentally from fisheries interactions or directly from subsistence hunts. Information gained includes stock structure, abundance, human induced mortalities, net productivity, and life history data. The Cetacean Assessment and Ecology program has primary responsibility in monitoring the status of several Alaskan cetacean and pinniped species including bowhead, beluga, gray, killer and humpback whales, harbor porpoise and the four species of ice seals. Both of these programs are designed to monitor populations to detect trends in growth and to investigate causes for declines in populations and provide valuable biological data for assessment of the impacts of contaminants on marine mammal populations in the Arctic. Some specific studies have focussed on the levels of contaminants in declining marine mammal populations.

In summary, all of the described NMFS programs are designed to assure the quality of contaminant analyses and to increase our ability to interpret the results from a biological standpoint. In order to adequately understand the fate and impacts of these contaminants, an understanding of their biological as well as physical and environmental context and the possibilities of interactions with other stressors must be addressed. Through NMFS programs, baseline data on contaminant loads and effects and on the biology of specific species and of ecosystems will continue to contribute to studies of contaminant and atmospheric impacts in the Arctic.

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U.S. Arctic Contaminant Research Planning Workshop August 10-13, 1996 Fairbanks, Alaska

The question of what research the United States should be doing related to contaminants in the Arctic is one of considerable importance, and it has received attention in many forums. in August 1996, the Environmental Protection Agency and the Office of Naval Research sponsored a workshop, the U.S. Arctic Contaminant Research Planning Workshop, to "understand, assess, integrate, and identify critical research that significantly reduces uncertainty in future risk assessment." The workshop agenda was organized around stressors to the environment and what is know about them in the context of ecological risk assessment. The workshop included presentations on the risk assessment paradigm, radionuclides, hydrocarbons, trace metals, organics, UVB, and acidification. EPA hoped to use the outcome of the workshop to prioritize research funding. The workshop involved approximately 40 people for three days of presentations and discussions.

That EPA/ONR workshop was a broad look at Arctic contaminants, including the full range of problems and looking at the research being done by many agencies, and it attempted to suggest national research priorities. This effort was considered a good starting point from which to proceed for the July 11 workshop on NOAA's Arctic Research Initiative (i.e., can we take the priorities suggested in 1996 and identify those best suited for NOAA's Arctic Research Initiative?) One problem hindering such a refinement is that although various background materials exist from the 1996 EPA/ONR workshop, no final document or proceedings was produced from that event. Thus there are no official conclusions or recommendations.

A copy of the 1996 agenda and one item of particular importance, a series of suggested Priority Research Areas generated by the workshop participants, are included here as reference materials. Please note that the lists of priority research areas are provided here as background information only, with permission from the organizers, to give participants in today's workshop some sense of the purpose and output of the 1996 meeting.

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U.S. Arctic Contaminant Research Planning Workshop

To understand, assess, integrate, and identify critical research that significantly r*educes uncertainity in future risk assessment*

AGENDA
Wedgewood Resort, Fairbanks. Alaska
The Boardroom
August 10-13

Saturday, August 10, 1996		
8:00-10:00PM	Ice Breaker/Reception	All participants invited
Sunday, August 11, 1996		
9:00 am	Welcome	Dr. Robert Huggett, EPA Dr. Robert Edson, ONR
9:10	Agenda, Process, Outcomes	Dr. Robert Huggett
9:30	Introductions	All participants
9:45	Logistics	Ron Slotkin, EPA
10:50		Break
MAIN SESSION		
Session 1		
11:00	**Ecological Risk Assessment Presentation**	Dr. Robert Huggett
11 :45	Questions/Discussion	
12:00	Lunch	
Session 2		
1:00 pm	**Radionuclides Presentation**	Dr. John knezovich, LLNL
1:30	Questions/Moderated Discussion	• Problem Formulation • Current Level of Knowledge • Data Caps in Assessment • Assess Risk Assessment Issues • Other Related Issues • Critical Research Needed to Reduce Uncertainity
3:00	Break	
Session 3		
3:20	**Hydrocarbons Presentation**	Dr. Jawed Hameedi, NOAA
3:50	Questions/Moderated Discussion	• Problem Formulation • Current Level of Knowledge • Data Gaps in Assessment • Assess Risk Assessment Issues • Other Related issues • Critical Research Needed to Reduce Uncertainity
5:20	Open Forum/Announcements	
5:45 pm	Adjourn	

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Day 2 US Arctic Planning Workshop Agenda		
Monday, August 12, 1996		
9:00 am	Opening & Announcements	
Session 4		
9:15	**Trace Metals Presentation**	Dr. Kate Mahaffey, EPA, et al
10:00	Questions/Moderated Discussion	
		• Problem Formulation • Current Level of Knowledge • Data Gaps in Assessment • Assess Risk Assessment Issues • Other Related Issues • Critical Research Needed to Reduce Uncertainity,
10:30	Break	
11:00	Discussion continued	
12:00	Lunch	
Session 5		
1:00 pm	**Organics Presentation**	Dr. Paul Becker, NIST
1:30	Questions/Moderated Discussion	
		• Problem Formulation • Current Level of Knowledge • Data Gaps in Assessment • Assess Risk Assessment Issues • Other Related Issues • Critical Research Needed to Reduce Uncertainity
3:00	Break	
Session 6		
3:30	**UVB Presentation**	Dr: Elizabeth Weatherhead, UCB Dr, Ed Defabo, GWU
4:15	Questions/Moderated Discussion	
		• Problem Formulation • Current Level of Knowledge • Data Caps in Assessment • Assess Risk Assessment Issues • Other Related Issues • Critical Research Needed to Reduce Uncertainity
5:15	Open Forum/Announcements	
5:45 pm	Adjourn	

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Day 3 US Arctic Planning Workshop Agenda		
Tuesday, August 1:3, 1996		
9:00 am	Opening & Announcement	
Session 7		
9:15	**Acidification Presentation**	Dr. Dan Jaffe, UAF
g:45	Questions/Moderated Discussion	
		• Problem Formulation • Current Level of Knowledge • Data Gaps in Assessment • Assess Risk Assessment Issues • Other Related Issues • Critical Research Needed to Reduce Uncertainity,
10:30	Break	
11:00	Discussion continued	
12:00	Lunch	
CLOSING SESSION		
1:15 pm	**Review Session Summaries** (typed/copied)	Break out/group
2:30	**Develop and Review** **Critical Research Needs**	All participants
		• Additions • Modifications
4:00	Open Forum/Announcements	
4:15 pm	Adjourn	

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Radionuclide Priority. Research Areas

	Exposure Issue	**Ranking.**		
		I	**II**	**G**
1	Diet: Quantitative and qualitative assessment of Alaska Native and arctic indigenous diets with respect to quantity and duration of food consumed, including effects of food preparation, transport and handling methods on concentrations of contaminants.	X		X
2	Source identification: Determine past, present and future sources of radionuclides and uncertainties in source terms (e.g., location, magnitude and release rate. Local sources examined should include Amchitka Island nuclear test site, Fort Greeley and Adak.	X		
3	Transport: Consider the effects of the entire transport system (including atmospheric deposition. sediments, rivers, sea ice, coastal currents, and biological vectors) on exposure. Studies should include model development and verification, with field and laboratory studies that include chemistry and biology.	X		X
4	Exposure and dose to different tissue types. Describe physiological redistribution of contaminants at target tissues (e.g., compare bone and gonad calculations with those of muscle and liver). Use contaminant measurements in human tissue (e.g.. hair, blood) as biomarkers of exposure and effect in human populations. targeting sensitive subgroups.	X		X
5	Uptake and effect by primary, and secondary. producers.	X		
6	More accurate estimates bio-accumulation factors.	X		
7	Timing of residue measurement vs. life history considerations.		X	
	Effects Issue	**I**	**II**	**G**
1	Low level chronic exposure vs acute effects and endpoints (genetic? other?)	X		
2	Information on effects for arctic species. (There is a lack of information on these species.)	X		
3	Data rescue: Are there clearly defined biological impacts/effects from prior studies? There is a lot of data from the 1950s and 1960s on low level effects on human with no follow-up. Follow up previous ^{90}Sr and ^{137}Cs studies.	X		
4	Strategies for sampling. especially large animals and physical conditions of animals.	X		X
5	Differential effect/exposure on 1/2 lives in different systems (e.g., lichens vs forests).	X		
6	Mechanisms for end points (cellular, etc.), e.g., studies on DNA repair mechanisms.		X	
7	Synergistic effects. particularly with UVB		X	

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Hydrocarbon Priority. Research Areas

	Exposure Issue	Ranking		
		I	**II**	**G**
1	Effect of food preparation, transport and handling (e.g., engine exhaust) on contaminants.	X		X
2	Source identification: For example, PAHs in sediment from petroleum combustion, and sources of non-petroleum PAHs.	X		
3	Exposure of humans to petroleum byproducts, especially benzene.	X		
4	Effects of oil on prolonging and concentrating exposure of ice algae and epontic communities. (Understand the ecosystem.)	X		X
5	Develop and test bio-markers for exposure in the Arctic.	X		
6	Effect of temperature on body burdens. Routes and pathways of exposure to top-level carnivores.	X		
7	Effects of salinity on PAH concentration and transport (sea ice formation and melting).		X	
8	Transport models: biological, physical. and chemical effects.		X	
	Effects Issue	**I**	**II**	**G**
1	Effects of oil and gas development on (psychological) stress in individuals and society.	X		X
2	Chronic discharges of oil. Effects of lease development (spills) on subsistence living (# of spills over time).	X		
3	Effects of hydrocarbons on metabolism, osmoregulation, thermoregulation, waxy esters (oil formation), chitin (and enzymes for digestion and rates of passage of chitin). Formation of harmful metabolic byproducts. Bio accumulation/bio-magnification (sub lethal impacts, including immune responses). Chronic effects of exposure (low levels), and ecological consequences other than mortality or fecundity.	X		
4	Effects of wood burning on human health at turn of century. (epidemiolology).		X	

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Persistent Organic Pollutant Priority Research Areas

	Exposure Issue	Ranking		
		I	**II**	**G**
1	Source identification. Need further investigation of emission sources. including military bases and refineries as local sources, and byproducts of combustion such as heterocyclic compounds..	X		
2	Transport: Consider effects of the entire transport system on exposure, e.g., transport by sea ice.	X		X
3	Differences in accumulation pathways for various arctic species. For example: measure stable isotopes to determine trophic level exposures, increase food web sampling in studies, and make measurements on individual fish rather than pooled samples.	X		
4	Analyze existing data on lichens and mosses as indicators of semi-volatiles.	X		
5	Examine and apply emerging (economical) techniques for dioxins, furans, toxaphenes, and coptanar PCBs.	X		
6	Temporal dynamics: seasonal change.		X	X
	Effects Issue	**I**	**II**	**G**
1	Risk perception and risk communication. Educate populations about risks of eating certain organs relative to specific contaminants, e.g., liver and kidneys.	X		X
2	Effects (including synergistic effects) of PCBs and other persistent organic pollutants on endocrine and genetic systems of arctic mammals. (See article in 6/7/96 issue of *Science*.)	X		
3	Pathways for turnover/metabolism in different pathways develop models of transport and accumulation	X		
4	Effects of PCB's and byproducts on DNA damage.		X	

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Acidification Priority Research Areas

Exposure Issue		Ranking		
		I	**II**	**G**
1	Source identification: Evaluate local sources and deposition (Pb/Zn mines).	X		
2	Geographic distribution (deposition/local and long range mapping): acid/non acid tundra deposition; deposition of arctic haze; fail-out to open water (effects on surface layer productivity).	X		
3	Investigate exposure from sea ice release and transfer to surface water, especially in Bering Sea.	X		
	Effects Issue	**I**	**II**	**G**
1	Effects on plants of acid, NO_x, etc. — important effects of herbivore consumption/deposition. For example, decline of caribou herds around Prodhoe, Cook Inlet, etc. over past 16 years is likely caused by nutrition deficits.	X		
2	Primary productivity studies — plankton and tundra.	X		
3	Human health.	X		X
4	Effects of acidification on treeline position. Is treeline moving?		X	
5	Nitrogen metabolism in sensitive ecosystems (target aquatic ecosystems).			X

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Generic Priority Research Areas

	Exposure Issue	**Ranking**		
		I	**II**	**G**
1	Diet: Quantitative and qualitative assessment of Alaska Native and arctic indigenous diets with respect to quantity. and duration of food consumed, including effects of food preparation, transport and handling methods on concentrations of contaminants. Explore more recent approaches to dietary changes. Many other countries have developed different techniques.	X		X
2	Transport: Consider the entire transport system (including atmospheric deposition, sediments, rivers, sea ice, coastal currents, and biological vectors) on exposure. Studies should include model development and verification, with field and laboratory studies that include chemistry and biology.	X		X
3	Exposure and dose to different tissue types: Describe physiological redistribution of contaminants at target tissues (e.g., compare bone and gonad calculations with those of muscle and liver). Use contaminant measurements in human tissue (e.g., hair, blood) as biomarkers of exposure and effect in human populations. targeting sensitive subgroups.	X		X
4	Exposure effects need to be determined for humans and other arctic species.		X	X
	Effects Issue	**I**	**II**	**G**
1	Examine synergistic effects, particularly with UVB radiation.	X		X
2	Data rescue: Are there clearly defined biological impacts/effects from prior studies?.	X		X
3	Effects psychological stress in individuals and society.	X		X
4	Investigate epidemiological methods used for small populations in the Arctic.	X		X
5	Strategies for sampling, especially large animals and physical conditions of animals.	X		X

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