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**Proceedings**

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**949 E. 36<sup>th</sup> Avenue**  
**Anchorage, Alaska 99508**

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**Prepared by:**

***MBC Applied Environmental Sciences***  
**3000 Redhill Avenue**  
**Costa Mesa, California 92626**

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## PREFACE

This Information Transfer Meeting (ITM), sponsored by the Alaska OCS Region of the Minerals Management Service, is the eighth major information meeting since 1978. This ITM was focused on the lease sale areas of Cook Inlet and the Beaufort Sea. Over thirty speakers presented updates of on-going MMS-funded and other related studies over a broad spectrum of topics, including Physical Oceanography, studies of Fates and Effects of Contaminants, Interdisciplinary Studies, other Biological studies, Social and Economic studies, and studies of Protected Species

The ITM was attended by over 100 individuals representing local, state, and federal government agencies, universities, industry, the private sector, and the general public. This document includes abstracts of presentations, edited summaries of discussions as well as the agenda and a list of attendees.

**JOHN GOLL**

Regional Director  
Alaska OCS Region  
Minerals Management Service  
949 E. 36<sup>th</sup> Avenue, Anchorage, AK 99508  
(907) 271-6010 ❖ FAX (907) 271-6805 ❖ Email: John.Goll@mms.gov

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I would like to welcome all of you today. This is our 8th Information Transfer Meeting (ITM) since the Environmental Studies Program began in the late 1970s, not including several previous sale-specific Synthesis Meetings and Information Update Meetings.

The specific goals of this meeting include:

1. Transferring and exchanging openly information obtained by our Environmental Studies Program, particularly to the public and our staff,
2. Sharing information with similar study programs in other agencies,
3. Meeting with the public, our cooperators, and partner agencies to share technical information pertinent to OCS decision making and
4. Obtaining input from attendees regarding potential study topics useful to MMS decision making.

**MMS Mission and Mandates**

The MMS mission is to manage the mineral resources on the outer Continental Shelf in an environmentally sound and safe manner and to timely collect, verify, and distribute mineral revenues from federal and Indian lands.

Under the OCS Lands Act, the MMS is mandated to “preserve, protect, and develop oil and natural gas resources of the OCS in a manner that is consistent with the need a) to make such resources available to meeting the nation’s energy needs as rapidly as possible; b) to balance orderly energy development with protection of the human, marine, and coastal environments; and c) to ensure the public a fair and equitable return on the resources of the OCS. . . .”

Reasons for achieving a Regional balance include the growing dependence of our National economy on foreign oil; the importance of Alaska production, approximately 17% of US production; the growing international emphasis on environmental protection; and concerns about effects of Arctic climate change and cumulative effects.

MMS implements these mandates through: 1) the preparation of lease-sale schedule; 2) review of Development and Production Plans; 2) the preparation of Environmental Impact Statements in accordance with National Environmental Policy Act (NEPA); 3) attention to the Endangered Species Act (ESA), Marine Mammal Protection Act (MMPA), Coastal Zone Management Act (CZMA); 4) conduct of specific lease sales; 5) timely responses to industry proposals for exploration or development; and 6) regulatory and safety role of Field Operations

MMS also coordinates with other energy programs such as the Bureau of Land Management (BLM), the National Petroleum Reserve-Alaska (NPR-A), the US Army Corps of Engineers (COE), state agencies with responsibility for nearshore waters and onshore lands, local municipalities, Cook Inlet Regional Citizens Advisory Committee (CIRCAC), North Slope Borough (NSB), Native corporation leases, etc.

MMS stresses careful and participatory planning, given the long lead-times on sales, assessments, and public reviews. Conferences such as this help us achieve that balance.

## **Highlights of Current MMS Activities**

The Alaska OCS Region in January of this year released a draft EIS for the proposed Liberty Development and Production Plan. This is the first development proposed that will be completely on the Alaska OCS. If approved, this project would be under construction in 2003 and in production by the end of 2004.

The Northstar development is under construction and production is expected in late 2001. While the Northstar Island is in State waters, 6 to 7 wells will be directionally drilled into the OCS. This will be the first production from the Alaska OCS waters.

The MMS is currently preparing the Draft Proposed Outer Continental Shelf Oil and Gas Leasing Program 2003 to 2007. This will set the framework for leasing and potential development.

In conclusion, I would especially like to welcome those attending from other organizations, the public, and all the invited speakers. For the invited speakers I wish to express my thanks for your work towards making this meeting a success. We look forward to your presentations.

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## **CLEVE COWLES, PH.D.**

Chief, Environmental Studies Program  
Alaska OCS Region  
Minerals Management Service  
949 E. 36<sup>th</sup> Avenue, Anchorage, AK 99508  
(907) 271-6617 \_ FAX (907) 271-6805 \_ Email: Cleve.Cowles@mms.gov

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Good Morning, everyone. It is pleasure to see so many familiar faces again, not only of our Principal Investigators, but also those of you representing diverse groups and agencies who follow the progress of the OCS program in Alaska.

As our Regional Director, John Goll, mentioned, the purpose of this meeting is to provide an opportunity for our Environmental Assessment staff and you to become more up-to-date on the status of ongoing studies.

Now, I'd like to take a few minutes to give a brief overview of the Alaska Environmental Studies Program.

### **Goals and Objectives**

The goals and objectives of the Alaska Environmental Studies Program are to: 1) obtain information for environmental impact assessment, 2) enhance decision processes and information transfer, and 3) in the event of offshore development, to conduct monitoring of any potential environmental changes.

These goals and objectives are derived from the framework set forth in the OCS Lands Act, as amended in 1978, section 20.

Regarding item 1, our high priority information needs include information that might be needed to accomplish specific lease sale assessments, development plan reviews, or determined necessary under consultation with other agencies such as under legislation such as the Endangered Species Act (ESA) or Marine Mammal Protection Act (MMPA).

### **Major MMS Activities**



Studies we initiate are intended to provide information to key steps of decision processes related to major activities such as the Northstar Development where production will be starting soon (2001). We expect the final EIS for the Liberty Prospect (just to the east of Prudhoe Bay on the federal offshore), to be released this fall. Construction for the Liberty site is scheduled for 2002-2003. We are now in the process of preparing the draft Five Year Program for 2003 to 2007.

### **MMS Planning Process**

There are three main areas of focus in our planning process. First, we are a mission-oriented agency. We try to keep our studies defined and focused on information related specifically to the pending decisions.

Second, the MMS planning process is participatory. We seek input from more than 200 organizational entities in Alaska, including federal, state, and local agencies and government; environmental groups, industry, academia, advocacy groups, village and tribal organizations, and subsistence organizations. We also discuss our plan with the MMS Scientific Committee and our counterparts at our national headquarters.

Third, the planning process is an annual cycle that entails obtaining input, preparing drafts of proposed studies by March or April, seeking comments on the plan from stakeholders, revising and updating the plans by about June, and a final review by national headquarters. Our plans are usually developed one to two fiscal years in advance. By November, our Scientific Committee discusses the plan with us, and by January a final plan is ready for distribution. In order to stay on target for such diverse, long range activities, we must plan our studies well in advance.

Our current annual Studies Plan - Fiscal Year 2001-02 - is the plan we are implementing this year. A portion of the proposed studies in this plan are being procured as new starts this year. There are copies of this plan available for your review. We also have released a FY 2002-03 plan for which funding decisions (FY 2002) are pending.

### **Plan Implementation and Coordination**

MMS study plans are implemented via three main pathways.

One method of initiating an approved (funded) study is via direct contracting or interagency agreements for specific studies. We follow procedures for competitive bidding as outlined in the Federal Acquisition Regulations. A Technical Proposal Evaluation Committee made up of MMS scientists, and, frequently, scientists from other agencies will review bidder's capabilities and technical proposals.

We also collaborate with US Geological Survey, Biological Resources Division (BRD) (Western Region/Alaska Biological Science Center). There are a series of steps that are followed in which BRD reviews MMS study plans and biological studies profiles, and MMS reviews BRD draft implementation plans and proposals.

In addition, we have a Cooperative Agreement with the University of Alaska Fairbanks for the Coastal Marine Institute (CMI). Through the CMI, there is an annual solicitation of letters of intent for proposals on key issues, followed by full proposals. A key feature of the CMI is the collaborative selection of funded projects, done jointly by MMS, State, and University representation on the Technical Steering Committee.

Another unique feature of the CMI is that matching funds are required. Matching funds must be non-federal, thereby leveraging the federal dollar. Other in-kind resources have been utilized as well, such as logistics platforms.

Another payoff of the CMI is the educational contribution we make through these studies by providing opportunities for university students to pursue advanced degrees or other participation as part of the research.

A final means of plan implementation, in a few cases, is via what we call in-house studies, where MMS will actually perform the research itself, such as the Bowhead Whale Aerial Survey Project (BWASP).

### **On-going Program**

Our current program includes 38 studies in multiple disciplines. About 60% of those studies are cooperatively funded through programs such as CMI. About 79% of the studies are focused on the central Beaufort Sea near the development projects just mentioned. About 29 % have a “monitoring” role such as the Arctic Nearshore Impact Monitoring in Development Area (ANIMIDA) Study, BWASP, and others.

Geographically, the Beaufort and Chukchi seas region currently receives the largest funding allocation, about 86%. About 14% of our funding is allocated to region-wide or generically applicable studies. A very small amount (less than 1%) are studies for the Cook Inlet Region.

From a discipline standpoint, Protected Species studies receive 39% of the total. Fate and Effects studies and Physical Oceanography comprise about 21% of allocated funds. Multi-disciplinary studies such as ANIMIDA receive about 21%. Another important discipline is Socio-economic studies which receives about 10%, followed by Biological studies which receive about 5%.

### **Other Environmental Studies Plan Functions**

There are a number of other activities in the program that we do besides just planning and implementing studies. We sponsor Information Transfer Meetings such as this, or synthesis projects such as the preparation of reports or books that collect a larger body of information. We attempt to integrate studies in such a way that one product of a study can move into another to avoid duplication and to maximize the sharing of information between studies. We support logistics and equipment sharing among studies. A very important function is information management and retrieval. There has been over \$260 million spent on hundreds of studies in the Alaska OCS Region over the past twenty-some years. MMS maintains an Environmental Studies Program Information System or ESPIS, which is accessible on the World Wide Web. There one can do key word searches and obtain information on MMS studies.

In conclusion, our program has been quite successful over the years and part of that is due to our basic foundations and philosophy of managing the program. MMS tries to stay focused on our mission, we seek to do quality science, and we consider and respect the local communities and their role in the studies process. We are always interested in product delivery, as many of our contractors and principal investigators know. We also attempt to coordinate and cooperate with other programs as much as possible.

Substantial evidence of the intent of these foundations can be found as we listen to the presentations in the next few days. There have been many scientific accomplishments over the years. I would like to mention a few examples:

As many of you are aware, MMS recently moved into Phase II of ANIMIDA. This multidisciplinary study has recently developed some sensitive techniques capable of detecting very low levels of hydrocarbons and trace metal contamination.

A CMI study recently conducted by the University of Alaska Fairbanks has provided the first continuous measurements of under-ice currents in the coastal Beaufort Sea waters less than 40 meters in depth.

A four-year study of bowhead whale feeding in the eastern Beaufort Sea will be completed this year, within which local input has been very instrumental. From this study we will have a much improved understanding of the use of the eastern Beaufort Sea by bowhead whales.

Similarly, a multi-year study by the Alaska Dept. of Fish and Game, one of our cooperative studies, of the social consequences of the Alaska OCS activities is near completion.

Recent efforts by the Biological Resources Division of the USGS for censusing polar bears dens using remote techniques are showing increased promise. These findings may be useful in mitigating a variety of potential disturbances to this important species.

Before I conclude, I would like to once again welcome one and all. Also I would like to thank Tim Holder, Geraldine Taylor, Dick Newman all of MMS, and MBC Applied Environmental Sciences for all of their excellent support in organizing and conducting the meeting. I would also like to add a special welcome to Dr. Scott Goldsmith and Dr. Will Schroeder, who are attending as representatives of the MMS Scientific Committee, and to Dr. Rodney Cluck from our headquarters office.

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### **VERA ALEXANDER, PH.D.**

Director, Coastal Marine Institute  
School of Fisheries and Ocean Sciences  
University of Alaska, Fairbanks, AK 99775  
(907) 474-6824 · FAX (907) 474-7386 ❖ Email: vera@sfos.uaf.edu

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The Coastal Marine Institute (CMI) at the University of Alaska Fairbanks (UAF) exists under a cooperative agreement between the Minerals Management Service (MMS) and the University. The Center supports research projects which are of interest to the MMS in support of offshore oil and gas exploration and development, but which also are of interest to the University and to the State of Alaska. Under this cooperative arrangement the University is required to match the \$1 million which the MMS contributes with a one-to-one contribution from non-federal sources. This provides for significant financial leverage.

Management of the Institute is under a technical steering committee, which is composed of two representatives from MMS, two from the University and two from the State of Alaska (appointed by the Governor). Recently, a non-voting member has been added from the Alaska Science and Technology

Foundation, although that is not included in the Cooperative Agreement. The Technical Steering Committee establishes the areas for proposal solicitation in the form of framework issues, and conducts the evaluation of pre-proposals and final proposals. The administrative support for the Institute lies within the School of Fisheries and Ocean Sciences, and the Dean of the School serves as its Director. A small staff manages the day to day business. The Institute is now in its 8th Award Cycle, and will soon be approaching its decadal anniversary. Currently there are nineteen projects underway.

A brief description of the current projects was presented. These include arctic work on ringed seals and on Beaufort Sea currents, circulation and structure, an Alaska Sea Ice Atlas, on two Beaufort and Chukchi Sea climate states, and satellite tracking of beluga whales. There is also work on hydrocarbon desorption, microbial hydrocarbon degradation, and the role of zooplankton in hydrocarbon distribution. Much of the work is conducted off the north coast of Alaska, although there are several projects in the Cook Inlet and Kodiak area.

Physical oceanography is receiving 72% of the support, with chemical oceanography and marine biology at 3% and 19% respectively. Graduate student involvement has been an important component of most projects. Matching comes from a number of sources, which include State agencies, the Alaska Science and Technology Foundation, British Petroleum Exploration, Cominco Alaska, the Japanese Marine Science and Technology Center, other universities, the Canadian Coast Guard and various units of the University of Alaska, among others. This brings many parties into the work of the Institute. Further details can be found at the CMI web page at <http://www.sfos.uaf.edu/cmi/>.

# PHYSICAL OCEANOGRAPHIC AND METEOROLOGICAL STUDIES

## BEAUFORT SEA NEARSHORE UNDER-ICE CURRENTS: SCIENCE, ANALYSIS, AND LOGISTICS

Thomas J. Weingartner, Ph.D.

Institute of Marine Science, University of Alaska  
Fairbanks, AK 99775-1080  
(907) 474-7993 ❖ FAX (907) 474-7204 ❖ Email: weingart@ims.alaska.edu

The purpose of this study was to measure under-ice currents and water property parameters useful in evaluating oil-spill risks and sedimentation processes in the nearshore environment of Prudhoe Bay. We collected hourly estimates of velocity, temperature, salinity, and transmissivity (a proxy for suspended sediment load) for one year (Sept. 1999 – Sept. 2000) within the landfast ice zone of Stefansson Sound. The measurements were made from three instrumented moorings deployed at sites up to 40 km apart. There are two seasonal circulation regimes that are defined by the presence or absence of the landfast ice. In the absence of ice, the nearshore currents are highly correlated with the local winds, often very strong ( $50 - 100 \text{ cm s}^{-1}$ ) and strongly sheared in the vertical. Once the landfast ice is established, the flow is uncorrelated with the winds, very weak (typically current speeds are  $5 \text{ cm s}^{-1}$ ), and with little vertical shear. Current speeds seldom exceed  $20 \text{ cm s}^{-1}$  under the landfast ice. In all seasons the current field is highly coherent over the 40-km range of the measurements. The suspended sediment load is also seasonal, with high turbidity in the open water season when currents are strong and low turbidity beneath the ice. However, there was a large three-week turbidity event in early June, before the landfast ice broke up and when the currents were weak. The exact cause of this event is uncertain, but we believe it is related to the under-ice spread of Sagavanirktok River water, which reaches its peak discharge in mid-June on average.

### Discussion:

A question was asked about the depth at which the current meters are deployed. Dr. Weingartner explained they are between 7 and 8 m on the bottom, though they may be one meter above the bottom. Dr. Eschenbach pointed out to Dr. Weingartner that bottom scouring from strudel holes could lead to the observed turbidity, as observed at Northstar. Dr. Weingartner inquired about detecting strudel scours, and Dr. Eschenbach explained you can do bottom and aerial surveys. However, bottom features tend to persist until a major storm levels everything out, so there can be large numbers of relict scours. There is additional data from satellite imagery to map the boundaries of the overflight, but that data will not show individual holes. Strudel hole data are available for the last three years from the Liberty Project, and some data are contained in MMS reports. Dr. Kelly asked if there are seal holes where river water drains, and Dr. Weingartner did not know.

Dr. Will Schroeder asked if anyone has looked at biological turbidity, such as plankton blooms or swarms of animals, particularly in spring. Dr. Weingartner explained that during the last year of monitoring, they will add fluorometry measurements. Algal mats can fall from the underside of ice in a matter of days. Dr. Alexander added that the only comprehensive work on blooms was done by Hornisch, and she found that algae dropped from the ice and formed bloom that lasted longer than a few days. In the marginal ice zone, material goes to the bottom quickly, but this may not be the case in the arctic. Dr. Ken Dunton (University of Texas at Austin) will be doing some more work in the Boulder Patch, and he will be using PAR sensors. Dr. Schroeder reiterated that their focus was/is current measurements. Dr. Andrey Proshutinsky asked about tidal and wind components. Dr. Weingartner explained there is a tidal component (about 2-3 cm/s). And while wind appears to be a factor, sometimes the currents are opposite the wind

direction. Lastly, a question was asked if there was significant biofouling on the instrument packages—Dr. Weingartner said there was not.

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## **CIRCULATION, THERMOHALINE STRUCTURE, AND CROSS-SHELF TRANSPORT IN THE ALASKAN BEAUFORT SEA**

Thomas J. Weingartner, Ph.D.

Institute of Marine Science, University of Alaska  
Fairbanks, AK 99775-1080  
(907) 474-7993 ❖ FAX (907) 474-7204 ❖ Email: weingart@ims.alaska.edu

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The objectives of this program are to provide a kinematical and dynamical description of the circulation and temperature/salinity fields along the Beaufort Sea shelfbreak and slope. The observations will be useful in model evaluation and development. We deployed 6 current meter moorings along the Beaufort continental slope between Barrow and the Mackenzie shelf between August 1999 and October 1999. The mooring data are supplemented with temperature and salinity data collected from a U.S. Navy submarine throughout the mooring array in April 1999. The measurements were made to determine: 1) the mean transport and the vertical and cross-shore scales of the mean flow field, 2) the magnitude of the flow variations and the associated temporal and spatial scales, 3) the relationship between variations in temperature and salinity and variations in the flow field, and 4) how these variations are related to the regional wind field. All of these characteristics can be easily compared with numerical model results.

The along-slope scales of spatial variability are ~20 km and possibly reflect the effects of flow interacting with bottom topography. The along-slope flow field is weakly eastward on average at a few  $\text{cm/s}^{-1}$ , but highly variable; current speeds range from  $40 \text{ cm/s}^{-1}$  eastward to  $30 \text{ cm/s}^{-1}$  westward on synoptic and seasonal time scales. The current variations were uncorrelated with the local wind field and horizontally incoherent over an along-slope distance of 200 km. Eastward currents (between 150 and 250 m depth) were strongest from October through March when westward winds were strongest. Atlantic Water predominates at about 150 m depth along the Alaskan Beaufort slope while fresher, colder upper halocline water occurs at this depth along the Mackenzie Beaufort slope. The reason for these differences is not known but there are several implications that this might have for the Alaskan Beaufort shelf.

Discussion:

A question was asked about the eddies. Dr. Weingartner explained slope flow was not correlated with the wind field. Dr. Jia Wang pointed out these observations are very similar to his modeling work that will be presented later.

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## **SYNTHESIS AND COLLECTION OF METEOROLOGICAL DATA IN THE NEARSHORE BEAUFORT SEA**

Brian Hoefler, P.E.

Hoefler Consulting Group  
701 Sesame Street Suite 200, Anchorage, AK 99503  
(907) 563-2137 ❖ FAX (907) 563-2164 ❖ E-mail: bhoefler@hoeflernet.com

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The goals of this study are to collect new meteorological data from the deployment of meteorological stations and to collect historical meteorological data from the Beaufort Sea locations that could be subject to immediate development. Four new meteorological monitoring stations have been installed and became operational on January 1, 2001. These new stations are located at Badami, Endicott, Northstar, and Milne Point. The observed parameters are wind speed, wind direction, air temperature, barometric pressure, relative humidity, and solar radiation. Water temperature will be observed during the ice-free season. All parameters are monitored continuously. Collected data is processed and downloaded every working day to an Anchorage-based server. The data are then scanned for obvious errors and posted to a web site that is available for public access. The web site address is [www.resdat.com/mms/](http://www.resdat.com/mms/). A quality assurance/quality control (QA/QC) review of the data is conducted quarterly. The QA/QC data is also posted to the web site. Analysis of the data are also performed quarterly and posted to the web site.

Discussion:

Mr. Tim Holder asked if high wind speeds caused failure of the Endicott wind generator and Mr. Hoefler said presumably, but the instruments have dampening mechanisms. When asked by Dr. Weingartner what the power demands are for the towers and instruments, Mr. Hoefler replied about 2.5 amps, though the cellular phone draws 5 or 6 amps. Dr. Tom Weingartner asked if Hoefler's platforms are available for ancillary instrumentation, such as a PAR sensor. Mr. Hoefler said he is willing to discuss that request. Dr. Jia Wang asked where the station locations are, and Mr. Hoefler presented a map with the locations of Badami, Endicott, Northstar, and Milne Point. Dr. Andrey Proshutinsky asked about the duration of the project. Mr. Hoefler explained the contract is for two years, but Mr. Warren Horowitz added there is a strong possibility that after two years, MMS will reassess the program and possibly add stations. Mr. Hoefler clarified the project is logistically difficult, especially with no service roads to the east, and it is not an inexpensive project to operate. Getting everything up and running is the largest expense. When asked about frosting problems by Ms. Anne Jensen, Mr. Hoefler stated the instruments have bearing heaters to keep the instruments warm. Still, frosting could pose problems. When asked about hoar frost on the solar radiation meters, Mr. Hoefler said that has not been an issue.

Data are available at <http://www.resdat.com/mms/>

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## **BEAUFORT AND CHUKCHI SEA SEASONAL VARIABILITY FOR TWO ARCTIC CLIMATE STATES**

Andrey Proshutinsky, Ph.D.

Woods Hole Oceanographic Institution  
360 Woods Hole Road, MS 29, Woods Hole, MA 02543  
(508) 289-2796 ❖ FAX (508)457-2181 ❖ Email: [pandrey@whoi.edu](mailto:pandrey@whoi.edu)

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There is a significant lack of data for the environmental parameters in the Beaufort and Chukchi seas. Our goal is to use coupled ice-ocean models and available data for reconstruction of oceanic, atmospheric, and ice characteristics for the anticyclonic (1946-1952, 1958-1962, 1972-1979, 1984-1988, 1998-present) and cyclonic (1953-1957, 1963-1971, 1980-1983, 1989-1997) climate states. Analyses of observational data and results of numerical experiments reveal significant differences in atmospheric, ice, and oceanic parameters during these two arctic climate regimes. During anticyclonic circulation regime, "winter" conditions with a cold and dry atmosphere, increased ice thickness and ice concentration, and a saltier and colder upper ocean water prevail during seasonal cycle.

Both wind and water density gradients maintain winter and summer anticyclonic ice drift and surface currents during years with the anticyclonic circulation regime.

During cyclonic circulation regime, "summer" conditions dominate with a relatively warm and wet atmosphere, and a fresher and warmer upper ocean than during anticyclonic regime. During cyclonic circulation regime wind and thermohaline circulation act in opposition because winds tend to be more cyclonic, and resulting circulation is weaker than during anticyclonic climate state or it becomes cyclonic.

As a result of the dynamic-thermodynamic processes, we expect that the rate of land-shelf and shelf-basin interactions (transport of ice, fresh water, sediments, and pollutants) is increased during the cyclonic circulation regime and decreased during the anticyclonic climate state.

Based on analysis of simulated storm surges we conclude that our models under estimate (about 30%) of the observed sea level rise during storm surges. Detailed studies show that this is a result of under-estimation of the atmospheric pressure gradients in the polar cyclones in the NCEP/NCAR sea level pressure reanalysis data. Studies of the storm-related processes will be carried out during 2001 in order to obtain statistics of sea level variability and coastal erosion rates for the anticyclonic and cyclonic circulation regimes in the Beaufort and Chukchi Seas.

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Discussion:

Dr. Jia Wang wondered if only a seven millibar difference between the cyclonic and anticyclonic regimes reflects anomalous behavior of climatology. Dr. Proshutinsky explained they have not looked at wind-driven circulation.

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## **ALASKA SEA ICE ATLAS**

Orson Smith, Ph.D., P.E.<sup>1</sup> and William Lee<sup>2</sup>

<sup>1</sup>University of Alaska Anchorage, School of Engineering, Dept. of Civil Engineering  
3211 Providence Dr., Anchorage, AK 99508  
(907) 786-1910 ❖ FAX (907) 786-1079 ❖ E-mail: afops@uaa.alaska.edu

<sup>2</sup>University of Alaska Anchorage, School of Engineering, Dept. of Geomatics  
3211 Providence Dr., Anchorage, AK 99508  
(907) 786-1106 ❖ FAX (907) 786-1079 ❖ E-mail: aswj13@uaa.alaska.edu

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The GIS-based Alaska Sea Ice Atlas is being compiled with a view toward risk assessment for navigation and mineral developments in ice-covered continental shelf waters of Alaska. The Atlas will include a comprehensive collection of georeferenced digital historical data on Alaska sea ice conditions and other environmental factors that bear on ice processes, updating previously printed ice atlases. Historical weekly average ice reports of the National Ice Center, from 1972 to 2000, form the foundation of the database of ice conditions. National Weather Service ice reports and other ice information are applied to refine ice descriptions and to compile related regional climatological summaries. Areas of uniform ice concentration, stage, and form are portrayed as polygons and superimposed on a 5-km-square grid. Grid cell statistics over the period of record for each week of the calendar year include distribution parameters, reported extremes, and combined probabilities of concentration, stage, and related atmospheric variables. Hindcast wind stress divergence is applied as an analog of ice compression and ridge formation. These statistics allow derivation of a navigability index for assessing difficulties in navigating ice-covered waters in various classes of vessels.

The Alaska Sea Ice Atlas will incorporate tools for user-defined analysis and mapping of sea ice effects on ships and fixed structures. These products will be delivered via a customized implementation of GIS tools at a public web site.

Discussion:

Mr. Warren Horowitz asked about the possibility of having one day of training so that people who are interested in using this database can learn how to use it, and Dr. Smith replied that could be done, and on-line help is critical. When Dr. Frank Bercha asked which GIS software Dr. Smith was using, Dr. Smith said they are currently using ArcInfo, though ArcIMS for Windows 2000 will soon be available. Dr. Bercha then asked if they had considered adding some high-level overlays which would provide probability of exceedance of ice loads, or linking up to a voyage simulator. Dr. Smith explained ice forces are not in the reports, though the closest derived parameter they intend to provide is the compression index. Dr. Smith has looked at modeling North Sea navigability, but it is beyond the scope of the current project. A parallel project is beginning now with CRREL and UAA looking at mobility indices.

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## **FATE AND EFFECTS STUDIES**

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### **REVISION OF THE OCS OIL WEATHERING MODEL: PHASES II AND III**

Mark Reed

SINTEF Applied Chemistry  
Environmental Engineering  
S.P. Andersonsvei 15B, Trondheim, Norway N7465

The purpose of this study is to provide and augment information needed to support development of environmental risk assessments, Environmental Impact Statements, review of contingency plans, and oil-spill response for offshore gas and oil leasing.

The MMS OCS Oil-Weathering Model (OWM) is a heavily used tool in the environmental assessment process for MMS. In the Alaska OCS Region, numerous estimates of oil-spill fate and behavior are derived from the OWM. The model provides analysts with a common, quantitative set of spill scenarios. The OWM is used to estimate whether State and Federal water quality standards and criteria would be exceeded by a spill, over what area, and for how long. The model calculates the area covered by a slick through time and the persistence of a slick. The model calculates how long the lighter, but most toxic components remain in the oil slick. The model is used to distinguish the effects of larger and smaller spills, for example between the effects of an average tanker spill versus an average pipeline spill. The in situ viscosity and degree of emulsification provided by the model are used in assessing the mitigation by and effectiveness of oil spill countermeasures such as mechanical recovery, dispersants, and in situ burning.

In the Gulf of Mexico Region, the OWM is more frequently used in environmental assessments to evaluate oil-spill contingency plans and the reliability of associated oil-spill models. The OWM is critical to the latter evaluation because, unlike most oil-spill models, the OWM incorporates specific chemistry of individual crudes.

SINTEF Applied Chemistry completed the Phase I review "Revision of MMS Offshore Continental Shelf Oil-Weathering Model: Evaluation," OCS Study MMS 98-0031 for MMS.

The objectives of Phases II and III of this study are: 1) to adapt the SINTEF Oil Weathering Model (OWM) to MMS needs, 2) to expand the OWM oil library to include oils of interest to MMS, and 3) to develop and collate data sets identified in Phase I from experimental oil spills for validation testing of algorithms and weathering models.

Discussion:

A question was asked about how prevalent the high-paraffin content oil (Norne) is, and if other fields are producing similar oils. Dr. Reed stated this oil shows up world-wide, but that he did not know how common it really is. Also, there are oils with less wax, say 5%, but after evaporation they may end up being 7% to 9% wax. Dr. Cleve Cowles asked if autocorrelation in the variables posed any problems in the final weathering model. Dr. Reed explained that the autocorrelation is accounted for in the multivariate analysis. Mr. John Brown asked if there were any correlations between metal concentrations and weathering behavior, to which Dr. Reed replied metals appear to play a role in the stability of emulsions. One theory is that the metals, waxes, and the asphaltines tend to collect around interfaces, thereby stabilizing the interface between the oil and the water droplets in the emulsion. Mr. Brown asked if this is apparent in parts per billion concentrations. Dr. Reed explained that in the multivariate analysis they do come out as a significant variable.

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## **KINETICS AND MECHANISMS OF SLOW PAH DESORPTION FROM LOWER COOK INLET AND BEAUFORT SEA SEDIMENTS**

John A. Terschak and Susan M. Henrichs

School of Fisheries and Ocean Sciences, University of Alaska Fairbanks  
P.O. Box 757220, Fairbanks, AK 99775-7220  
(907) 474-7807, ❖ FAX (907) 474-7204 ❖ E-mail ftjat@uaf.edu, henrichs@ims.uaf.edu

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Adsorption to sediment particles is a key process in determining the transport and fate of PAH (polycyclic aromatic hydrocarbon) contaminants in the marine environment. Previous Coastal Marine Institute-funded studies of lower Cook Inlet sediments have shown that some adsorbed PAH are not desorbed when sediments are suspended in clean seawater. Hence, adsorption could contribute to the persistence of PAH contamination of marine sediments. We are studying the rates of adsorption and desorption of the PAH phenanthrene in order to understand these processes and, thus, be able to predict how they will influence the environmental behavior of PAH. A variety of humic acids, components of sediment organic



matter, were synthesized in the laboratory and extracted from marine sediments collected from the Beaufort Sea, Lower Cook Inlet, and Port Valdez. The proportion of aromatic structural units (aromaticity) and the initial PAH concentration were measured for each synthetic and natural humic substance. The humic substances were coated on a standard clay mineral for use in the adsorption studies. The natural humic acids adsorbed more phenanthrene than the laboratory-prepared humic acids. Neither the aromaticity of the humic materials nor their initial PAH content explained the variations in adsorption among the different humic acids. The concentration of phenanthrene did not influence the extent of adsorption, indicating that all adsorption sites of a given material were approximately equivalent. The presence of a limited number of very strong adsorption sites did not appear to explain the incomplete desorption of phenanthrene. Adsorption was at steady state after a reaction time of one week, up to reaction times of 30 days or more, indicating that slow diffusion was probably not the major reason for incomplete desorption of PAH from sediment particles.

Discussion:

Dr. Mark Reed inquired about the uncertainty associated with the measurements. Dr. Henrichs explained measurements were made in triplicate. In one of the plots, the error bars overlap. However, the range of the error bars is similar to the range between the three means, with an error of about 20%. Dr. Reed said it is hard to discern if there is a trend or not, and error bars would help visually. Dr. Henrichs added that error bars would be in the final report, but for this presentation, error bars make it difficult to view the figure.

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## **PETROLEUM HYDROCARBON DEGRADING MICROBIAL COMMUNITIES IN BEAUFORT SEA SEDIMENTS**

Joan Braddock, Ph.D.<sup>1</sup> and Kathleen Gannon<sup>2</sup>

<sup>1</sup>Institute of Arctic Biology and Department of Biology and Wildlife  
University of Alaska Fairbanks, Fairbanks, AK 99775  
(907) 474-7991 ❖ FAX (907) 474-6967 ❖ E-mail: ffjfb@uaf.edu

<sup>2</sup>Institute of Arctic Biology and Department of Biology and Wildlife  
University of Alaska Fairbanks, Fairbanks, AK 99775  
(907) 474-6601 ❖ FAX (907) 474-6967 ❖ E-mail: ak-penguin@gci.net

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There have been no published studies on hydrocarbon degrading populations and activities of microorganisms in Beaufort Sea sediment since the 1970s when oil reserves were first developed. In samples collected in 1999 and 2000, we enumerated populations of total bacteria, viable heterotrophs, and hexadecane (a linear alkane) and phenanthrene (a polycyclic aromatic hydrocarbon) degraders in Chukchi and Beaufort Sea sediments. In addition, we used radiorespirometry to measure mineralization potentials for phenanthrene and hexadecane, and examined the partition coefficients,  $K_p$ , for phenanthrene in sediments with different physical and chemical properties. We found that even though the total bacterial counts were relatively similar between the Chukchi and Beaufort Seas, all of the other microbial populations measured were significantly higher in the Beaufort Sea around Prudhoe Bay than they were in the Chukchi Sea around Barrow. Despite the location, mineralization potentials for both hexadecane and phenanthrene were low with hexadecane exhibiting slightly higher potentials at most locations. These results indicate that the populations present are not acclimated to use of these hydrocarbons. As expected, we found the partition coefficients for phenanthrene increased as the organic carbon content of the sediment increased, but for the organic poor sediments, other properties of the sediment also affected adsorption. These data provide a useful monitor of the populations of microorganisms occurring in these sediments as oil development has progressed since the 1970's. The study also provides information that will help assess the fate and effects of petroleum hydrocarbons in this environment if a spill were to occur.

### Discussion:

Mr. John Brown asked about the bioavailability of hydrocarbons present in Prudhoe Bay sediments compared with sediments from Shelikof Strait or *Exxon Valdez* Oil Spill studies. Dr. Braddock explained that in Cook Inlet sediments, adding sediment particles almost always led to a 50% or 75% reduction in the utilization of phenanthrene. This was not looked at specifically at Prince William Sound; however, they did use a cut-off of  $10^4$  oil degraders as an indicator of a hydrocarbon-polluted site. Interestingly enough, the sites around Prudhoe Bay, likely for different reasons, had populations approaching  $10^3$  oil degraders per gram of sediment, which in Prince William Sound would be considered a polluted site. Dr. Braddock clarified that she did not mean to imply that the Prudhoe site was contaminated. Mr. Don Hansen asked if natural oil seeps have been sampled. Dr. Braddock said she would like to, but it has been logistically difficult getting to those sites. Also, anecdotal information is available on natural oil seeps, but there has been some difficulty thus far finding out exactly where these sites are. Mr. Hansen added one location along the coast near Kaktovik was pointed out in an Outer Continental Shelf Environmental Assessment Program (OCSEAP) publication in conjunction with a study done by Dr. Paul Becker. Dr. Braddock said the most accessible areas she could find were terrestrial areas. It was also mentioned by Dr. Becker that these sites may have changed drastically since the OCSEAP work was reported.

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## **A NOWCAST/FORECAST MODEL FOR THE BEAUFORT SEA ICE-OCEAN- OIL SPILL SYSTEM (NFM-BSIOS)**

Jia Wang, Ph.D. and Meibing Jin, Ph.D.

International Arctic Research Center-Frontier and Institute of Marine Science  
University of Alaska Fairbanks, Fairbanks, AK 99775  
(907) 474-2685 ❖ Email: jwang@iarc.uaf.edu

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This MMS/CMI sponsored project was kicked off last May. We first started with the large-scale (27 km resolution) coupled ice-ocean model in the pan Arctic-North Atlantic Ocean, because this model will provide the boundary conditions

to the NFM-BSIOS with 3 km resolution that is eddy-resolving. Therefore, the correctly simulated large-scale circulation is a necessary condition to a possibly successful implementation of the NFM-BSIOS. Nevertheless, it does not promise the small-scale model taken granted if the nested numerical schemes are not physically sound and not accurate.

With boundary conditions (surface elevation, 2D-averaged velocities, 3D velocities, and T and S, presented by a switch with 1 being on and 0 being off) provided by the pan Arctic-North Atlantic Ocean model, we conducted a series of tests of nested schemes and came out with the following three being our candidates: 1) 1111, 2) 0111, and 3) 1000. Test 1 means we prescribed all the boundary conditions. Test 2 prescribed all the boundary conditions except for surface elevation. Test 3 only prescribed the surface elevation. All three cases can produce the Beaufort Sea coastal current (10-20 cm/s) along the slope and mesoscale eddies. This eastward coastal current was observed by current meter mooring in the region conducted by Weingartner (MMS project). However, test 2 seems to be the best because it produced less noise along the boundaries, compared to the two others. Physically, we found that test 1 over-specified the boundary conditions with no degree of freedom for the model to adjust, while test 3 only specified the surface elevation and therefore, the boundary conditions were under-specified with no volume transport conservation. Only test 2 can conserve the volume transport and allow surface elevation to radiate out of the model.

Based on the experiments on the nested schemes, we came out with the following criteria. The optimal nested scheme must comply with the conservation of volume transport and must allow fast waves and noises/computation errors to freely leave (radiate out of) the model domain. The next step is to simulate the ocean circulation and sea ice flow in the 3 km-grid domain using the optimal nested scheme for both ocean and sea ice. Then, a trajectory model (Wang 2001) will be applied to the same region. The model results will be validated using the observations in the region.

#### Reference

Wang, J., 2001. A nowcast/forecast system for the coastal ocean circulation using simple nudging data assimilation. J. Atmos. Oceanic Technol., 18(6): 1037-1047.

#### Discussion:

Ms. Pam Miller suggested that for presentation purposes, it would be helpful to present geographical names on maps to better orient the audience.

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## AN EXPERIMENTAL INVESTIGATION OF THE ROLE OF ZOOPLANKTON IN THE DISTRIBUTION OF HYDROCARBONS

Thomas C. Shirley, Ph.D. and Switgard Duesterloh

Juneau Center, School of Fisheries & Ocean Sciences, University of Alaska Fairbanks  
11120 Glacier Highway, Juneau, AK 99801

(907) 465-6449 ❖ FAX: (907) 465-6447 ❖ Email: Tom.Shirley@uaf.edu and ftsd@aurora.alaska.edu

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The role of zooplankton in distributing polyaromatic hydrocarbons (PAH) and the effects of PAH on copepod reproduction are poorly known. Copepods may contribute to the distribution of PAH in three ways: 1) through the food chain, 2) through sedimentation of carcasses and feces laden with PAH, and 3) through incorporation in reproductive tissue and delayed release of eggs. Due to their seasonally high biomass, the copepods *Neocalanus*, *Calanus*, and *Pseudocalanus* are important prey for various fish and birds. Bioaccumulation of oil by plankton is expected to vary with lipid content and size of the organism; this correlation will be tested with a series of experiments in 2001. Development of a method to expose live plankton to a constant concentration of sublethal doses of the water soluble fraction of oil over an extended period of time was a major accomplishment of the first year of the project.

Two aspects of the ongoing research are highlighted in our presentation: "Reproduction of copepods in culture experiments" and "Effects of photoenhanced toxicity of oil on copepods." In summer, 2000 a study to determine the variability in egg production of *Pseudocalanus* spp. and *Calanus marshallae* was conducted. The experiments revealed

two distinctly different reproductive strategies by the two species. However, low female abundance in the study area and high variability in egg production rates precluded a comparison between oiled and unoled specimens.

New evidence suggests increased oil toxicity to copepods in the presence of ultraviolet radiation. In preliminary experiments, both increased mortality and impairment of mobility were observed in low dose oil exposures followed by exposure to ambient daylight. These effects may alter hydrocarbon distribution by copepods via changes in the proportion of lethal and sublethal effects on the population. Increased mortality may increase the proportion of oil being transported to the benthos by sedimentation of corpses, but alternately, may decrease oiled prey availability for fish that depend on these resources for early life stage survival.

## **INTERDISCIPLINARY AND OTHER STUDIES**

### **ARCTIC NEARSHORE IMPACT MONITORING IN DEVELOPMENT AREA (ANIMIDA) PROGRAM: A MULTI-YEAR MONITORING PROGRAM IN THE NEARSHORE BEAUFORT SEA**

John Brown<sup>1</sup>, Paul Boehm<sup>2</sup>, and Linda Cook<sup>1</sup>

<sup>1</sup>Arthur D. Little

20 Acorn Park, Cambridge, MA 02140

(617) 498-5387 ❖ FAX (617) 498-7296 ❖ E-mail: brown.john@adlittle.com

<sup>2</sup>Battelle Ocean Sciences, Duxbury, MA 02332

Offshore oil and gas development and production activities have been initiated at Northstar Island and are planned for the coming years at the Liberty prospect site in the nearshore Beaufort Sea. There is concern about the long-term effects of these developments, as well as, the long-term effects of any development associated with future offshore lease sales. Historical data in the region have been collected over several decades. Nevertheless, the sensitivity of the region adjacent to Northstar and Liberty, and the highly variable and complex environmental conditions, make further monitoring necessary. In response to interagency reviews of related environmental impact statements (EISs) and development and production plans, the U.S. Department of Interior, Minerals Management Service (MMS) initiated the ANIMIDA Program as a long-term study for monitoring potential impacts of the Northstar and Liberty developments. ANIMIDA Phase I was started in June 1999 and included hydrocarbon and metals chemistry measurements in sediment and tissue samples, as well as acoustic measurements adjacent to the Northstar and Liberty sites. Phase II of the ANIMIDA Program was initiated in July 2000 and incorporates seven tasks including hydrocarbon and metal chemistry studies, suspended sediment studies, an assessment of subsistence whaling at Cross Island, biota contaminant assessment, and a study of the "boulder patch" area.

Discussion:

Mr. Tom Brower asked what the scope of Task 4 was going to be. Mr. Brown replied Michael Galginaitis has permission to go to Cross Island to get more information on how whaling there affects Nuiqsut, but the study will not extend to Barrow or Kaktovik. Mr. Brower was surprised that some aspects of this study were not done in Phase I, to which Mr. Brown replied this is the beauty of this study, it allows for annual changes. Mr. Paul Stang asked what changes have been made to the program as a result of Liberty delays. Mr. Brown explained delays with Liberty have allowed for more design changes. For example, some Liberty sediment chemistry stations have been relocated to Northstar. Dr. Cleve Cowles added the delays gave people more time to get things together.

### **ANIMIDA: HYDROCARBON CHEMISTRY OF SEDIMENTS AND BIOTA IN THE NEARSHORE BEAUFORT SEA**

John Brown<sup>1</sup>, Paul Boehm<sup>2</sup>, and Linda Cook<sup>1</sup>

<sup>1</sup>Arthur D. Little, 20 Acorn Park  
Cambridge, MA 02140

(617) 498-5387 ❖ FAX (617) 498-7296 ❖ E-mail: brown.john@adlittle.com

<sup>2</sup>Battelle Ocean Sciences, Duxbury, MA 02332

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Hydrocarbon chemistry is one component of the multidisciplinary MMS ANIMIDA Program. The hydrocarbon chemistry study has focused on sediments and biota (clams and amphipods) from the nearshore Beaufort Sea. During the 1999 and 2000 summer field seasons, sediments and biota were collected from stations throughout the study area, including site-specific stations adjacent to the Northstar and Liberty prospects. The samples were analyzed for a full suite of hydrocarbons which are useful in determining petroleum contamination, including: saturated hydrocarbons, polynuclear aromatic hydrocarbons (PAH), and chemical biomarkers (steranes and triterpanes). The hydrocarbon data will be used to develop a database that can identify potential trends and inputs of petroleum contamination in the region and the development areas. The 1999 hydrocarbon data serve as an important pre-development baseline for the Northstar and Liberty area. The 1999 results reveal that the area sediments generally contain low levels of naturally occurring background hydrocarbons, consistent with historical data from 1989 and earlier Beaufort Sea Monitoring Programs. However, there are two stations where small increases in petroleum hydrocarbons, likely due to anthropogenic inputs, were identified in the 1999 data set. In addition, the hydrocarbon data can be compared to sediment quality guidelines to gain a preliminary assessment of potential adverse effects to biota. No exceedances of petroleum hydrocarbon sediment quality guidelines have been noted thus far.

#### Discussion:

A question was asked if identified geochemical biomarkers from oil sources and source rocks versus triterpanes from river sediments produced a small signal from the development versus natural sources. Mr. Brown replied they did not have access to source rocks (drill cuttings), which tend to be contaminated with other drilling fluids. They have collected field oils, but that is beyond the scope of this project.

Mr. Craig Nicolson asked about the scale on the different plots presented. Mr. Brown explained the plots are not on the same scale. Crude oil is naphthalene-enriched, and it is important to look at relative abundances. Dr. Joan Braddock asked what weathered North Slope crude would look like. Mr. Brown said it would lose the light components (naphthalenes), then fluorenes, phenanthrenes, dibenzothiophenes, and chrysenes. Dr. Braddock then wondered how you could distinguish weathered versus terrigenous material. Mr. Brown suggested looking at biomarkers.

Dr. Paul Stang asked if each field could be identified, and how accurately stations are located. Mr. Brown explained some fields could be identified, but field oils change with time. Stations were sited using GPS, not differential GPS, so accuracy is 20 to 50 m. There is also some hit-or-miss patchiness with the data (e.g., outlier Station 5D).

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## **ANIMIDA: AMBIENT AND INDUSTRIAL NOISE MEASUREMENTS NEAR THE NORTHSTAR AND LIBERTY SITES DURING APRIL 2000**

G. W. Shepard<sup>1</sup>, P.A. Krumhansl<sup>2</sup>, M.L. Knack<sup>3</sup>, and C. I. Malme<sup>4</sup>

BBN Technologies, 70 Fawcett St., Cambridge, MA 02138

<sup>1</sup>(617) 873-3593 ❖ FAX (617) 547-8918 ❖ E-mail: gshep@bbn.com

<sup>2</sup>(617) 873-4158 ❖ FAX (617) 547-8918 ❖ E-mail: pkrumhansl@bbn.com

<sup>3</sup>(617) 873-3560 ❖ FAX (617) 547-8918 ❖ E-mail: mlknack@bbn.com

<sup>4</sup>Charles I. Malme Engineering and Scientific Services

25 Rockwood Rd., Hingham, MA 02043

(781)749-1661 ❖ FAX (617) 547-8918 ❖ E-mail: cimalme@worldnet.att.net

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As part of the Minerals Management Service (MMS) program entitled "Arctic Nearshore Impact Monitoring in the Development Area," a winter field survey was conducted from 25 April to 30 April, 2000. Measurements of site-specific underwater noise, in-air noise, and ice vibrations were made at eight locations near and between the Northstar and Liberty prospects. Both prospects are located in the nearshore portion of the outer continental shelf in the Beaufort Sea near Prudhoe, Alaska.

The goal of this effort was to characterize noise and vibration conditions near the Northstar site which was under construction and near the Liberty site which is planned for development in the near future.

Analysis results are presented that document the underwater noise at two water depths, the airborne noise conditions, and the ice vibration levels at ranges varying from 0.15 km to >4 km from Northstar. The results present measured levels caused by construction activities at Northstar including sheet pile driving using a vibrahammer, plowing operations, general truck movement on and near the island, island mounted machinery generated noise, and trench backfilling operations.

Similar measurements were made at and near the Liberty site which document the conditions with minimal, if any, man-made noise present.

### Discussion:

Dr. Scott Goldsmith asked if, based on these results, he is comfortable with standard models. Mr. Shepard explained acoustic propagation is site-dependent and depends on local conditions. A model needs to be validated at the site. Dr. Goldsmith also wondered if permafrost is a big problem. Mr. Goldsmith said permafrost and water column depth are important variables. Dr. Will Schroeder asked if the model could be validated. Mr. Shepard stated you would have to characterize the variability expected in the environment, and if it is too varied, you could not do it. Mr. Warren Horowitz asked if radial measurements were taken all around the developments, and Mr. Shepard said that they were not able to do all of the radials, it was too expensive. Mr. Shepard went on to describe how complex it is to do modeling in the arctic, because it is so site-dependent.

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## **ANIMIDA: TRACE METALS IN THE ANIMIDA STUDY AREA**

John H. Trefry, Robert P. Trocine, and Robert D. Rember

Department of Marine & Environmental Systems, Florida Institute of Technology

Melbourne, FL 32901

(321) 674-7305 ❖ FAX (321) 674-7212 ❖ E-mail: jtrefry@fit.edu

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Our component of the ANIMIDA program is quite diverse and includes the following areas of investigation: (1) Distribution of trace metals in sediments, biota, water, and suspended particles from water and sea ice, (2) Concentrations of organic carbon and values for stable carbon isotopes in bottom and suspended sediment, and (3) Concentrations of suspended sediment and turbidity throughout the study area including under ice and in open water after a storm event. The

evolving data base and interpretation are most developed for trace metals in sediments and this topic will be the focus of our presentation. Sediments were collected from throughout the study area during 1986, 1989, 1999 and 2000 and analyzed for total concentrations of seventeen metals including barium, cadmium, lead and mercury. These data have been used to develop a procedure for identifying natural concentrations of metals in area sediments and thereby enabling us to recognize sediments that have been contaminated from anthropogenic inputs of metals. Overall, the area is relatively pristine with respect to metal contamination in sediments; however, we can easily discern minor barium contamination in Harrison Bay for sediments collected during 1989 and minor anthropogenic loadings of cadmium, lead and mercury near West Dock for sediments collected during 1999. When the sediment data are cross referenced with various sediment quality guidelines, we can make a preliminary assessment of potential adverse biological effects; none are predicted from metals at this time. The real power of the data base and the approach for identifying metal contamination is that we now have a useful tool for carefully monitoring area sediments in the future.

Discussion:

A question was asked if tracking year-to-year changes is complicated by spatial variability, and if there would be an advantage to re-navigating to the same site and taking replicates during the same year or period to try to get three truly independent samples that are representative of variability due to navigation. Dr. Trefry said that explaining what is going on everywhere in the ANIMIDA area is virtually impossible, so taking samples throughout the area and using the normalization technique should help with interpretation of results. Since the water column is well-mixed, analysis of suspended sediments is a way to look at things on a very fine scale. Dr. Will Schroeder asked how critical clay species are, and if Dr. Trefry has an archive set for analyses thus far. Dr. Trefry has archived wet and cold samples for clay mineralogy, and some analysis will be done on trace metals. Dr. Trefry is assuming the suite of clays coming in over a period of years is similar from year to year. Dr. Scott Goldsmith asked for some clarification on ERL (Effects Range Low) and ERM (Effects Range Median) levels. Dr. Trefry defined these levels, explaining how they attempt to relate the potential for biological effects with chemical and toxicity data. If several elements are present at concentrations above the ERL the effects are compounded versus having just one element above the ERL. These ranges should be used as indicators in conjunction with other measurements.

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## **ALTERNATIVE OIL SPILL INDICATORS FOR THE BEAUFORT AND CHUKCHI SEAS OCS - FAULT TREE APPROACH**

Frank G. Bercha, Ph.D., P.E.

Bercha International, Inc.  
2926 Parkdale Blvd., NW, Calgary, Alberta, Canada T2N 3S9  
(403) 270-2221 ❖ FAX (403) 270-2014 ❖ E-mail: [berchaf@berchagroup.com](mailto:berchaf@berchagroup.com)

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This paper focuses on the approaches and preliminary results from the application of fault trees to the estimation of oil spill indicators associated with future exploration and production activities in the Beaufort and Chukchi Seas Offshore Continental Shelf (OCS). Because no significant empirical history exists for such operations, and leases have not been developed and in some cases still remain to be sold, methods predicting the behavior of systems without history need to be applied. The most feasible method for the current application is believed to be the fault tree method, a probabilistic network method perfected by the U.S. Regulatory Commission in the late 1960s and early 1970s for the prediction of risks associated with civilian nuclear reactor power plants. In the current application, a two-step fault tree approach will be made. First, based on the most relevant historical data for offshore oil spills (such as the Gulf offshore and Alaska onshore data), fault trees emulating these data to as great a level of detail as is available in terms of causal factors will be constructed and populated with available historical values. We call these the baseline fault trees. Second, scenarios based on conceptual engineering for the future offshore developments will be formulated and corresponding fault trees will be constructed in a form directly comparable with the baseline fault trees. The input data for these future scenario fault trees will be restricted to the lowest levels of causal events, and will be based either on comparative historical values (e.g., offshore and onshore blowouts) or on direct inputs based on probabilities developed elsewhere (such as scour probabilities for given water/burial depth locations). Finally, these future scenario fault trees thus evaluated will be used to generate predictions of oil spills for the future offshore facilities for different locations and water depths. This presentation will focus on subsea pipelines, and cover the preliminary baseline spill data identified, baseline fault trees, future scenarios developed for shallow,

medium, and deep water locations, and the future scenario fault trees and sample results. Both the qualitative and quantitative details should be viewed as only illustrative of the approach due to the current early stage of this project.

Discussion:

Mr. Tom Bucceri asked if Dr. Bercha's estimates tie-in favorably to MMS estimates for oil spills. Dr. Bercha replied this was an illustrative example, but as far as he can see, the spills per barrel produced are similar, realizing this is only one component of a whole system.

Mr. James Craig noticed the primary component on Dr. Bercha's diagram was the third party problem related to oil spills and wondered if that was from the Gulf of Mexico. Dr. Bercha clarified that the biggest component was actually the corrosion and defect problem. Furthermore, some of these areas are hard to quantify. Mr. Craig commented third party problems don't seem applicable to the Beaufort Sea, where there are relatively few pipelines and there is less confusion overall. Mr. Craig asked what kind of methodology was employed to produce subjective reliability probabilities. Dr. Bercha agreed with Mr. Craig's observations, and explained he reduced third party effects on pipelines by 50%, but realistically it could be reduced more. No scour was included in baseline data, but there is now since scour data is readily available. Corrosion and defect problems are the main cause at over 50% of the attributable failure cases. These will all be looked at with time, but at this point baseline data are not in appropriate shape yet.

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## **INITIAL WORK ON A STATISTICAL APPROACH TO OIL SPILL OCCURRENCE ESTIMATES FOR THE BEAUFORT/CHUKCHI SEA OCS**

Ted Eschenbach, Ph.D., P.E.

TGE Consulting

4376 Rendezvous Circle, Anchorage, AK 99504

(907) 333-7817 ❖ FAX (907) 337-2928 ❖ Email: [matbach@alaska.net](mailto:matbach@alaska.net)

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As this project is still in an early phase, this presentation will describe the problem being addressed, but it will not present the final model or results. When estimating the probability of an event, such as an oil spill, the statistically ideal case is that there is a large data set gathered under the same environmental conditions and with the same operating techniques.

As there has been no OCS production in the Beaufort and Chukchi Seas, there is no direct data. Thus, the existing MMS approach for estimating the risk of a large oil-spill (> 1,000 bbl) relies on data from operations in the OCS areas of the Gulf of Mexico and California. Fortunately, from 1964-92 there is not a large data set, rather there are 10 platform and 12 pipeline spills (Anderson and Labelle 1994). Especially for pipeline spills, the observed causes come from different environmental conditions than in the Alaskan OCS areas. Anchor, trawl, and hurricane damage are the three leading causes. However, marine traffic, trawl fishing, and hurricanes are not significant hazards in the Beaufort and Chukchi seas. New hazards include moving pack ice, ice keel gouging, and strudel scours. In addition over 40 years of operation, there have been continuing efforts to reduce the chance of spills through better materials, design, monitoring, and operations.

In addition to data from other OCS areas, there is over 20 years of data on North Slope operations (Hart Crowser 2000). While onshore, it is an arctic environment, and the operators and regulators are similar to that expected for the OCS areas. In addition there has been significant work on estimating the risk for near-shore operations with buried marine pipelines for the Northstar and Liberty projects (for example MMS Alaska OCS Region 2001). There is also data from other areas of the world.

The expected result of this work is a spill risk per barrel of oil produced or per well-drilled and per pipeline-mile-year. In either case, the result can be used for estimating the risk for spills in the OCS areas of the Beaufort and Chukchi Seas.

References:

Anderson, Cheryl McMahon, and Robert P. LaBelle. 1994. Comparative Occurrence Rates for Offshore Oil Spills. *Spill Science & Technology Bulletin* 1(2):131-141.



Hart Crowser Inc. 2000. Estimation of Oil Spill Risk from Alaska North Slope, Trans-Alaska Pipeline, and Arctic Canada Oil Spill Data Sets. MMS 2000-007.  
MMS Alaska OCS Region. 2001. Liberty Development and Production Plan: Draft Environmental Impact Statement, Volumes I – III. MMS 20001-001.

Discussion:

Dr. Dick Prentki clarified that MMS identified one oil spill which was not in the Hart Crowser report, and that is why numbers between the two do not match. Dr. Eschenbach added there are some discrepancies on numbers of spills between MMS and trend analysis numbers from LaBelle and Anderson. He is working on discriminating between old data and new data. Mr. John Goll explained that Anderson and LaBelle looked at discrete time segments to see if there was a change, and that is why their numbers changed. Mr. Goll asked if they will be looking at buried pipelines versus surface pipelines and pigging. Dr. Eschenbach affirmed they would look at those factors, and explained pigging allows you to watch pipelines age. Mr. Goll stated many of the Gulf of Mexico pipelines cannot be pigged.

## BIOLOGICAL STUDIES

### FEEDING ECOLOGY OF MATURING SOCKEYE SALMON (*ONCORHYNCHUS NERKA*) IN NEARSHORE WATERS OF THE KODIAK ARCHIPELAGO

Albert Tyler<sup>1</sup>, Charles Swanton<sup>2</sup> and Bruce McIntosh<sup>3</sup>

<sup>1</sup> University of Alaska Fairbanks, School of Fisheries and Ocean Sciences  
P.O.B. 757220, Fairbanks, AK 99775  
(907) 474-6732 ❖ E-mail: ffavt@uaf.edu

<sup>2</sup> Alaska Department of Fish and Game, 1300 College Road, Fairbanks, AK 99701  
(907) 459-7225 ❖ E-mail: charles\_swanton@fishgame.state.ak.us

<sup>3</sup> University of Alaska Fairbanks, School of Fisheries and Ocean Sciences  
P.O.B. 757220, Fairbanks, AK 99775  
(907) 474-7594 ❖ E-mail: fsbcm1@uaf.edu

Of the five species of Pacific salmon commercially harvested in Kodiak Archipelago waters sockeye salmon (*Oncorhynchus nerka*) landings accounted for approximately 65% (\$137,320,000) of the total ex-vessel value for salmon in the Kodiak area during the period 1994 to 2000. The North Shelikof Strait lease area, adjacent to Kodiak waters, is important for maturing sockeye salmon of Kodiak origin, as well as from other regions. Prevailing currents in lower Cook Inlet and Shelikof Strait potentially extend impacts from oil and gas development throughout the inshore areas of the Kodiak Archipelago and the eastern Alaska Peninsula. Perturbations from human activities can increase metabolic demands, decrease prey diversity and reduce prey abundance, adversely affecting the growth and available energy stores of pre-spawning fish. Evaluation of the food web dynamics and feeding habits of maturing salmon are necessary to understand potential ingestion pathways for hydrocarbon contamination, especially in areas swept by currents from potential oil exploration and drilling.

During 1998 and 1999 the stomach contents of commercially caught sockeye salmon, migrating through the nearshore marine waters of the Kodiak Archipelago, were examined to determine the level of feeding activity in the population and the taxa of dominant prey items. Representative samples were collected throughout the majority of the migration (early June to late August) from areas known to be principally migration corridors, and from areas proximate to several natal streams. Feeding levels and dominant prey varied both among areas and within areas over time. Higher percentages of actively feeding sockeye and greater stomach content weights were associated with increasing distance from natal streams. Feeding activity diminished gradually, rather than ceasing abruptly, as sockeye prepared to re-enter freshwater. The dominant prey of sockeye salmon were decapod larvae, Pacific sandlance (*Ammodytes hexapterus*), and the pteropod *Limacina helicina*. Diminished feeding activity and smaller meal size suggests that local stocks of sockeye would be at

lower risk of contamination via ingestion than non-local stocks occupying the same area.

Discussion:

Mr. Tom Brower asked if there was any consideration on taking liver and fatty tissue samples on the sockeye and chinook or just stomachs. Mr. McIntosh explained the study was limited to stomach contents, from the esophagus to the start of the intestines. One could look at other organs, though. However, most processing plants today use mechanical evisceration. But at the plant where Mr. McIntosh's salmon came from, everything is still done by hand so it was possible to obtain the samples.

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## **SEABIRD SAMPLES AS RESOURCES FOR MARINE ENVIRONMENTAL ASSESSMENT**

Deborah A. Rocque<sup>1</sup> and Kevin Winker<sup>2</sup>

University of Alaska Museum

907 Yukon Drive, Fairbanks, AK 99775-6960

<sup>1</sup> (907) 474-6727 ❖ FAX (907) 474-5469 ❖ E-mail [ftdar@uaf.edu](mailto:ftdar@uaf.edu)

<sup>2</sup> (907) 474-7027 ❖ FAX (907) 474-5469 ❖ E-mail [ffksw@uaf.edu](mailto:ffksw@uaf.edu)

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The Arctic marine ecosystem is one of the most productive in the world. Monitoring the long-term impact of climate change, fishing, and pollution on the health of marine ecosystems is often logistically and financially unrealistic. However, sentinel species can be used to assess the marine environment. The variety of trophic positions and marine systems that seabirds occupy as a group makes them ideal environmental monitors. As top predators, seabirds can be used to monitor perturbations in lower trophic levels. Species that specialize on single prey species are potentially more sensitive indicator species and can be used to monitor the health of specific food webs.

Assessing long-term trends in the marine environment requires historical samples. Environmental trace metals and stable isotopes are incorporated into feather keratin during growth and then remain inert. Elements bound in these feathers can be used in retrospective studies to document changes in contaminant concentrations and, in the case of stable isotopes, changes in diet or food web structure.

Recognizing the need for long-term data in assessing changes in marine ecosystems, the University of Alaska Museum received support from MMS and the Coastal Marine Institute to archive seabird specimens. Seabird studies are the main source of donated specimens, but by-catch from long-line fisheries has also provided many salvaged birds. In an attempt to anticipate future capabilities and needs for seabird specimens, the museum is archiving as much of the bird as practical. Presently, we are filling growing requests for tissues and feathers by fellow researchers. The increasing number of studies depositing samples at the museum demonstrates the success of this project. We anticipate the continued growth and use of this resource as the need to assess human impact on the marine environment continues.

Discussion:

Dr. Cleve Cowles asked if the present project is linked to the previous project MMS had with the museum, which was to develop an electronic database for frozen tissues oriented towards mammals. Dr. Rocque said Dr. Gordon Jarrell will cover that project later, but presently this database is not. Dr. Joel Hubbard asked if Dr. Rocque could explain the geographical and taxonomical extent of the collection. Dr. Rocque stated CMI wants them to concentrate on bird/seabird samples from the North Slope area or the Bering Sea. However, they never turn away birds that people bring in. Over half of the collection is salvaged specimens, whether they are window kills or bycatch from longline fisheries. The majority of the seabird specimens are coming in from the Aleutian Islands and the Bering Sea. Taxonomically there are a lot of murre, kittiwakes, and different gull species, and it usually depends on what researchers are studying at any given time. We are actively collecting cormorants for a contaminants study. These specimens are being loaned to a fellow researcher who is attempting to describe a new species.

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## **ALASKA MARINE MAMMAL TISSUE ARCHIVAL PROJECT**

Paul R. Becker, Ph.D.<sup>1</sup> and Geoff W. York<sup>2</sup>

<sup>1</sup>NIST, 219 Fort Johnson Road, Charleston, SC 29412  
(843) 762-8503 ❖ FAX (843) 762-8724 ❖ E-mail: paul.becker@nist.gov  
<sup>2</sup>USGS Biological Resources Division, Alaska Biological Science Center  
1011 E. Tudor Road, Anchorage, AK 99503-6199  
(907) 786-3928 ❖ FAX (907) 786-3636 ❖ E-mail: geoff\_york@usgs.gov

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The Alaska Marine Mammal Tissue Archival Project (AMMTAP) began in 1987 as an MMS funded project of the Outer Continental Shelf Environmental Assessment Program (OCSEAP). Presently, USGS/BRD, NMFS, and NIST are the principal federal partners conducting this project in collaboration with numerous State and local organizations. The goal of the AMMTAP is to archive a representative collection of Alaska marine mammal tissues for retrospective chemical analyses and documentation of long-term trends in environmental quality. These tissues are archived in the National Marine Mammal Tissue Bank (NMMTB) at NIST. The NMMTB presently holds 1,000 duplicate samples collected from animals in Alaska, primarily during Alaska Native subsistence hunts. The majority of these samples are from ringed seals, belugas, bowhead whales, and polar bears; however, other species are also represented. Aliquots of some of the archived samples have been analyzed for persistent organic pollutants, metals, and nutrients. These data have contributed to several marine mammal studies and to the Arctic Monitoring and Assessment Programme (AMAP). An offshoot of the AMMTAP is the Seabird Tissue Archival and Monitoring Project (STAMP) which is conducted by USGS/BRD, USFWS, and NIST. This project is presently collecting egg samples from murre colonies in the Alaska Maritime NWR for archival and contaminant analyses. Aliquots of these egg samples are presently being analyzed for persistent organic pollutants in a study on the geographical patterns of these compounds in the murre colonies of the refuge. In addition to specimen banking, NIST conducts an analytical quality assurance (QA) program specifically designed for marine mammal research. The AMMTAP is an important partner in this QA program. Recent results from the AMMTAP and STAMP are presented and the marine mammal analytical QA program is briefly reviewed.

#### Discussion:

Dr. Joel Hubbard referred to a slide presenting contaminant data on common murre eggs from St. Lazaria Island, near Sitka, where there were higher concentrations of PCBs and DDEs than murre eggs from two colonies in the Bering Sea (Little Diomedea and St. George Island). Dr. Hubbard asked if this is correlated with the cruise ship industry. Dr. Becker did not know, stating that the results are preliminary. Dr. Becker also clarified that the levels of PCBs and DDEs are similar to what is seen in ringed seal blubber, so the levels are not relatively high. Emergence of patterns such as these is a good reason to expand studies to other colonies in the Gulf. Mr. Steve Treacy asked if Dr. Becker could summarize heavy metal analyses, and where they are headed with the PAH and PAH metabolite analyses. Dr. Becker listed barium and vanadium, but they need to find out what some of the constituents of the new drilling fluids are. All samples are available for PAH analysis, but they don't do that. Contractors wishing to do PAH analyses are welcome to use samples that are already homogenized. Mr. Bud Rice inquired about sample sizes necessary for persistent organic pollutants and heavy metal analyses. Dr. Becker explained the typical size sample in the archive is 300 grams, though seabird eggs average 80 grams. For organic analyses, 6 grams is required for replicated analyses for PCBs and pesticides, and for heavy metals using ICP/MS, you could probably get away with 3 grams. Large sample volumes were collected so there would be materials available for a long period of time.

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## **THE ALASKA FROZEN TISSUE COLLECTION: A RESOURCE FOR BIOTECHNOLOGY**

Joseph A. Cook, Ph.D.<sup>1</sup> and Gordon H. Jarrell, Ph.D.<sup>2</sup>

University of Alaska Museum  
907 Yukon Drive, University of Alaska Fairbanks, Fairbanks, AK 99775-6960  
<sup>1</sup>(208) 282-3765 ❖ FAX (208) 282-4570 ❖ E-mail: cookjose@isu.edu  
<sup>2</sup>(907) 474-6946 ❖ FAX (907) 474-5469 ❖ E-mail: fnghj@uaf.edu

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The Alaska Frozen Tissue Collection (AFTC) has become the primary regional archive for frozen zoological samples and a major contributor to regional biotechnology studies under six years of CMI/MMS sponsorship. The collection now contains over 30,000 samples from mammals and is the official repository for marine mammal specimens from two Alaska Native commissions for the co-management of marine mammals.

The online database has been upgraded to a full enterprise system using the Oracle database engine on a Sun server. This means that essentially all specimen data is available to World Wide Web clients. The database model is being expanded to include the Museum's plant, insect, bird, and fish collections. Migration of data from these additional collections is underway and we will probably incorporate about one collection per year over the next three years. In addition, the database model can be extended to include environmental samples that have not been taxonomically described; e.g., "unsorted lots" such as oceanographic samples, soil samples, etc.

The AFTC played a signal role in attracting National Science Foundation support for the Museum's new (July 2000) Arctic Archival Observatory, an initiative to archive environmental samples for future and ongoing work primarily related to global warming. This grant is now supporting extension of the database, the development of an insect collection, and increased sampling effort in several existing collections. The Museum is now seeking to establish a separate, new, tenure-track position for a Curator of the AFTC.

Discussion:

A question was asked if when this database reaches out across the web and touches another database, for example to get a publication citation, the people who make the publication database need to be contacted. Dr. Jarrell replied no, those publications are in the database. Someone asked if when someone looks at these web pages, if all this information is controlled in some way. Dr. Jarrell affirmed at that point they are controlling all the information. The only parameter outside of their system is latitude/longitude, which is sent to the XEROX PARC map viewer. But from there, you can click back to their web site.

## **SOCIAL AND ECONOMIC STUDIES**

### **SOCIOCULTURAL CONSEQUENCES OF ALASKA OCS ACTIVITIES - DATA ANALYSIS AND INTEGRATION**

James A. Fall, Ph.D.

Division of Subsistence, Alaska Department of Fish and Game  
333 Raspberry Road, Anchorage, AK 99518  
(907) 267-2359 ❖ FAX (907) 267-2450 ❖ E-mail: jim\_fall@fishgame.state.ak.us

The primary goals of this project were to analyze and integrate subsistence, economic, and sociocultural data from two previous cooperative agreements between ADF&G and MMS regarding sociocultural and socioeconomic consequences of the Exxon Valdez oil spill (EVOS), and to collect new ethnographic information about cultural continuity and change in communities of the EVOS area. Five ethnographic reports were produced, focusing on Nanwalek/Port Graham (lower Cook Inlet), Ouzinkie/Old Harbor (Kodiak Island Borough), Chenega Bay/Tatitlek (Prince William Sound), Cordova, and Valdez. In collaboration with the communities of Nanwalek, Port Graham, Tatitlek, and Chenega Bay, a series of oral histories was developed and combined with maps, photographs, and other texts into an interactive, multi-media program in a CD-ROM format, called a "Jukebox."

The final report is a comprehensive, comparative analysis drawing upon the project's quantitative and qualitative information. It acknowledges the disparate claims that arose about the spill's effects on human communities that contribute to alternative social constructions of the meaning of the event and in turn shape responses to it. It also details changes after the EVOS to subsistence harvests and the cash sector of local economies. The litigation that followed the spill is described, as is the role of the EVOS Trustee Council in directing restoration efforts.

The report concludes that the EVOS was a determinant event for the Alutiiq that elaborated and accelerated sociocultural, economic, and sociopolitical trends. Alutiiq communities adapted to the EVOS in ways that protected family members and preserved traditional cultural elements of the communities' way of life. Households reduced wild food harvests because of food safety uncertainties but limited harvests were channeled to those families most in need.

Subsistence harvests rebounded during the second or third years after the spill, although harvesters reported scarcities of resources and consequent greater effort to achieve harvests. Initially, while subsistence harvests declined, cash incomes rose due to cleanup employment, indicating flexibility and short-term adjustments by households between sectors of the local economy. After settlement of civil claims against Exxon by the state and federal governments, \$900 million became available for spill restoration. As a result of lobbying by Alutiiq communities, subsistence restoration projects for community involvement, resource enhancement, and cultural revitalization were funded. Through the Trustee Council's habitat protection program, over 450,000 acres of mostly Alaska Native lands have been purchased. The sales have created controversies in Native communities concerning the wisdom of selling Native lands and how to manage and distribute the money obtained from the sales. Damage settlement money has been invested in community-based restoration programs. Co-management and tribal initiatives are occurring. But new sources of cash also provide the means for people to leave the villages. And the sale of Native lands raises uncertainties about future access to resources and a future role for tribes in land and resource management decisions.

Discussion:

A question was raised by Dr. Scott Goldsmith on what portion of the \$400 million that resulted from the sale of native lands went directly to individuals as transfers and how much of it went to communities and other institutions. Dr. information on this topic is contained in the report. Mr. Bud Rice asked if ADF&G will revisit these communities in another ten years to investigate changes and lingering effects from the *Exxon Valdez* Oil Spill. Dr. Fall thinks the communities will be revisited. Many of the communities have taken an interest in collecting information and monitoring things themselves. During the last project done in 1998, 60% to 70% of the interviews held were done by local residents trained by the Division of Subsistence, compared with 40% to 50% during MMS projects in the mid-1990s.

A comment was made that the title of the presentation encompasses more than the *Exxon Valdez* Oil Spill, and if this implied further work was being done on the North Slope. Dr. Fall explained that the final report is more focused on the *Exxon Valdez* Oil Spill. Ms. Anne Jensen asked if the training of hunting skills to young people was affected by the scarcity of resources. Dr. Fall explained communities responded to the *Exxon Valdez* Oil Spill in different ways, and the response is mixed.

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## **EXXON VALDEZ OIL SPILL, CLEANUP, AND LITIGATION: A COLLECTION OF SOCIAL IMPACTS INFORMATION AND ANALYSIS**

John C. Russell, Ph.D.,<sup>1</sup> Michael Downs, Ph.D.,<sup>2</sup> Betsy R. Strick, Ph.D.,<sup>3</sup> and Michael S. Galginaitis<sup>4</sup>

All authors originally with Impact Assessment Inc., 2166-F Avenida de la Playa, La Jolla, CA 92037

Current contact information: <sup>1,2</sup> EDAW/KEA 1420 Kettner Blvd., Suite 620, San Diego, CA 92101  
(619) 233-1454 ❖ FAX (619) 233-0952

E-mails: downsm@edaw.com, russellj@edaw.com, <sup>3</sup> bstrick@earthkam.ucsd.edu

<sup>4</sup> Applied Sociocultural Research, P.O. Box 101352, Anchorage, AK 99510  
(907) 272-6811 ❖ FAX (907) 222-6023 ❖ E-mail: msgalginaitis@gci.net

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The product of this work is a CD-ROM that contains two types of information. The first type of information is found in summary reports of the social impacts associated with the *Exxon Valdez* Oil Spill (EVOS) and the social factors involved in shaping the nature and magnitude of those social impacts. These reports include: (1) a Final Comprehensive Report that provides a community by community summary of social impacts, sections on "lessons learned" and "recommendations" for natural resource managers, observations about the interaction of community impacts and litigation, and a stand-alone summary of findings; (2) a Final Analysis on Social Factor by Social Factor Basis, that analyzes several key social factors: culture, social organization, social health, economics, and subsistence and their environmental and event-related contexts; (3) a Final Social Factors report that identifies and defines the types of social factors examined for analysis; (4) an Introduction to the Final Annotated Bibliography and Abstracts that includes background on the effort, the bibliographic style used, and a layout of the bibliography itself, including contents of all of the keyword fields; and, (5) the Final Annotated Bibliography and Abstracts that contains the major sources of information regarding the EVOS and community social factors. The second type of information contained on the CD is a searchable database of the final annotated bibliography and abstracts. This is an AskSam file that is organized in a multi-document format to facilitate search capabilities of the AskSam database program. For example, the reader can easily search for data by using the CITATION

field (e.g., by author, date, or words in the title), or by any of the other predefined fields that are organized by types of keywords. The original CD-ROM was completed in 1999; and an expanded CD-ROM containing additional full-text public domain sources sponsored by MMS and ADF&G is expected in mid-2001.

Discussion:

Ms. Vivian Kinnaird asked where this work is available. Mr. Tim Holder explained that another report will be added to this CD, and it should issued at the end of May. Mr. Steve Braund asked if there is a bibliography in this work, and if documents were scanned in or transformed to PDFs. Dr. Downs affirmed the inclusion of a bibliography, and the text includes an abstract and an annotation, but full text is not necessarily there for all reports. Full text of MMS *Exxon Valdez* Oil Spill technical reports and ADF&G *Exxon Valdez* Oil Spill technical papers is included.

## **ESTABLISHING A COMPUTER ACCESSIBLE TRADITIONAL KNOWLEDGE DATABASE ON THE ALASKAN NORTH SLOPE**

Anne Jensen

Science Division, Ukpeagvik Iñupiat Corporation  
Box 577, Barrow, AK 99723  
(907) 852-3050 ❖ FAX (907) 852-4882 ❖ E-mail: [ajensen@nuvuk.net](mailto:ajensen@nuvuk.net)

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The North Slope Iñupiat Traditional Knowledge Project is a contract from MMS to Ukpeagvik Iñupiat Corporation (UIC). The project began in early 1999 and is scheduled to finish in late 2001. Other participants besides UIC and the MMS include the North Slope Borough (NSB) Department of Wildlife Management (DWM), the NSB Commission on Iñupiat History, Language and Culture (IHLC), KEA Environmental, Inc., and Applied Sociocultural Research

The main goal of the project is the construction of a traditional knowledge database (TKDB) framework containing North Slope Iñupiat traditional knowledge. This TKDB will be used by individuals and entities within and outside of MMS seeking to combine the information contained in the database with other types of information.

The project has several parts. These include: an Iñupiaq epistemology to be used with the TKDB that is directed to specific uses (e.g., MMS and other federal agency environmental baseline and impact assessment types of NEPA documents) to which it will be applied by non-Iñupiaq users; a listing of keywords; an annotated bibliography; and a lessons-learned final report. The main product is the TKDB itself.

### **The Traditional Knowledge Database**

The structure of the TKDB is such that it is both an annotated bibliography and also a container of actual documents. The documents constitute a deeper, narrower portion of the information assembled during the course of the project. The numbers and types of documents included at this time are limited by funding. Currently, plans are to include documents that can be scanned or are already on computers, and that have no restrictions as to distribution. The priority is on translated material at this time (i.e., material already suitable for immediate MMS use). Locational information at the area level is included. Optix, the document management program being used, will let us include pictures, sound, video and other formats when funds are available to obtain the necessary data storage. The final TKDB to be produced under this contract will be available to MMS and perhaps other users on CD-ROM.

A web-accessible solution is being utilized to produce the TKDB. The number of keywords MMS wished to use is quite large; in fact, 50% larger than the Optix team had previously dealt with. It took some time to find and implement a solution, but this has been done. Data entry screens corresponding to the major subdivision of data (Land, Ocean, Sociocultural and Technological) have been developed, tested and are being used. Records for hundreds of documents, with annotation and keywords have been entered, and this process continues. The records for the IHLC audiotope database (1715 records) will be created shortly. Actual transcript documents will be attached to many of these records once they are created. The underlying database being used is Oracle, which is compatible with ESRI's range of ArcView/ArcInfo GIS products.

UIC is looking for ways to keep this database growing in the future once the current MMS project is complete. It is hoped that this can be a living document. The Optix Vault web-based option, which is being used for preparation, makes this goal fairly simple to implement, provided that some means can be found to cover the on-going Vault rental costs. Vault allows direct access over the World Wide Web, while allowing access restrictions as desired. The use of Oracle as the underlying database means that implementing a GIS front end for this data will be straightforward.

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## **BOOK/SYNTHESIS OF INFORMATION ON SOCIOECONOMIC EFFECTS OF OIL AND GAS ACTIVITIES IN ALASKA**

Stephen R. Braund<sup>1</sup> and Jack A. Kruse, Ph.D.<sup>2</sup>

<sup>1</sup>Stephen R. Braund & Associates  
P.O. Box 1480 Anchorage, AK 99510  
(907) 276-8222 ❖ FAX (907) 276-6117 ❖ E-mail: srba@alaska.net

<sup>2</sup>Professor Emeritus  
Public Policy Institute of Social & Economic Research University of Alaska Anchorage  
(413) 367-2240 ❖ FAX (413) 367-0092 ❖ E-mail: afjak@uaa.alaska.edu

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Since 1973, the Alaska OCS Region has supported a socioeconomic component in its Environmental Studies Program that has resulted in the publication of 162 Technical Reports at a cost of over \$19 million. These reports are often lengthy, use different methodological approaches, and have different study objectives. In addition, many authors have also published journal articles, monographs, and books based on their MMS sponsored work. MMS is sponsoring a synthesis of its socioeconomic studies with the objective to produce a single-volume, scientific reference book that synthesizes selected Alaska social and economic research findings in a series of peer-reviewed chapters. This presentation discusses the status of this project.

As MMS proposed 25 topics organized under cultural, economic, cumulative, and decision, regulatory and monitoring issues, the first task of this project was to conduct a literature review to assess whether there was adequate peer-reviewed literature to support a synthesis of 25 separate socioeconomic topics. The literature review resulted in 10 peer-reviewed chapters organized around the following topical themes: oil development in Alaska; petroleum and the statewide Alaska economy; the regional and community effects of oil development; an overview of subsistence in Alaska; subsistence and oil development on Alaska's North Slope; the long-term consequences of the *Exxon Valdez* Oil Spill on subsistence uses of fish and wildlife; the community effects of the *Exxon Valdez* Oil Spill; cultural persistence and change on the North Slope of Alaska; and a discussion of potential future social and economic research directions related to management of oil and gas activities on the Alaska OCS.

To date, the literature review, topic refinement, and chapter outlines have been prepared and reviewed by MMS. Currently, the contractor is working with authors to respond to MMS comments on chapter outlines and draft chapter preparation.

Discussion:

Mr. John Goll asked when the publication date for this project is, and Mr. Braund explained he is trying to coordinate writing schedules with the ten authors. He hopes to have draft chapters completed by August. Dr. Cleve Cowles joked that if page limitations arise, the MMS shortcomings section could be cut back!

## **MODELING THE ECONOMIC IMPACTS OF OFFSHORE OIL EXPLORATION AND DEVELOPMENT ACTIVITIES IN THE ALASKA ARCTIC**

Jonathan Skolnik<sup>1</sup> and Chris Holleyman<sup>2</sup>

Jack Faucett Associates, 4550 Montgomery Avenue, Suite 300N, Bethesda, MD 20912  
<sup>1</sup> (301) 961-8834, <sup>2</sup> (301) 961-8763 ❖ FAX (301) 469-3001

Email: skolnik@jfaucett.com, holleyman@jfaucett.com

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Production of oil and gas in the offshore Alaskan Arctic relies upon a set of technologies unlike those used anywhere else in the world. Remote locations, temperatures of -60°, and shifting ice flows that rule out traditional platforms, waterborne craft and sea-floor pipelines are just a few of the challenges that must be overcome from the rest of the United States. The solutions include roads and islands built of ice, man-made gravel islands, pipelines buried below the ocean floor, and cold weather retrofitted vehicles and equipment that are run for years without ever being turned off.

Economic impact modeling of these activities also requires a set of methods that are unique. Readily available regional economic impact models contain production functions that are based on national averages. These national-level input coefficients cannot accurately reflect the unique arctic production function. These models are also unable to accurately trace the regional distribution of purchases made by the industry or the workers who commute to the site. Finally, these readily available models do not have enough detail to accurately model the differing impact of specific projects.

This presentation describes the development of a first step model that can be combined with a readily available regional model to produce more accurate estimates of economic impacts. The first step model utilizes vectors of purchases disaggregated by both geographic area and activity to allow a more accurate accounting of the inputs required by area for a specific project. The vectors are constructed by coding detailed engineering estimates of inputs to the individual activities. These direct inputs can then be used to stimulate the standard regional impact models.

#### Discussion:

Dr. Scott Goldsmith asked how complicated it would be to break out the Alaska portion of the model into submodels. Mr. Holleyman explained it depends on the variable you want to look at. Variables like transportation margins and retail and wholesale margins would be difficult to allocate to specific areas. Dr. Goldsmith also wondered if they were able to take into account the harsh conditions of the Arctic into their model. Mr. Holleyman said yes, where they could take that into account they did. Mr. Tim Holder clarified that the consultants tried to determine the origin of the equipment, whether it was Alaskan, from the United States, or from foreign sources, and he is impressed with the level of detail contained in this model. Dr. Richard Lanctot asked if there is a similar model being funded for socioeconomic issues. Mr. Tim Holder explained this is solely an economic model, but since the 1970s MMS has done 166 socioeconomic studies at a cost of about \$20 million (not adjusted for inflation). He went on to explain most were either monitoring studies or baseline studies, not necessarily EISs looking at impacts.

Mr. Tom Brower asked if the model will extend out from Fairbanks and Anchorage to include villages throughout the state. Mr. Holleyman explained the model will look at the North Slope Borough (NSB) in its entirety, as opposed to the rest of Alaska. Mr. Brower commented the NSB did a two-year economic study looking at workers at Prudhoe Bay and negative and positive impacts on the villages pertaining to subsistence and culture. Mr. Holder noted Mr. Sverre Pederson, Alaska Dept. of Fish and Game, is currently studying this at Kaktovik and Nuiqsut, seeing how cash and subsistence economies are related. There is an older study that looked older residents of the NSB working in the oil industry and how that affected their motivation to move in or out. Dr. Goldsmith asked if the current study summarizes the percentage of workers coming from Alaska versus out-of-state. Mr. Holleyman said this is a simulation model, so that was not in their scope of work.

## **REFERENCE MANUAL AND GIS OVERLAYS OF OIL INDUSTRY AND OTHER HUMAN ACTIVITY (1979-1995) IN THE BEAUFORT SEA**

Peter Wainwright

LGL Ltd., environmental research associates  
9768 Second Street, Sidney, British Columbia, Canada V8L 3Y8  
(250) 656-0127 ❖ FAX (250) 655-4761 ❖ Email: pwwright@lgl.com

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*Presented by: Bill Wilson, LGL, Alaska*



We have incorporated all available information from daily drilling reports and geohazard studies at proposed drilling locations into the database and compiled information from sources such as side-scan sonar surveys, aerial surveys of whales, and vessel locations recorded in aerial surveys.

However, only one oil company has authorized access to proprietary information about seismic surveys conducted under permit. If we were to rely on publicly available information, there would be significant data gaps for the seismic surveys conducted under permit. Typically, the best publicly available information identifies a large geographic area (sometimes the entire Beaufort Sea) and a wide time period (often the entire open water season).

An important objective is the ability to use this database to analyze whether noise and disturbance associated with drilling, seismic surveys, and ice-breaking is affecting the bowhead whale migration route. Such an analysis requires an adequate level of detail. As a consequence, it was decided to restrict access to the database for MMS staff use only and to incorporate proprietary permit information.

With the exception of ice-breaking activity, the information for the period 1990 to 1998 is complete and adequate. However, there are significant gaps in the data for the period 1979 to 1989.

It was deemed appropriate to confirm the ability to use the database to perform the desired statistical analyses before proceeding with an elaborate GIS application and acoustic model. Therefore, project effort was reallocated towards an assessment of the feasibility of using the human activities database and the BWASP/NOSC data to analyse potential effects on the fall bowhead whale migration.

## **PROTECTED SPECIES STUDIES**

### **BOWHEAD WHALE FEEDING IN THE EASTERN ALASKAN BEAUFORT SEA**

William Griffiths<sup>1</sup>, W. John Richardson<sup>2</sup>  
and Denis H. Thomson<sup>2</sup>

<sup>1</sup> LGL Ltd, environmental research associates  
9768 Second Street, Sidney, British Columbia, Canada V8L 3Y8  
(250) 656-0127 ❖ FAX (250) 655-4761 ❖ E-mail: bgriff@lgl.com

<sup>2</sup> LGL Ltd, environmental research associates P.O.B. 280, 22 Fisher Street  
King City, Ontario, Canada L7B 1A6  
(905) 833-1244 ❖ FAX (905) 833-1255 ❖ E-mail: wjr@lgl.com

The 1998-2000 bowhead whale feeding study was inaugurated to compile existing traditional and scientific knowledge about feeding by bowhead whales in the eastern Alaskan Beaufort Sea, and to integrate those results with data from three more years of field research. This project was to be done in collaboration with subsistence hunters and other local stakeholders. A similar MMS-sponsored study was conducted in the same area during 1985 and 1986. The North Slope Borough's Science Advisory Committee had expressed concerns about the short duration of the 1985-86 study, and about some methodological limitations. The current project, although similar in scope and purpose to the previous study, contains changes and refinements. These changes include more involvement by North Slope residents and other stakeholders in the planning, conduct, and interpretation of the study, and use of a Scientific Review Board to review project plans and reports. Also, results are now based on five seasons of fieldwork specifically concerning feeding (1985-86 and 1998-2000), plus an 14 additional years of bowhead whale distribution data collected primarily by MMS. Thus, the present study encompasses data from a wider range of years and field situations.

LGL Ltd. is conducting several parts of the present study, including boat-based sampling of zooplankton via nets and an echosounder; aircraft-based studies of whale distribution, numbers, activities, residence times, and sizes; and development of an energetics model. Subcontractors carry out other aspects of the study. Applied Sociocultural Research gathers traditional ecological knowledge on bowheads from local whalers, and participates (with local residents) in surveys for bowheads that arrive in the Kaktovik area before the onset of the main westward migration. The University of Alaska

Fairbanks conducts isotopic analysis of whale tissue and zooplankton to assess regional feeding dependencies. The Alaska Department of Fish and Game studies prey types based on the stomach contents of harvested bowheads and fatty acid analysis of whale tissue vs. zooplankton. All of these data, along with related data from the 1985-86 study, are being combined to assess the importance of the eastern Alaskan Beaufort Sea to feeding bowhead whales.

One aspect of the boat-based zooplankton study was to use a sonar system with digital acquisition and processing to estimate zooplankton biomass. This requires the establishment of a relationship between the acoustic signal ("echo strength") and the biomass of zooplankton as estimated by net sampling. The resulting relationship can then be used, in conjunction with continuous echosounder data, to provide continuous information on the horizontal and vertical distribution of zooplankton biomass along transects. In 1999, 63% of the observed variation in the zooplankton biomass was accounted for by the backscattering data from the 430 kHz transducer. Based on this relationship, we estimated the zooplankton biomass along acoustic transects across the study area. A strong relationship is sometimes difficult to obtain because of several biotic and abiotic factors that can influence the quality of the acoustic data.

Fieldwork for this study was completed in the autumn of 2000, and analysis of the data from all years of the project is underway. A final report on all aspects of the study will be completed later in 2001.

#### Discussion:

Mr. Bill Wilson asked if appears that the eastern Beaufort Sea is an important area for bowhead whale feeding. Mr. Griffiths explained the eastern Beaufort can be important for individual whales, but not necessarily the entire population, keeping in mind there is only five years of data on an animal that probably lives to be 100 to 150 years. Mr. Craig Nicolson asked for an explanation on the design and operation of the bongo net. Mr. Griffiths showed slides of the bongo net, and clarified there is one plankton net on each side, and that suspended sediment will pass through the net. In 1998 they sent a video camera down and saw large clouds of suspended sediments. More sophisticated instrumentation has produced similar values. Mr. Ken Coyle did work in the Chukchi and Bering Seas using multiple frequencies and sophisticated analysis, and there was a good relationship with euphausiids and fish, but not with copepods or chaetognaths, which unfortunately are the prime component of this community. Mr. Nicolson asked if suspended sediments could be corrected for by collecting samples, and Mr. Griffiths said possibly, but you might need to know more that just the amount of suspended sediment in the water. Mr. Mike Wofford asked for some clarification on one of the figures presented. Mr. Griffiths replied darker colors corresponded to higher zooplankton concentrations, and the transects ranged from 15 to 25 km out. Mr. Wofford wondered if these data say anything about feeding habits, and Mr. Griffiths illustrated higher concentrations (about 700 mg/m<sup>3</sup>) seen in the figure are concentrations where whales start to feed--they will actually go down and probe, to see if concentrations are high enough to feed. Mr. Warren Horowitz asked how these concentrations compare to other areas, for example the Mackenzie. Mr. Griffiths explained similar work has not been performed elsewhere in the Beaufort Sea. Dr. Richard Lanctot asked about the variability among the transects as you move from one area to another. Mr. Griffiths explained transects were not sampled parallel to the coast, so there will be variability in the extrapolations as you move from east to west. Mr. Nicolson asked about year-to-year variability, and Mr. Griffiths replied results from this survey look similar to data from 1985 and 1986, with less zooplankton near the surface, and large subsurface bands that extend 10 to 15 km.

## **MINERALS MANAGEMENT SERVICE AERIAL MONITORING OF FALL 1998-1999 BOWHEAD WHALE MIGRATIONS**

Stephen D. Treacy

Alaska OCS Region

Minerals Management Service

946 East 36th Avenue, Anchorage, AK 99508

(907) 271-6603 ❖ FAX (907) 271-6805 ❖ E-mail: [Steve.Treacy@mms.gov](mailto:Steve.Treacy@mms.gov)

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Each year since 1987, the Minerals Management Service (MMS) Bowhead Whale Aerial Survey Project has used MMS personnel to monitor the fall migration of bowhead whales across the Alaskan Beaufort Sea.

During Fall 1998, general ice cover during September and October was the third-mildest open-water season (1979-1999), with the 5-tenths ice-concentration boundary 240 nm north of Point Barrow in September. The very high number of sightings of bowhead whales (n=383) as well as the very high number of individual bowhead whales counted (n=1,045) likely resulted from favorable open-water conditions along with some potential repeat counting between days of large aggregations of feeding and/or milling whales that appeared to remain in the same area for several days. A total of 1,045 bowhead whales, 5 gray whales, 306 beluga whales, 38 bearded seals, 938 ringed seals, 3 Pacific walrus, 20 unidentified pinnipeds, 235 polar bears, and 26 sets of polar bear tracks were observed during 180.64 hours of survey effort that included 93.79 hours on randomized transects.

During Fall 1999, general ice cover across during September and October was considered light overall, with high concentrations of ice by mid-October. There were 214 sightings of bowhead whales, for a total of 397 individual whales counted. A total of 397 bowhead whales, 446 beluga whales, 2 gray whales, 1 unidentified cetacean, 81 bearded seals, 1,325 ringed seals, 10 unidentified pinnipeds, 37 polar bears, and 70 sets of polar bear tracks were observed during 114.16 hours of survey effort that included 60.15 hours on randomized transects.

The axis of the bowhead whale migration in the West Region during Fall 1998 was closer to shore than in any other year (1982-1999). The Tukey HSD test of randomized sightings of bowheads between pairs of years showed that the Fall-1998 migration corridor was significantly nearer to shore in both the East and West Regions of Alaskan Beaufort Sea than in 1999, a year with no offshore seismic exploration or drilling activity during September or October. The relatively small median distances from shore and median water depths at bowhead sightings in Fall 1998 and 1999 in the West Region are consistent with a tendency for bowheads to migrate closer to shore and in shallower water during years of light general ice cover. Power analyses of the ANOVA for distance from shore ( $\alpha = 0.05$ ,  $\beta = 0.01$ ) have shown a minimum detectable difference of 4.8 statute miles in the East Region of the study area and 6.03 miles in the West.

#### Discussion:

Mr. Bill Wilson wondered if there is a relationship between the effort and success of the hunt to the position of the mean migratory corridor from year to year. Mr. Treacy explained they haven't examined that, but that data are presumably available to those who might wish to do so. Mr. Brian Havelock asked about the apparent lower density between the Colville and Canning rivers, and if it is related to the barrier islands or industry infrastructure. Mr. Treacy said that industry-funded site-specific studies, incorporating BWASP data with their own, have shown a 20-km radius of avoidance around certain active seismic vessels, but that the apparent uneven distribution of whales in 1998 was likely due to certain large aggregations of feeding bowheads in particular areas. Mr. Brian Havelock asked if there have been any problems double- and triple-counting whales. Mr. Treacy explained they minimize that problem by not flying transects twice in the same survey block on the same day, by having transects fairly far apart, and by attempting to spread survey effort over the entire study area between days. There would be a potential for multiple counts if the same whales aggregated in a specific area over several days, which might have been the case near Cape Halkett in 1998. Dr. Joel Hubbard wondered if there is any correlation with feeding activities observed and the high-density plankton lenses observed by Mr. Griffiths. Mr. Treacy hopes Mr. Griffiths' group will look at that. Mr. Griffiths added that photogrammetry in his study allows tracking of individual whales to see if they spend extended periods in a single area. Mr. David Shield asked where flight effort is directed on a daily basis. Mr. Treacy explained weather conditions most often determine the target area for flight operations on a particular day, although they try to end up with relatively even coverage from east to west over the field season.

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## **POLAR BEAR DEN RESEARCH IN THE BEAUFORT SEA**

Steven C. Amstrup

USGS, Biological Resources Division, Alaska Biological Science Center  
1011 East Tudor Road, Anchorage, AK 99503  
(907) 786-3424 ❖ FAX (907) 786-3636 ❖ Email: [steven\\_amstrup@usgs.gov](mailto:steven_amstrup@usgs.gov)

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*Presented by Geoff York*

Pregnant female polar bears occupy dens from early November to early April in order to provide a mild microclimate

for neonates. Between 1980 and 1992 (hereafter called the early period of den studies), over half of the population occupied dens on drifting pack ice. The remainder denned in widely scattered areas on land. Preliminary evaluations suggest that after 1992 (hereafter called the later period), numbers of bears denning on land may have increased. During early den studies, significantly more land dens were found in the eastern Alaskan Arctic than in points west. Coincident with increased numbers of dens on land, in the later period, has been an increase in the proportion of bears denning in more westerly locations. An explanation for the apparent increase of denning in more westerly locales has not yet been apparent. We plan to analyze data from the later period of den studies this summer and update the analyses published in 1993. During the last year, we finished a digital map showing the highest probability denning habitat in the central portion of Alaska's north slope. Although we still cannot predict where any individual may choose to den; we can now highlight areas where denning is most likely to occur. We used characteristics of previously observed dens and aerial photos to identify 1,782 km of bank habitats suitable for denning. These habitats comprised 0.18% of the coastal study area between the Colville River and the Tamyariak River in northern Alaska. Final testing of the ability of forward looking infrared (FLIR) to detect polar bears in their dens was again hampered by poor weather. We hypothesized that clear and cold weather, early in the winter when the snow pack is thin should be ideal for detection of the heat signature of a den. Unfortunately, we never saw those conditions in the winter of 2000-2001.

Our tests did show, however, that FLIR has promise for detecting dens even in less than ideal conditions. Final analyses of data collected will be performed at a workshop in May of this year, and recommendations for use of the FLIR system will be made in a final report prepared thereafter.

#### Discussion:

Mr. Brian Havelock asked about three instances where polar bears were in close proximity to infrastructure. Dr. York explained one was beneath the Badami pipeline, one denned in an abandoned staging area pad, and the third one denned at Flaxman Island. There was successful denning there and the bear has since exited the den. Mr. Bill Griffiths inquired about how close the aircraft has to be to recognize a den with FLIR. Dr. York said about 800 feet within a fairly narrow field, but the habitat they survey is fairly restricted. When asked about future Biological Resources Division plans by Mr. Steve Treacy, Dr. York hinted the direction they are tentatively planning a five year mark-recapture effort in the Beaufort Sea. Dr. Joel Hubbard wondered why there is only offshore denning off Alaska, and if it is a result of a lack of telemetry data in other areas. Dr. York explained the Canadians have considerable telemetry and satellite data, and their bears tend to den on high Arctic islands and not on the ice. Dr. Will Barber inquired if efforts have been focused around the Arctic National Wildlife Refuge (ANWR). Dr. York clarified that ANWR is where a lot of bears chose to den, but capture efforts were spread equally between Barrow and Demarcation Point. Prior to 1991, 46% of known land dens were in ANWR, but since that time there has been an increase in dens on land to the west and in the central area of the Beaufort Sea.

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## **MONITORING BEAUFORT SEA WATERFOWL AND MARINE BIRDS**

Richard B. Lanctot

U.S. Geological Survey, Alaska Biological Science Center  
1011 East Tudor Road, Anchorage, AK 99503  
(907) 786-3609 ❖ FAX (907) 786-3636 ❖ E-mail: Richard\_Lanctot@usgs.gov

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Offshore industrial development in the Beaufort Sea began in the winter of 2000 at Northstar Island. This and other proposed offshore developments have the potential to significantly increase human-related activities, such as helicopter overflights and barge traffic, in the lagoons and offshore waters of the Beaufort Sea. Consequently, there are concerns about how these activities and the potential for oil spills may impact breeding, molting, and migrating waterfowl and marine birds. Our objectives in this project are to: 1) document and compare present abundance/distribution patterns of sea ducks and other marine birds within and among 'industrial' and 'control' (i.e., undeveloped) areas in a manner that allows comparisons with earlier surveys, 2) monitor breeding Common Eiders and molting Long-tailed Ducks using the lagoons and associated barrier islands, and 3) examine life-history parameters of these species to enhance interpretation of disturbance. We chose the Jones and Return Island complexes in Simpson Lagoon as our industrial study area and the Stockton, Maguire, and Flaxman island complexes as our control study area. Statistical analysis of aerial survey data for long-term trends is pending. Summary analyses from 1999 and 2000 indicated Long-tailed Ducks and Common Eiders used barrier island habitat extensively, whereas abundance and densities of these species was relatively low in other near-shore

habitats. In contrast, Spectacled and King Eiders were distributed in offshore waters, generally West of Oliktok Point. There were few differences in Common Eider productivity between study areas in terms of nest initiation dates, clutch size, nesting success, or duckling survival. We are currently developing a population model that will indicate current population trends for this species. Foraging behavior and body composition of molting Long-tailed Ducks varied across study areas. However, the patterns of variation were inconsistent with disturbance being a causative factor, and may be explained by a virus outbreak in the Eastern study area. Long-tailed Ducks have a fairly consistent diurnal pattern of roosting on or along the barrier islands at night, and foraging out in the lagoon during the day. Experimental disturbance appeared to have little influence on this pattern.

Discussion:

Dr. Will Barber asked if there were differences in habitat between eastern and western regions, and between industrial and non-industrial regions. Dr. Lanctot explained there are more islands in the west than in the east. As far as industrial effects, data are preliminary and should not be summarized yet, but there doesn't seem to be any noticeable negative effects. Dr. Joel Hubbard wondered if predation by glaucous gulls is a problem for common eiders. Dr. Lanctot emphasized that glaucous gulls depredate nests and are definitely a problem. The gulls nest within feet of the eider nests, so to avoid predation, the gulls literally have to sit on the eggs all the time. This complicates research efforts, since trapping the birds can lead to depredation events. This is minimized, though, by injecting eiders with a mild anesthetic (propofol), then returning them in front of their nests so when they wake up there are no humans nearby. They are disoriented, but their nest is right in front of them when they waken. Dr. Susanna Blackwell asked about the low frequency of crècheing observed. Dr. Lanctot listed a potential reason as birds in a difficult body condition, such as emaciated females may give up their young to others if there is another female around. Most of the ducklings don't make it, they still have to get to open water and forage, which is hard with all the gulls flying around.

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## **CORRECTION FACTOR FOR RINGED SEAL SURVEYS IN NORTHERN ALASKA**

Brendan P. Kelly, Ph.D.<sup>1</sup>, Lori T. Quakenbush<sup>2</sup>, and Brian D. Taras<sup>3</sup>

<sup>1</sup>Juneau Center, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Biology Program, University of Alaska Southeast

11120 Glacier Highway, Juneau, AK 99801

(907) 465-6510 ❖ FAX (907) 465-6447 ❖ Email: [ffbpbk@uaf.edu](mailto:ffbpbk@uaf.edu)

<sup>2</sup>School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Fairbanks, AK 99775

(907) 474-7662 ❖ FAX (907) 474-7204 ❖ Email: [loriq@ims.alaska.edu](mailto:loriq@ims.alaska.edu)

<sup>3</sup>School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Fairbanks, AK 99775

(907) 474-7026 ❖ FAX (907) 474-7204 ❖ Email: [btaras@ims.alaska.edu](mailto:btaras@ims.alaska.edu)

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Ringed seals, the most numerous seal in the northern hemisphere, are an important resource to Native people and the most frequent prey of polar bears. Aerial surveys have been used intensively and extensively to relate seal numbers to ecological variables and industrial activities. Much of the uncertainty in estimates of ringed seal numbers is associated with the unknown proportion of seals visible during aerial surveys, because they are concealed under water or within subnivean lairs. We are investigating the proportions visible and the environmental influences on those proportions. Eight and ten ringed seals were live-captured in 1999 and 2000, respectively, and the time spent concealed in lairs and resting visibly in the open was monitored by radio telemetry. Over a 7-day period in 1999, 75% of the tagged seals left their lairs and began resting in the open. That same transition took place over 24 days in 2000. The midpoint of the transition period was 31 May in both years. Tagged seals spent approximately 20% of the time out of the water before basking began and approximately 30% of the time out of the water after basking began. The transition from lair use to basking appeared related to measurable characteristics of the snow. In 2001 - 2003, we will relate the proportion of seals visible on the ice to snow conditions determined in real time using satellite-borne radar and snow temperature profiles. We also shall investigate the use of historical snow temperature records from tundra sites as proxies for snow conditions on the ice. The findings of this study will be used in a reanalysis of past ringed seal surveys

Discussion:

Dr. Cleve Cowles asked a question regarding the radar techniques in use. Dr. Kelly explained that a collaborator at

JPL in California has been using K-U band radar from satellite to look at snow conditions in the tundra. One of Dr. Kelly's co-principal investigators realized they were seeing a bright signal, a large change in the return on this band of radar that laboratory personnel correlated with the onset of the snow melt. Last year Dr. Kelly asked JPL to look at his study site when they were sampling, and using this technique, JPL picked the same date when the snow pack became isothermal as Dr. Kelly's group. More measurements will be done between the two groups. Dr. Chuck Monnett asked about the upcoming field season and new collaborators. Dr. Kelly is now collaborating with the Cold Regions Research Laboratory of the U.S. Army to make snow and weather measurements more regional instead of focusing in the area around Prudhoe Bay. Monitoring this year will occur at Barrow, Prudhoe Bay, and Kaktovik. Seal behavior will remain focused at Prudhoe Bay, but data on seals basking at Kaktovik will be collected with help from Kaktovik High School.

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## MONITORING DISTRIBUTION AND ABUNDANCE OF RINGED SEALS IN NORTHERN ALASKA

Kathryn J. Frost<sup>1</sup>, Grey Pendleton<sup>2</sup>,  
and Casey Hessinger<sup>3</sup>

<sup>1</sup>University of Alaska Fairbanks  
1550 Coyote Trail, Fairbanks, AK 99709

(907)455-6885 ❖ E-mail: kjfrost@eagle.ptialaska.net

<sup>2</sup>Alaska Dept. Fish and Game, Box 240020, Douglas, AK 99824  
(907) 465-4634 ❖ FAX (907) 465-4272

<sup>3</sup>University of Alaska Anchorage

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Aerial surveys of ringed seals (*Phoca hispida*) were conducted in the Beaufort Sea from Point Barrow to Barter Island during late May-early June 1996-1999 using previously established survey protocols. We surveyed approximately 13,100 linear km of transects covering an area of 10,776 km<sup>2</sup>, and sighted 9,935 seals in 5,833 groups. Estimated observed densities ranged from 0.36 seals/km<sup>2</sup> in sector B1 (1996) to 1.54 seals/km<sup>2</sup> in sector B4 (1999). Sector B4 had the highest density of total seals on both fast and pack ice in all four years, except for pack ice in 1996 where B2 was higher but based on a very small sample.

Only sectors B3 and B4 were surveyed in all four years, making among-year comparisons possible. In sector B3, the raw density of ringed seals on fast ice, based on standard strip transect analysis, was highest in 1999 (0.98 seals/km<sup>2</sup>) and lowest in 1996 (0.57 seals/km<sup>2</sup>). In sector B4, the density on fast ice was also lowest in 1996 (0.67 seals/km<sup>2</sup>), similar in 1997 (1.17 seals/km<sup>2</sup>) and 1998 (1.16 seals/km<sup>2</sup>), and highest in 1999 (1.77 seals/km<sup>2</sup>). On pack ice, the estimated densities were similar from 1996-98 in sector B3 (0.81 to 0.92 seals/km<sup>2</sup>) and higher in 1999 (1.16 seals/km<sup>2</sup>). Seal density on pack ice was quite variable in sector B4 (1.17 seals/km<sup>2</sup> in 1996; 2.37 seals/km<sup>2</sup> in 1997; 1.57 seals/km<sup>2</sup> in 1998; 1.35 seals/km<sup>2</sup>). Densities for sectors B3 and B4 in 1996-1999 generally fell within the range of estimated densities for 1985-1987.

During 1997 surveys, an additional observer collected data using line transect methods. Line transect analysis produced an overall density estimate of 0.90 seals/km<sup>2</sup> (SE=0.072, CV=7.96), with a 95% confidence interval for estimated density of 0.77 to 1.05 seals/km<sup>2</sup>. This was not significantly different than the strip transect density estimate of 0.89 seals/km<sup>2</sup> (SE=0.067).

Covariate analyses were conducted to examine the effects of weather and habitat variables on seal counts. Date, ice deformation, water depth, distance from shore and from the fast ice edge, and longitude were all found to affect the observed density. Seal counts increased with date, from May 24th through June 3rd. Estimated density decreased as ice deformation increased. Both observed and predicted density increased from shore to about 15-25 m water depth, then decreased in water deeper than 25 m. Density was higher in the eastern part of the survey area than in the west, and increased with distance from shore. However, the model also indicated that density was highest near the fast ice/pack ice edge, decreasing both shoreward and seaward of the edge. Distance from shore, distance from the fast/pack edge, and water depth are all inter-related to some extent, and this complicates interpretation of the model.

Comparison of data from this project with aerial survey data collected in a similar manner in the mid 1980's indicates that relative ringed seal densities in the central Beaufort Sea were 2-3 times higher ten years ago than they are now.

We recommend that future surveys be conducted using standard strip transect methods described in the previous MMS-ADF&G protocol. We further recommend that surveys be analyzed using a covariate approach which takes into account the effects of habitat variables on relative seal densities.

This is a cooperative project funded primarily by the U.S. Department of the Interior, Minerals Management Service, with additional support being contributed by the Alaska Department of Fish and Game, the National Marine Fisheries Service, the University of Alaska, and the North Slope Borough.

Discussion:

Dr. Chuck Monnett brought up recent evidence suggesting aerial surveys at 300 feet might cause seals to dive after the aircraft has passed, and asked if Ms. Frost had any information on whether flying higher might affect the survey. Ms. Frost stated flying at 500 ft would have a dramatic effect. At that elevation, about one-third fewer seals are counted, which may not be a problem if you are looking at a relative index. However, in the Beaufort Sea, the average ceiling in June is about 310 ft. In Kotzebue, the ice is relatively smooth, whereas in the Beaufort there is dirty ice and deformation, which makes counts difficult. Seals are more sensitive to disturbance and more likely to dive while flying during calm and bright days in the Beaufort Sea. Flying during foggy and overcast days the seals are less sensitive. Adding to the complications are other factors seals are responding to, such as those mentioned by Dr. Brendan Kelly previously.

Dr. Kelly explained it appears the transition period, when seals give up their lairs and rest in the open, actually happens to 75% of the population in about a one-week period just before the snow goes isothermal. This suggests that if flights occur as they have traditionally been flown, comparisons over time are confounded by these rapid changes in proportion of seals visible. Ms. Frost stated another problem was influx of seals from other areas. There are so many variables involved, you can get some good data and information on relationships of seals to ice and bathymetry, but it may not have answered MMS' question—"Is there a quick and simple way to index how many seals are out there?"

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## **SATELLITE TRACKING OF BELUGA WHALES IN THE CENTRAL ARCTIC OCEAN**

Robert Suydam<sup>1</sup>, Lloyd F. Lowry<sup>2</sup>, and Kathryn J. Frost<sup>2</sup>

<sup>1</sup> North Slope Borough Dept. Wildlife Management, P. O. Box 69, Barrow, AK 99723  
(907) 852-0350 ❖ FAX (907) 852-0351 ❖ E-Mail: rsuydam@co.north-slope.ak.us

<sup>2</sup> University of Alaska Fairbanks, 1550 Coyote Trail, Fairbanks, AK 99709,  
(907) 455-6885 ❖ E-mail: llowry@eagle.ptialaska.net or kjfrost@eagle.ptialaska.net

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In Alaska, there are five stocks of beluga whales, which are identified based on traditional summering areas. Two of these stocks, the eastern Beaufort Sea and the eastern Chukchi Sea stocks, occur seasonally in the Beaufort Sea. The Beaufort Sea stock migrates along the spring lead in April and May from the Bering Sea to the eastern Beaufort Sea and returns west through the Beaufort Sea in September and October. The eastern Chukchi Sea stock occurs off northwestern Alaska in late June and early July and, as discovered recently, travels into the Beaufort Sea for the remainder of the summer.

Beluga whales are important to Alaskan Native hunters for subsistence; more than 300 belugas are harvested annually in Alaska. These same belugas migrate through both Alaskan and Canadian offshore oil and gas leasing areas and are a subject of increasing international discussion regarding cooperative population management for stocks shared by Alaskans, Canadians, and Russians. Concerns about potential effects of offshore oil and gas exploration and development on beluga whales exist on local, national, and international levels.

Studies in the early 1980s provided information about beluga reproduction, food habits, and distribution and abundance in summer. More recently studies have provided information about harvest levels, stock identity and genetic characteristics, and abundance in summering areas. However, despite the importance of belugas as a subsistence resource and their protection under the Marine Mammal Protection Act, late summer distribution and fall migration patterns are poorly known, wintering areas are effectively unknown, and areas that are particularly important for feeding have not been identified.

Satellite tagging offers a proven cost-effective and technologically sound approach to obtaining information on beluga distribution and movements. In 1998 and 1999, the Alaska Beluga Whale Committee, North Slope Borough, Alaska Department of Fish and Game, NMFS National Marine Mammal Laboratory, and the village of Point Lay cooperated to capture and tag a total of 10 belugas from the eastern Chukchi Sea stock. The belugas were caught by entangling them in large-mesh nets set across channels in Kasegaluk Lagoon. One-half-watt satellite-linked depth recorders (SDRs) were attached using two nylon pins bolted through the cartilaginous dorsal ridge. The SDRs transmitted data each time the beluga surfaced. These data were then received by earth-orbiting satellites.

The information from these first satellite-tagged belugas in the eastern Chukchi Sea provided new and surprising information about their movements and distribution during late summer and autumn. These tagged belugas did not, in contradiction to previous assumptions, spend the summer in pack ice of the north central Chukchi Sea. Instead, they moved into the Beaufort Sea and Arctic Ocean. Some traveled more than 2,000 km from the tagging location and reached 80°N latitude and 133° W longitude almost 500 km northwest of Banks Island. This required travel through 700 km of 9-10/10<sup>ths</sup> ice cover. Several of these whales then returned to the Point Barrow area along different tracks, followed by another trip to an area west of Banks Island at approximately 133°N. Movements were similar in 1998 and 1999.

Eight of the 10 belugas tagged in the eastern Chukchi Sea were large males, one was a large female and one was a small female. All the large belugas moved far to the north into the Arctic Ocean pack ice, but the small female only moved to approximately 72°N in the western Beaufort Sea. This indicates that there may be some sex or age related differences in distribution and movement patterns.

This study demonstrates the benefits of cooperation between local residents and scientists in conducting research in the Arctic. It has provided the first information on where belugas from the eastern Chukchi stock go after they leave coastal areas of the eastern Chukchi Sea. Similar cooperative efforts in the future can greatly expand our knowledge about belugas in other regions of Alaska. This study by the Alaska Beluga Whale Committee will serve as the foundation for a satellite tagging study funded by MMS through the Coastal Marine Institute at University of Alaska. Tagging did not take place as scheduled in June 2000 due to poor ice conditions and the scarcity of belugas near Point Lay. Field work has been rescheduled for June 2001.

#### Discussion:

When asked by Mr. Tim Holder to differentiate the different colors used in the presentation slides, Ms. Frost explained yellow represents 90% to 100% ice coverage, blue is open water, and the two arrows represent two separate animal tracks. Mr. Warren Horowitz asked about the time of year tagging took place. Ms. Frost replied the first of July, with the last tag coming off in November. The belugas came back towards Barrow and then they lost them. Of interest, though, is what happens after they leave Barrow. The speculation is they head over to the Chukchi Sea coast. Mr. Horowitz reported the Canadians found they headed to Wrangel Island then followed the ice to the Bering Strait.

Ms. Frost added that, to their amazement, about the time that Mackenzie Estuary belugas begin to head west in August-September, Chukchi Sea animals headed north and east over to their area. So there are two different stocks or populations of animals doing opposite things at about the same time of year. That was a surprise to both the Inuvialuit hunters and the Alaska hunters. Dr. Ted Eschenbach wondered if the animals are returning to the same areas in subsequent years. Ms. Frost explained the stocks are genetically distinct, and there are four different summering concentrations of belugas in Alaska.

A question was asked if all the whales tagged were male. Ms. Frost replied that eight of the ten whales were males, one was a large female and one was a small female. Dr. Cleve Cowles asked if the tags give data on dive time and behavior, like the past project with the Canadians. Ms. Frost said the information is there, but it hasn't been analyzed. When the animals are over deep water they are diving 600 to 700 meters. In coastal areas they often feed nearshore, diving as shallow as 5, 10, or 20 meters to feed, then they go offshore and feed at abyssal depths in the high Canadian arctic, and doing it repetitively. In Alaska, the animals may be going back to the same feeding areas year after year. The Canadians have also been surprised by movements of their large males—they go through the Northwest Passage backward, leaving the Mackenzie Estuary and heading up to the high Canadian arctic islands.



When asked by Mr. Steve Treacy what the animals are eating that far north, Ms. Frost said it is unknown at this point. In the eastern Arctic, they eat flat-fish. In nearshore Alaska waters, they're eating echiurid worms, decapod crustaceans, and saffron cod, similar to spotted seal feeding habits. Though not part of this CMI project, Ms. Frost is starting to look at fatty acid content of the animals. At Point Lay, hunters are providing a sample of fat for every beluga they harvest so diet can be analyzed. A positive aspect of this project is the cooperative efforts—not just CMI working with a federal agency, but involving the local community.