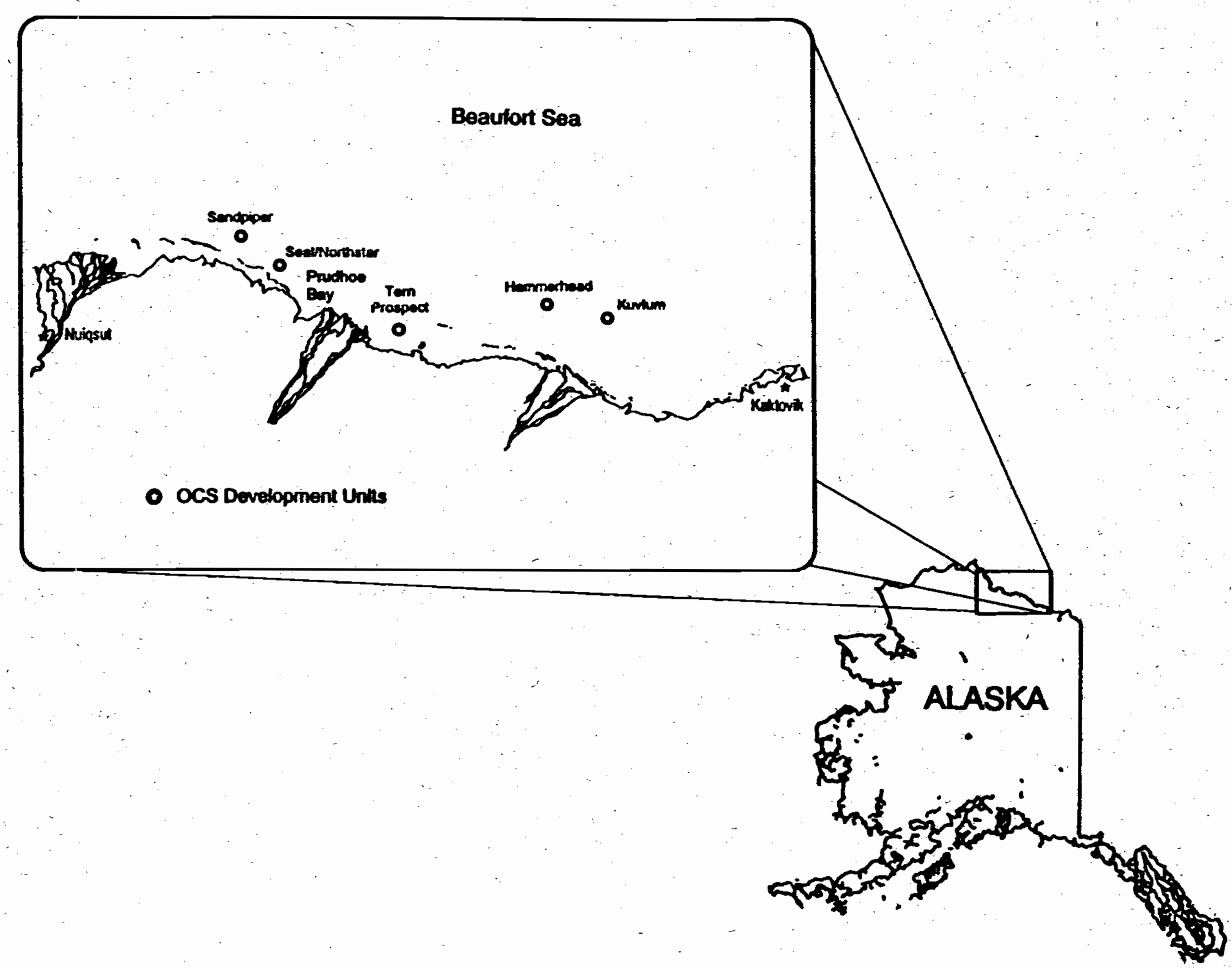
OCS Study
MMS 95-0065

Alaska OCS Region

PROCEEDINGS OF THE 1995 ARCTIC SYNTHESIS MEETING



MMS
U.S. Department of the Interior
Minerals Management Service
Alaska OCS Region

OCS Study MMS 95-0065

ALASKA OCS REGION

PROCEEDINGS OF THE 1995 ARCTIC SYNTHESIS MEETING

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Executive Synthesis

EXECUTIVE SYNTHESIS

Based on the Concluding Synthesis Session

Dr. Cleve Cowles, Conference Chair

This was Minerals Management Service's (MMS) sixth Information Transfer Meeting. It was a little different from previous meetings, so a couple of general concepts for the meeting will be described.

In the past, when MMS had synthesis meetings with a variety of scientific disciplines, the challenge was to bring the information into a tentative environmental assessment. Those scientific disciplines existed within the context of other knowledge. This other knowledge included that of the attendees who were not scientists but who were constituents or stakeholders — sources of traditional knowledge. In the past, their knowledge was incorporated into our scientific disciplines.

One other characteristic of these earlier syntheses was that we had very specific scenarios in terms of what we were trying to assess. As you know, MMS is now looking farther ahead compared to some of our scenarios in the past, and using industry scenarios without the same specifics.

Further, a synthesis is an aggregation of specialists or disciplinary-information sources with a certain amount of information overlap. Perhaps that overlap represents areas of agreement about information. The purpose of a meeting such as our synthesis has been to pull those disciplinary information sources closer together and to increase those zones of overlap. For example, initially there were very substantial differences, it is fair to say, in the information that came from the industry representatives, the sociocultural scientists, the Alaska Eskimo Whaling Commission, and the whalers, and the bowhead whale scientists. A purpose has been to pull together — to synthesize the information — and we definitely saw a synthesis of the information!

Those are some general concepts as to the MMS purposes for this meeting.

Lastly, several comments were made during the meeting, acknowledging MMS's support of studies. MMS would like to similarly acknowledge the other parties who have brought their information to the table. There was a broad diversity of participants who were non-MMS and the quality of the presentations was excellent. The people who participated might not have received a lot of information in return, but they have certainly provided MMS with excellent presentations. I am acutely aware of the work that goes into presentations and am thankful for it.

Next, the Session Chairs will give their perspectives or summary statements about the pertinent conclusions and directions from their sessions.

Mr. Jeff Walker, Chair, Introductory Session

The agenda for the Introductory Session provided industry with an opportunity to address where they are headed with the oil and gas activities in the Arctic. We sensed a readiness to develop the offshore prospects, including Northstar, Sandpiper, Hammerhead, and Kuvlum (Figures 1, 2, and 3). The speakers who addressed this more than exceeded our expectations in setting the stage for that. Mr. Terry Obeney with BP, Mr. Jim Watt with Union Texas, Mr. Nick Vanderkooy with CANMAR, and Mr. David McKeehan with INTEC, did an outstanding job in

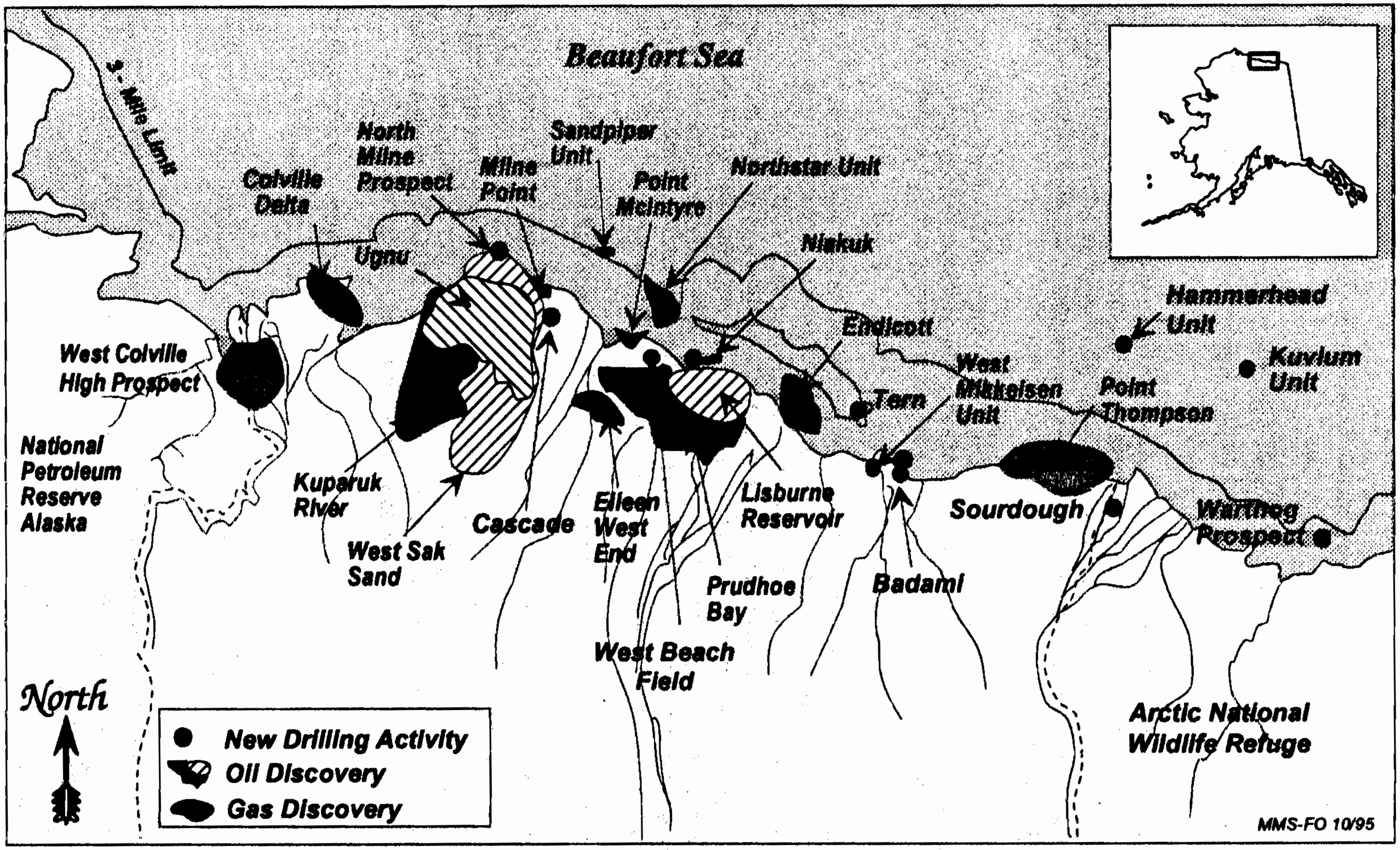

Figure 1. North Slope oil and gas fields and new discoveries.

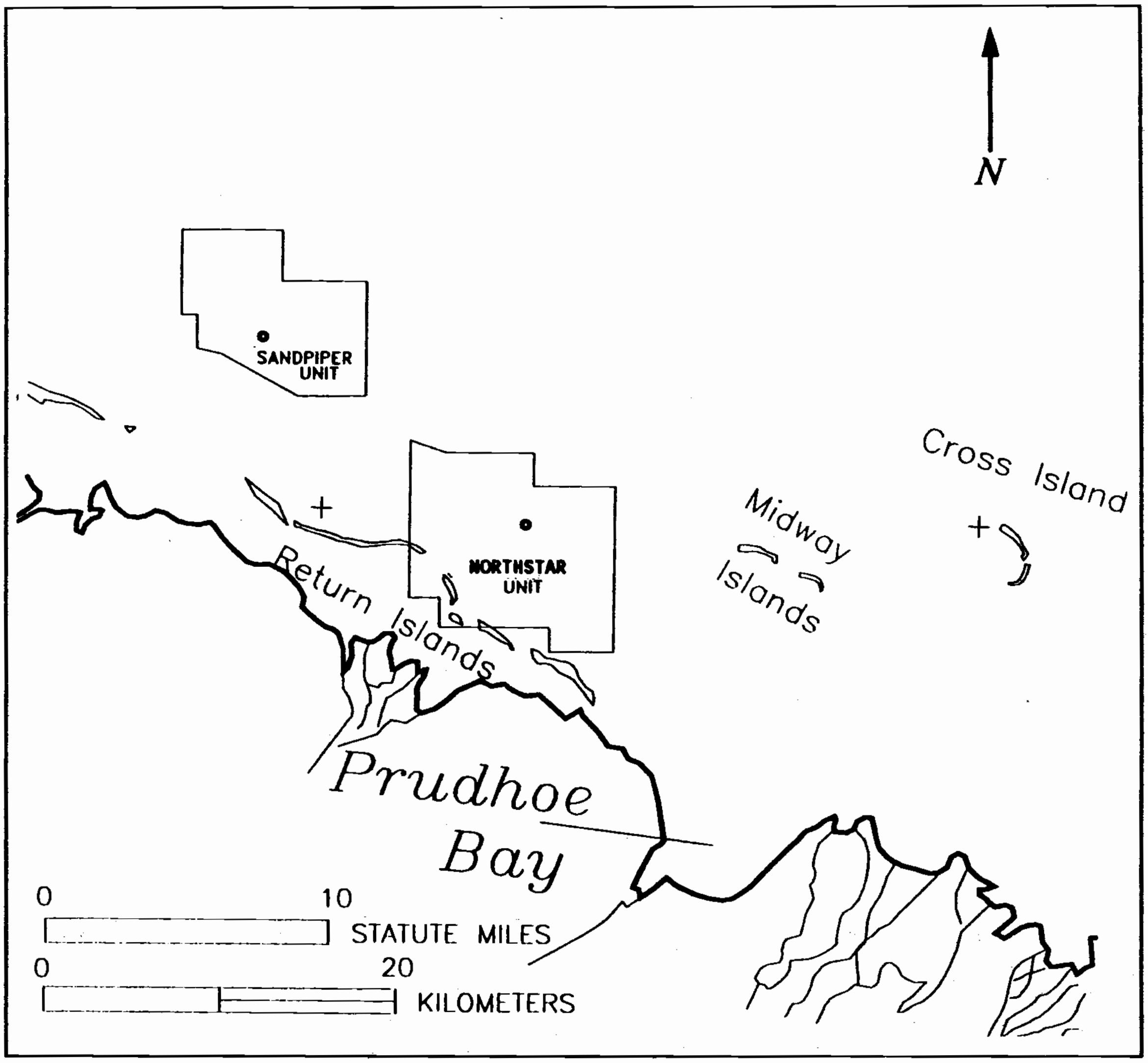

Figure 2. Location and shape of Sandpiper Unit and Northstar Unit.

presenting that there is a new attitude — a new effort by the industry — to bring offshore fields on line.

Mr. Obeney talked about new philosophies and new attitudes within the companies. As he stated in his summary of the presentation on the Northstar Development Project, the field was discovered by Shell in 1983 and remains undeveloped today because of its location, small size, and projected economics of development. It remains, however, one of the best opportunities to develop remote offshore oilfield in the Beaufort Sea. A new philosophy regarding marginal developments has emerged from work within BP over the past 18 months. BP now believes that fields such as Northstar can become commercial opportunities, capable of competing effectively with the rest of the world for investment dollars. Further, he pointed out that such developments can occur without material impact to the ecosystem and without threats to traditional lifestyles and cultures. BP is focusing on *Alignment* of all the stakeholders, *Simplicity* in design and project execution, willingness and commitment to *Change* business processes, and application of appropriate *Technology*, new and borrowed. Lastly, he described how these levers can be

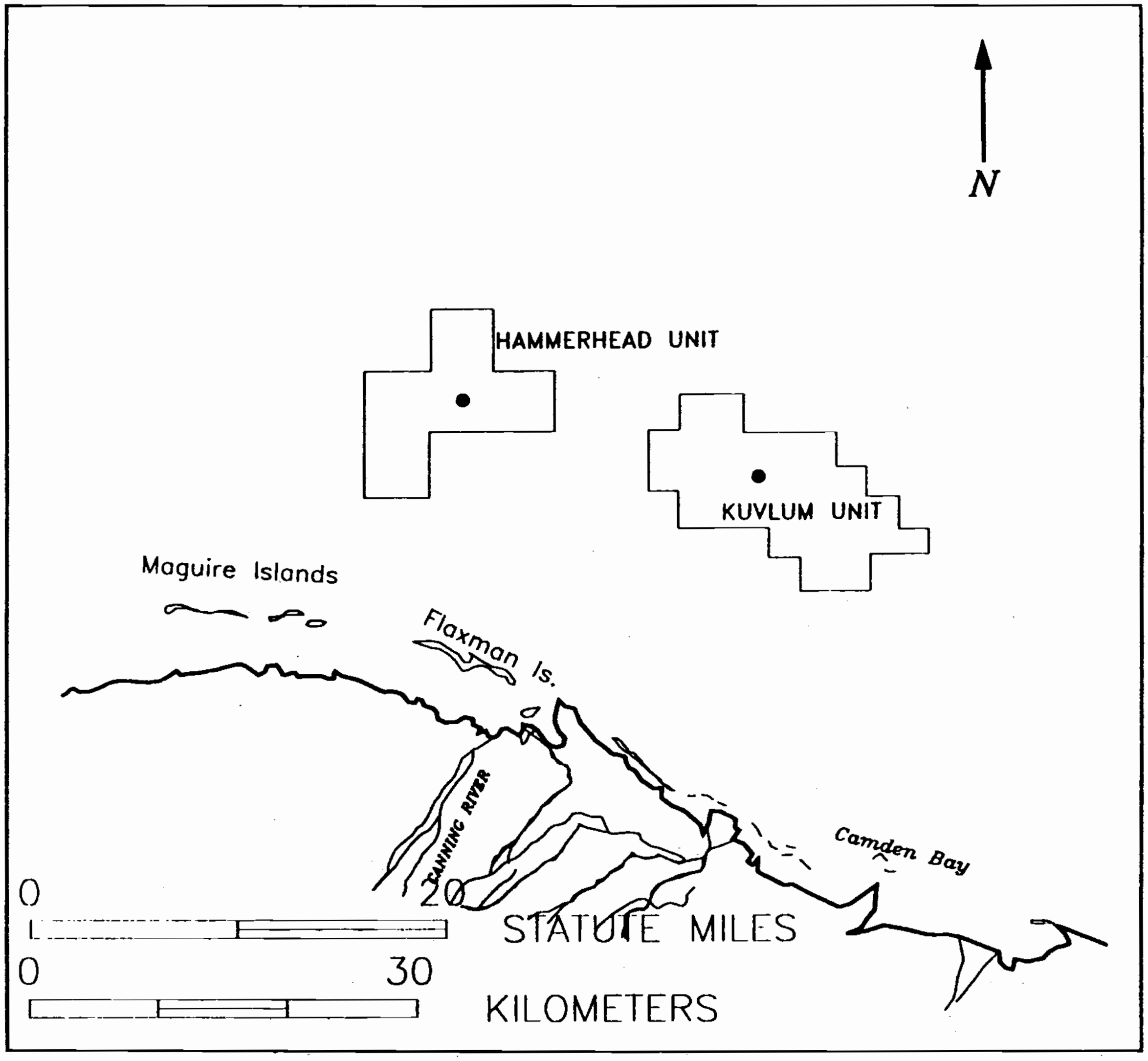

Figure 3. Location and shape of Hammerhead Unit and Kuvlum Unit.

brought to bear on the challenge of developing Northstar and other marginal fields.

Mr. Watt described similar engineering designs, using the term "leveraged technologies." As he stated in his summary of development options for the Kuvlum Unit, their engineers are focusing on low cost marginal development approaches. A study in 1993-1994 focused on the use of a permanent bottom-founded production platform structure and a crude transport system consisting of a trenched pipeline. The results indicated the proposed production system was technically feasible but reserves in the 500-600 million barrel range would be necessary for a stand- alone development. Union Texas investigated the application of a subsea development and the use of existing drilling structures for developing Kuvlum. These low cost development methods and other leveraging technologies could produce fields in the 300 million barrel range. Lastly, he pointed out that a joint development, sharing the costs of infrastructure, similar to ETAP in the North Sea, could be the most leveraging concept for the eastern Beaufort Sea discoveries.

Mr. Vanderkooy also talked about looking at new information and applying it to new technology, or even new information and applying it to old technology. As he stated in his summary of a Canadian perspective on Arctic offshore production, during the past 20 years of exploration activities, it has been demonstrated that year-round safe and efficient operations can take place in the Arctic offshore environments. He pointed out the significant database of expertise and technology that has been developed and that can be applied to production scenarios. His conclusion is that offshore development in the Arctic region can be economically attractive. His assessment is based on the fact that many changes have taken place especially with respect to design ice loads, structural concepts, and operating costs. He concluded that the technology is now available to develop a reservoir in the order of 200 to 300 billion barrels located in the Beaufort Sea, using marine transportation to ship crude oil either directly to the market or via the Trans Alaska Pipeline System (TAPS).

Mr. McKeehan talked about the feasibility of laying Arctic pipelines and options for development of Northstar. As he stated, initial studies focused on transportation of oil and gas out of the Arctic in tankers. These ideas have fallen out of favor now in terms of risk. The focus has shifted towards pipelines which have significantly higher reliability. He pointed out that the risk to pipelines, of course, is ice scour. The scour depth will determine the depth to which a pipeline must be buried below the seabed. The depth must be great enough so that ice keels won't contact the pipe when they plow or bulldoze over it. He expects a scour depth of about 3 m or 10 ft based on the information shoreward from the Northstar Prospect.

He added that the depth of the trench would range from 3 to 4 m (9 to 12 ft). The main expense would be for excavation. A very interesting excavation method appears to be working in mid-winter; cutting the ice with trenchers, using a backhoe on the ice to excavate the trench, and then laying the pipe into the trench. He described an installation option that is commonly referred to as the bottom tow or bottom pull. The pipe is assembled on land or on ice in strings that are about two or three thousand feet long. A pull barge is stationed just offshore with large winches which are capable of exerting about 400 tons of pull load on a cable. The cable literally yanks the pipe off the shore and ice, sliding it along the sea bottom. The next pipeline string would be assembled and this process would be repeated. Lastly, he pointed out that it is useful to consider what makes the Arctic, from a pipeliner's perspective, different than any other conventional area in the world. His answer was: logistics, ice, permafrost, unique soils, and a unique sociocultural situation.

All of these introductory speakers acknowledged that the industry is working to move marginal fields onto development, to apply new technologies, to develop alliances and partnerships. The tone was set that we, as the agency and the stakeholders, need to look forward to the future. We need to be cognizant of development issues and how they relate to environmental work, environmental studies, and environmental concerns.

Dr. Steve Langdon, Chair, Sociocultural Session

There are a couple of comments that I would like to make pursuant to the sociocultural and socioeconomic session, relating to one of the points that was made during Mr. Sverre Pedersen's presentation. The society on the North Slope is a mixed subsistence and cash-based society. Both the subsistence opportunities and the ability to have employment and have cash incomes are crucial. Both make possible a good standard of living — it no longer has to be one of the most impoverished areas in the nation.

Also, the population is increasing and especially the immigrant population is increasing. Questions about employment are important. This past week, the Alaska Federation of Natives entered into a new agreement with the Department of the Interior about the issue of employment on the Alyeska Pipeline. If you review the old commitments that were made at the outset of the Alyeska Pipeline with regard to the amount of Native hire that was to occur, you'll discover that over this period of time, as Alyeska has admitted, they have not come close to the kind of employment system that they had promised. Let's get ahead of the curve with offshore oil development — recognize that there are some long-term employment and income circumstances, and get to work on training and implementing the kind of working relationships that can sustain a mixed cash and subsistence society for a growing and expanding population.

Mr. Frank Long, Whaling Captain, Nuiqsut

I appreciate being part of this very important meeting. I would like to thank MMS for inviting several of the whaling captains from the North Slope. All of the issues and topics that were discussed are very important and familiar to not only MMS and industry but also to us — the subsistence hunters.

We are very familiar with the area. For instance, when we talked about ice, one thing that wasn't mentioned about all of the experiments and studies was that currents move the ice more forcefully than the wind. The currents are a very strong force. They can knock down ice ridges, like large waves.

Other people described the development plans for the new Beaufort Sea prospect called Northstar. It is important, we know, to have enough oil for everyone. It is also important that we learn to work together. We could, as Natives, support industry and the agencies that work on this — if they will also support us in our subsistence way of life.

I appreciate being here with "you all" as I know they say in Texas. Again, thank you for letting us participate in this meeting.

Dr. Thomas Albert, Chair, Bowhead Whale Session

The first point I would like to make is that having a separate Bowhead Whale Session illustrates the importance of this animal in the Beaufort Sea. It is not only a very large animal — especially if you are trying to cut one up — but also politically and culturally it is very large. This does not detract from any of the other animals. If satisfactory protections are given to the bowhead whale, most of the other animals can, as I look at it, ride along on the bowheads' "coattails," one way or another.

The second point is that I want to thank MMS, and, in particular, Dr. Cowles and Dr. Newbury, for having the Synthesis meeting in the first place. It is a good idea to bring people together and to make as much sense as possible out of conflicting views and lack of data — just to try to figure out what we now know and what needs to be studied further.

The third point is that research on the bowhead whale, as has already been stated, has been done by different groups. The major groups of stakeholders who have really contributed to this are not only the MMS, the National Marine Fisheries Service (NMFS), and the oil industry, but also the Native community through the North Slope Borough (NSB) and the Alaska Eskimo Whaling Commission (AEWC). Many groups are helping, but we need to keep one other thing in mind; a group that is far away is watching all of this — the International Whaling Commission (IWC). They are keeping an eye on what is going on in the Beaufort Sea and the Chukchi Sea. Sometimes they perceive industrial activity as representing a threat to this animal; sometimes they seem to perceive the threat as becoming significant. If so, they will probably take steps to reduce the subsistence harvest quota to further protect the animal. So, this is one of the reasons that the NSB and the AEWC are so vigorous in trying to make sure that industrial activities are conducted safely.

The fourth point seems obvious from the presentations — we are very concerned about underwater industrial noise. The major pollutant, from the perspective of the people who live up there, is noise.

The fifth point is that there are two very divergent views about the effects of industrial noise, and particularly, the noise from marine seismic exploration. For one view, we have a limited series of scientific studies with a few data that were analyzed as best they can be. On the other hand, we have the observations of people in three different villages for about fifteen years. Their view is the same in all three villages: when there is noise from industry operations and particularly, seismic noise, something happens to the whales. Namely, they are just farther offshore. This is a clear issue for MMS to help resolve.

Another point is to remember who are the major stakeholders. The major stakeholders are the bowhead whale itself, the people who depend on it, the oil industry, conservation groups, and various others. We should remember which stakeholders have been there the longest. That doesn't mean that the stakeholders who have shown up recently have no right to be there. It just means that out of common decency you shouldn't "rattle the apple cart" too hard.

As a whaling captain pointed out, let's try to get the job done; everybody wants the oil, so the development stage is going to start. But get it done in a safe way, which is not necessarily the most cost effective. We heard a lot about cost effective ways; but when you say it many times, it starts to sound like "cutting corners." If an accident is going to happen, it will probably occur during "normal" weather, which is extremely bad — not during the time when most photographs are taken, which is when the weather is nice. You don't see good weather very often. Response to a catastrophe up there is going to be horrendous. So, if you want to do things in a cost effective way, you have to remember that the Beaufort Sea is a very unforgiving place. This is one reason for the regulatory agencies, and to some extent, the NSB and the State of Alaska, to be very concerned; it is their job to enforce good regulations.

I think that we have had a reasonable overview of the Bowhead Whale Session and other relevant information. Some really good research has been done on tagging, noise studies, industry monitoring, etc. Operations need to be done in a manner which is "cost effective" and also "environmentally sound." And let's not forget all the stakeholders. There are other people also who subsist on the bowhead whale. We had a representative from Canada where people depend on this animal. They are planning to become more active in hunting this animal for subsistence. Also, the Native people in Chukotka (Russia) are going to resume the hunting of this animal.

Overall, I think that it was a good meeting. I thank you again, Drs. Cowles and Newbury, for letting me participate.

Ms. Lori Quakenbush, Chair, General Biology Session

I, too, noticed a difference in this meeting from some of the previous meetings, although I don't know if my observations are the same as Dr. Cowles. One of the things that I noticed, especially in the biology session, is that MMS used to be a lot more active, funding large studies; these meetings used to bring together many MMS Principal Investigators who talked about their studies. In the General Biology Session of this meeting, we had no presenters show data from recent MMS-sponsored projects in the Beaufort Sea. The opposite was true, of course, in the Bowhead Whale Session — but that wasn't the case in the General Biology Session.

It appears to me that OCS development in the Arctic is something that will definitely occur. Everything that we have heard in this meeting makes it sound like the technology is there and the interest is there; we are just talking about a matter of time. My fear is that at the same time that we are moving in that direction, we are also downsizing, cutting budgets, and restricting the amount of research that is being done — the amount of baseline information that is being collected. The situation reminds me of our biggest regret about the Endicott Development Project. This is an example of a baseline database with only one year of pre-construction information. This relates to what Dr. Albert just said — that it is a very variable ecosystem. One year of data means almost nothing to us. We probably have 12 years of data after the causeway construction; but when we compare that to our baseline of one year, we don't understand how the ecosystem worked before construction, so we can't say what construction has impacted. I guess my fear is that we are headed in that same direction with OCS developments. I would advocate that we need to consider collecting more baseline information now for the Beaufort Sea development areas so that we don't end up in the same situation — trying to collect data simultaneously with development. We don't have much lead time now, but this is the time to get started, to gear up, and to collect some of that information that we know we are going to need and that we are going to regret not having if we wait.

My specific recommendations would be that MMS should consider long-term studies to collect baseline data. There are some examples of things that could be done that would head in that direction and that wouldn't necessarily be expensive, new studies — such as syntheses of existing studies. One example would be a compilation and synthesis of all fish data that has been collected in the Beaufort Sea development areas.

One of the themes that we heard throughout this meeting is that we need to incorporate more Native knowledge and combine it with the science for a better understanding of the region.

Another specific idea is a baseline on contaminants studies. We have measured high levels of cadmium and mercury in some of the marine bird and mammal species. Ms. Anne Dailey showed that cadmium and mercury are both components in drilling muds. So, it would be really important to get a baseline for those types of metals in the ecosystem now before we have a lot of discharges. We will want to know whether we are looking at baseline levels of contaminants in these species, or if we are looking at metals that they are picking up because of further exploration and development.

Also, something that we are all concerned about is improvement in the technology of cleaning up oil spills in ice-covered environments. It is not an easy thing to do but there could be improvements in that field. Prevention is always a good place to start, and there has been a fair amount of work helping to prevent the spills. But we still need to look at spill clean up in ice-covered and broken-ice situations.

I would also like to add that when regulatory agencies don't have sufficient information — information the agencies need to develop stipulations and mitigation to protect fish and wildlife and their subsistence uses — the agencies end up having to err on the side of the conservative. That is the reason we ask for greater monitoring requirements and for things that appear unreasonable or even hostile to development. The more information that we have, the better we can regulate.

Dr. Richard T. Prentki, Chair, Physical and Geological Session

One of the major themes has been the importance of interannual variability. It was mentioned in people's talks throughout the meeting. There are many things which do not seem to change annually, such as basic ocean circulation. But this is partly due to limited observations. Simulations of interannual circulation with models are one way to better estimate variability. We know the ice changes from year to year. It is not only the amount of ice in the ocean, but where it is. We saw this in the two talks on ice forecasting. There is interannual variation, but it cannot be detected in a one-year scientific study. Also, you never have a typical year in the Arctic: there is no such thing.

Another point I noticed is that there is concern about aspects of scale. We are talking about development at specific sites which are "oceanographically" close to shore — within a few kilometers from shore. Previously, when we worked with lease sale issues, we were talking about entire planning areas and vast distances. The way in which we treated circulation models would be entirely different than the way we would look at one development site that is close to shore. Oil spill statistics, for example, would have to be modified to adapt them to specific development projects, taking into account pipeline length.

Also, as we get closer to development of small projects, we are concerned about different issues. For example, with muds and cuttings discharges, we have a general permit for the entire area during exploration, which might mean three or four wells in the same area. However, at a production site you are going to have a couple of hundred wells — although maybe there won't be any discharges of muds and cuttings.

Ms. Anne Dailey pointed out that under the current permit that was reissued a year or two ago, industry re-injects the drilling muds at Endicott. The discharge is very slight — only domestic and sanitary waste. The major discharges are re-injected, including produced waters. This is important because water quality issues have been a major emphasis with the public in Alaska during the last few years.

GENERAL COMMENTS

Cleve Cowles: In the first session we heard that there is flexibility in engineering design and in addressing new economic situations for development. We also heard about the very substantial information base regarding the effects of seismic noise on bowhead whales. We tend to study the whale and we tend to study the behaviors of whales in relation to noise. However, we heard that the effects are still a major issue. We assume that the seismic source is a constant. I think there are people here that perhaps could discuss this subject. New findings from the satellite tagging studies shows that there may be some distinct depths within the ocean that the whales tend to use. Perhaps we need to examine the engineering of seismic equipment, thinking of ways that they may be redesigned to minimize the propagation of sound in the depth strata used by whales.

Jack Lentfer: There was a lot of talk about stakeholders early in the meeting and it was mentioned again in the summary. It seemed to me the concepts pertained mainly to industry and the Native community; there weren't many comments about the environmental community nor of the public as a whole. I think they need to be brought into the discussion. We have people all over the country and all over the world that have an interest in the Arctic and what is happening there. I would consider them a major stakeholder also.

Another point is that industry representatives talked about alliances with government and Native groups. I can see that might be of value, working together early. However, I think that the government has to be careful about entering into alliances. They should maintain a slightly different position because they have an overview responsibility so that they can effectively regulate and enforce. This, it seems to me, should be more the role of government rather than entering into alliances right from the beginning.

Cleve Cowles: Thank you, Dr. Lentfer. I think that is a point well taken about the definition of stakeholders and public. I think it is a question that confronts all government agencies, whether they are at the federal, state, or local level. It is a question that we are looking at. This meeting is perhaps focused on the Alaskan stakeholders, but there are other ways of gaining public input through, for example, comment on our draft five year programs. Other stakeholders will be addressing, in fact very soon, the federal budget, so that will also have an influence on the future of the program and its specific goals and purposes.

Grant Walthers: I would like to encourage the corporations, the State of Alaska, and the federal government to consider the other circumpolar nations and the Pacific Rim nations that are impacted by all of these issues. My suggestion would be, that before any new policies are initiated, scientists be brought together in a major forum. Also, the Inuit of some of these circumpolar countries should be involved. They have had some circumpolar conferences, but has their input been brought into these types of issues? Further, note that Russia and Japan have advanced ice breaker technology. Norway has extensive oil development. Sweden and Finland have extensive experience in Arctic design. And the British have North Sea developments. I think we should give this creative and serious consideration.

Cleve Cowles: The same thought occurred to me when we were talking about ecosystem management. Obviously, the Fish and Wildlife Service is making an effort to organize on ecosystems basis; some of the boundaries were along the international lines. I am sure that they are integrating their program — as is MMS — with international organizations. It is an important concept that it is occurring at a lot of different levels than the individual and federal level. In the academic community there is international dialogue. We do need to keep that in mind if we are truly systems managers.

Charles Greene: I am aware of a new Arctic research project that will be of interest to the participants in this meeting and that should be part of the record. This is a proposed study of the ocean processes of the Arctic Ocean — the oceanographic, mesoscale circulation patterns, the ocean and the ice. It will be done using sound transmission across the Arctic Basin. The sound is in a coded wave form; during reception, the variability in time and amplitude will reveal information about the temperature/structure, and the water motion (the eddies) within the Basin. This is a Russian, Canadian, and U.S. international project. It is not just a plan, they had a pilot study, an actual experiment, in the spring of 1994. I am sure you are going to hear more about this. It will contribute to he kind of information Dr. Kate Hedstrom needs for her circulation modeling and it may interest the biologists.

Cleve Cowles: I would like to thank the many participants, and particularly our organizers — Dr. Tom Newbury of MMS and Ms. Kathy Mitchell, of MBC Applied Environmental Sciences — for making the meeting as interesting as it has been. Again, I would like to thank our session chairs and presenters for some very excellent contributions; and, of course, the attendees who, in a true interdisciplinary sense, have shown interest in all areas of discussion.

Judy Gottlieb: I do want to congratulate you on your enthusiasm, for having so much curiosity, and for having as many questions the last few minutes as you did the first day. I appreciate everyone's hard work on this meeting. We had a good representation from across the state, from around the country, and internationally. Specifically, I want to thank MMS Director Quarterman and Ms. Deborah Williams, Secretary Babbitt's Special Assistant, for attending. I also want to express appreciation to Dr. Langdon and to Dr. Albert and others who have said many positive things about MMS. That is a nice change from the past.

I think I might have been the first person to use the word "stakeholder" at the start of this meeting, but I don't regret that. I heard a lot of people say during the meeting that we all do have to work together. We talked about communication. We all know what that means — the two-way exchange of ideas. I think we all used this opportunity to really make that happen and will continue to do so. Many of the things that we heard, the ideas we've heard, are the sentiments we've heard as we travel and meet throughout the state — those ideas we've tried to incorporate not only in the meeting, but in the way we do our work.

Opening Remarks

OPENING REMARKS

Dr. Cleve Cowles, Chief,
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This Arctic Synthesis Meeting, sponsored by the Alaska OCS Region of the Minerals Management Service, is the sixth major information meeting since 1978 dealing with the status of information on the Beaufort Sea. In the past, the emphases have been focused on pre-leasing information needs and issues, however, we plan to focus this meeting on information about potential development areas in the central coastal Beaufort Sea, such as Northstar, Kuvlum, and others. A session on industry plans will be followed by sessions on sociocultural information, bowhead whales, general biology, and physical oceanography. The meeting will conclude with a synthesis session, when our session chairs will distill the essence of their presentations and discussions.

I would like to add that science-based decision making is one of the policy objectives of the Minerals Management Service. As part of that process, our Alaska program recently released its Environmental Studies Strategic Plan for Fiscal Years 1996 and 1997. The goals, purposes, and background of the Environmental Studies Program are in that document. In keeping with the planning themes of the Alaska Environmental Studies Program, which are Mission, Quality Science, Partnerships, and Responsiveness, please let us know any environmental studies which you would recommend to be included in our future considerations. Of particular relevance, as you think about the future for the OCS program in Alaska, would be the new draft proposed five-year leasing program and, of course, the essence of this meeting.

Before I introduce our first speaker, I would like to recognize Dr. Tom Newbury, who has coordinated the development of the agenda for MMS, and Ms. Kathy Mitchell, from MBC Applied Environmental Sciences, who, once again, has ably assisted MMS in setting up the meeting logistics.

That concludes my introductory remarks, now please welcome our first speaker, Judy Gottlieb, the Regional Director for the Alaska Region.

Judith Gottlieb
Regional Director
Alaska OCS Region
Minerals Management Service
Anchorage, AK 99508

I am also pleased to welcome you to our Arctic Synthesis Meeting. The last meeting of this type was about two years ago: that's too long, so it's now time to renew our relations and to look forward and plan for the future.

I'm pleased to see so many familiar faces and, in particular, many from the North Slope Borough (NSB). Not only are there distinguished representatives from the North Slope Borough, but we're also happy to have representatives from the villages and whaling captains. Maybe we should schedule these meetings more often to occur right after the Alaska Federation of Natives' Convention.

I'm equally pleased to see such a good representation from the oil and gas industry, academia, consulting firms, Federal and state agencies, and other organizations. This large diversity of interests gives me confidence that this meeting will be successful in helping MMS identify what needs to be done to address potential future oil and gas activities in the Arctic.

This morning there will be several speakers who will review what's happening with North Slope leasing, exploration, and development activities. I would like to briefly review the activities of the Minerals Management Service. The Alaska Outer Continental Shelf Region has been undergoing a substantial down-sizing — from 149 to 85 positions. Over the last year we've been able to achieve our reduced staffing levels and yet maintain the core expertise, knowledge, and skills necessary to maintain our proposed lease sale activities, to prepare technically sound Environmental Impact Statements (EIS) and resource assessments, to conduct multi-disciplinary environmental studies program, and to assure that post-lease activities are conducted in a safe manner. We have recently consolidated our Anchorage offices on to the third floor at the University Plaza Building, and are in the process of structuring our organization based on these reduced staffing levels. These efforts will help improve communication among staff and result in a more focused team.

The next proposed lease sale in the Beaufort Sea, Number 144, is tentatively scheduled for September 1996. The draft EIS is currently out for public review, and the comment period ends November 15, 1995. We recently conducted workshops in Kaktovik, Nuiqsut, and Barrow on ways to review and understand the environmental assessment process. Public hearings on the draft EIS will be held in these communities the first week in November, and in Anchorage on Thursday, October 26.

Last February, the Department of Interior announced that we would defer the proposed Chukchi/Hope Basin lease sale, originally scheduled for June of 1997, until the next five-year program. This was a result of low industry interest, as well as concerns about potential environmental effects. As part of this sale effort, the MMS worked with our counterparts in the Russian Far East to hold a simultaneous lease sale in the area. The Russians have also deferred possible lease offerings in this area. Although the sale activity was deferred, we have held seminars and workshops with the Russians on our environmental assessment techniques, geological and economic modeling for resource evaluation, and conveyance of mineral rights. Additional workshops may be conducted that would address other aspects of our program, including the public process.

The draft proposed Five-Year Oil and Gas Leasing Program for 1997 to 2002 was published in August. The public comment period ended on October 10. The program includes five proposed lease sales in Alaska: a small focused sale in the Beaufort Sea in 1998, a Cook Inlet/Shelikof Strait sale in 1999, an area-wide sale in the Beaufort Sea in 2000, Gulf of Alaska sale in 2001, and a combined Chukchi/Hope Basin sale in 2002. Comments are still filtering in, but so far comments have been generally supportive of the draft program, although there are some issues and alternatives that we need to review and consider.

To help with development of the proposed five-year program in Alaska, we proposed an Alaska Regional Stakeholders Task Force. This Task Force was formed by the OCS Policy Committee — the same committee which advises the Secretary of Interior on the offshore program of the Minerals Management Service. Mr. Jeff Walker will be giving a more complete review of the task force.

My priorities for a successful OCS program in Alaska include more outreach efforts with our stakeholders to resolve potential conflicts. Mr. Walker, who I just introduced, has moved into a full-time position on my staff as an Outreach Coordinator to improve and facilitate these efforts. Incorporation of indigenous knowledge into our decision making process, and establishing broader relations with Alaska Native and tribal interests, are also high priorities.

I personally have traveled through quite a few of the coastal communities around the State — those which might be affected by our program — to meet with Native and tribal leaders and to hear concerns first hand. I, and my staff, have also participated in the Inuit Circumpolar Conference, Alaska Federation of Natives Convention and other conferences, met with groups, such as Rural CAP, to improve our understanding of acquisition and use of traditional knowledge. We have also made initial contacts with the Alaska Native Science Commission and other community leaders, and are currently working to assure that this knowledge is incorporated into our Environmental Impact Statements. And, of course, at two of the sessions at this meeting, the Sociocultural Session and the Bowhead Whale Session, we have invited speakers from the villages to present and discuss their traditional knowledge in these areas.

In the future, new initiatives, creative solutions, new alliances and partnerships will be used with development of existing marginal fields. You will be hearing about these in the following presentations. I am optimistic about the future of the OCS Program in Alaska, especially in the Arctic. The Arctic continues to be an area of interest to industry. There is general support at the state level for our program, and the NSB has expressed a desire to work with us to resolve potential conflicts. I look forward to working with all the stakeholders of Alaska who have concerns. The future of the program will depend in large part on improved communication between us and our stakeholders. The identification of problems and development of solutions must include everyone. I think this meeting is a good opportunity for that communication. I encourage you to participate in the meeting and discussions. I wish you success in working together, discussing the available information and building open communication.

I will now introduce our Minerals Management Service Director, Cynthia Quarterman. Ms. Quarterman has traveled to Alaska three times in the last year and a half, and we do appreciate that!

Cynthia Quarterman
Director
Minerals Management Service
Washington, D.C. 20240

I, too, would like to welcome you to the Arctic Synthesis Meeting. I am particularly pleased to be here with you this morning and to see such a broad representation of the Alaska Native community, the oil and gas industry, and the other constituents with whom we work on the OCS Program.

I, like most of you, am here for the next few days just to listen and to learn. The Alaska OCS Region is a very important part of our Nation's offshore minerals management program, and this synthesis meeting is an important step for us, helping to determine the environmental studies and information needs to support both pre-leasing and post-leasing decisions in the Alaska OCS.

Science-based decision making, as was mentioned earlier, is the foundation on which the OCS program should be and will be built. This synthesis meeting is an important part of building that foundation, and I thank you for coming here to help us build a sound foundation.

The Alaska OCS Region was formed in October of 1975 with promising new lease sale areas with very high potential — potential for large discoveries and for near-term development. Unfortunately, the results so far have been discouraging. However, there have been substantial discoveries in the Beaufort Sea; our own resource estimates and the responses to our last Five-Year Program show that industry continues to be interested in that area. So we continue to believe that there are opportunities here.

The Alaska OCS Region — with 17 lease sales, 81 exploration wells, and over $250 million in environmental studies — may not be the frontier area than it was 15, 10 or even 5 years ago; but new technologies, like three-dimensional geophysical interpretative techniques, are paving the way for new analyses of the information that may show oil and gas resources which were hard to identify in the past, or were perhaps even invisible. We've seen this happen in the Gulf of Mexico and we expect that to be the case here in Alaska.

New technology and the partnership approaches that will be discussed this morning are important to cutting costs to support marginal field development in Alaska. So despite the discouragements that have occurred in the past, we expect a glowing future for the Alaska OCS area.

Of course, the OCS Program, to be successful, has to be built on open communications, as was mentioned earlier. The Alaska Regional Stakeholders Task Force, we believe, is a good first step in that endeavor. That group has begun to pull together all of our multiple constituents and to discuss the problems and concerns of the Alaskan community with OCS development — and to try to resolve those concerns. Both Ms. Gottlieb and I share the same objectives of providing the best customer service possible, of listening to all of our constituents, and of having open communications. We want to not only listen, but to resolve disputes, and then to make our decisions based on sound scientific information. Improvements in communications and resolution of disputes are as an important as improved technologies in the success of the Alaska OCS region.

Alaska may not have the level of production that there is in the Gulf of Mexico nor is it the frontier area that it was years ago, but in the future we see potential development on the horizon. While leasing and exploration and development may continue, we expect operations to be more focused, more reserved, because of lower oil prices and because of opportunities in the international community. I would encourage you, as you listen over the next two and a half days, to keep in mind those things.

I will be here for the next two and a half days, and if anybody would like to ask me questions, I would be happy to answer them. Thanks again and welcome.

Introductory Session

THE NORTHSTAR DEVELOPMENT PROJECT

A Challenge of Innovation and Relationships
One Vision of the Door to the Future

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BACKGROUND

The Northstar field was discovered by Shell in 1983 with the drilling and testing of the Seal Island #1 well. Several more wells, drilled by Shell and Amerada Hess between 1985 and 1994, confirmed the reservoir was of modest size, a little over 100 million barrels, and economically unattractive. The field lies offshore, outside the barrier islands in a water depth of 12 m (40 ft). The reservoir zone is found at a depth of 3,400 m (11,000 ft) and covers an area of 3,600 hectares (9,000 acres) on state and federal leases. Well productivities are expected to be relatively high with field offtake estimated at 50,000 barrels per day from about 25 wells, including injection wells. BP acquired its current interest and operatorship in the field by purchase of the interests of Shell and Amerada Hess earlier this year. Murphy Oil is the only other partner with a small interest, approximately two percent by area.

WHAT WILL IT TAKE TO DEVELOP NORTHSTAR?

A typical paper on the subject of oilfield development would devote the rest of the available space to description of the physical development plan, lists of hardware, pipeline sizes, process description, number of wells, and production forecasts. The future of North Slope onshore and offshore development, indeed the future of Alaska's economic prosperity, will depend on our ability to think and work in a different way.

"Success does not come the way we think it does, it comes from the way we think."

This paper is therefore devoted to a different view of the future - one vision of the way ahead for the oil business in Alaska. Table 1 contains an outline of the possible development scope for interested readers.

CORNERSTONES OF SUCCESS

The cornerstones for successful development of Northstar, and marginal fields in general are:

- Alignment
- Simplicity
- Ability to Change
- Technology

These have been listed in their order of importance and degree to which they can leverage the outcome. This may not appear too intuitive as technology-based companies, such as BP, typically put technology at the top of the list and usually fail to recognize the dramatic step-changes that can be achieved with alternative approaches to apparently intractable

Table 1. Northstar development scheme(s) characteristics.

• 25± wells drilled from a single drill site
• A drilling/production structure Gravel island Caisson retained gravel island Existing mobile structure (CIDS, Molikpaq, SSDC, etc.)
• Pipeline(s) Single or multiple Hot or cold Buried (trenched) or partially elevated on piles Drilled (shallow or deep)
• Process facilities New Northstar-specific, onshore or offshore Gas and produced water re-injection Seawater injection for improved recovery Option for use of existing facilities Prudhoe Bay Lisburne Milne Point Endicott
• Infrastructure Shared or new Logistics Air Barge Hovercraft Ice Road

problems. This paper will unfortunately only scratch the surface of these ideas but will hopefully provide a stimulus for others to discuss this issue. Taking each in turn:

Alignment

Simply, this is need to explicitly align all stakeholders in the Northstar development. Stakeholders means BP and its partners: the people of the North Slope; state, federal and local governments; industry; contractors; and the public in general. This can appear a daunting task until we break it down into logical elements.

For the people of the North Slope, regulatory agencies, and the general public, we have to be able to address all of their concerns and issues to their satisfaction. There will be no development if this is not achieved. The logical way to do this is *early involvement and integration* of interested parties in the development planning process. Only by learning together can all the parties feel true ownership and confidence in the outcomes. On Northstar we have voluntarily offered to submit the project to an Environmental Impact Statement (EIS) process. Historically, we would have fought such a process for costs and schedule reasons, arguing that an Environmental Assessment was adequate. Acknowledging the sensitivities that surround an offshore development, we are now trying to jointly develop an efficient, timely process with the affected constituencies to reduce the cost and time burdens of the EIS. We aim to avoid duplication of costs by performing "normal" engineering studies concurrent with the EIS scoping and alternative analysis. Similarly, all project team meetings are open to the participation of all regulatory agencies and on many occasions agency staff have contributed during the brainstorming sessions as full members of the project team. By this process of early involvement, integrated workplans, and open dialogue, it is possible to align the interests of all parties around a single outcome.

We are also involved in early discussions with the State of Alaska to better align our commercial interests to ensure optimum development of all the reserves in the area. This might involve *flexible lease terms* to incentivize development of incremental reserves through continued investment. HB-207, recently passed by the State Legislature, is an illustration of the kind of thinking it will take to align government and industry.

We are also in the process of developing a new "technology," the technology of alignment of our contractors and suppliers. The term "alliance" has been overused and abused in reference to relationships with our contractors. Often those arrangements are just another way for the oil producers to succeed at the expense of their contractors. A true alliance, one of the type developed for Badami and under development for Northstar, *explicitly links the profitability* of all involved in the project, with a clear sharing of commercial risk based on the expectation of sharing the benefits of outstanding performance. All parties view the alliance as an opportunity to create business that would not otherwise exist. It is one thing to design a multi-party incentive scheme and quite another to develop a shared vision of the future and shared commitment to succeed. The key to success in creating alliances is in the selection process - selecting people and companies who see strategic value in what we are trying to achieve, can share a common goal, and have the ability and desire to "think outside the box."

It is difficult, but possible, to align the interests of all stakeholders. The most difficult thing for all to do is "listen," particularly when we carry with us the baggage of past experience and relationships. It is only through nurtured relationships that the aspirations of all parties can be understood and incorporated into a development proposal.

Simplicity

"Any problem, no matter how complicated, when looked at in just the right way, can be made ever more complicated."

The oil business in Alaska is a classic example of how we solve technical problems by making the simple, complex. Often when faced with the challenge of cutting capital costs, we attempt to do the same complex thing more cheaply. The key to success is to eliminate that which is not absolutely necessary. We often design facilities full of "nice-to-haves." By looking to other parts of the world, the Gulf of Mexico and Northern Canada, we can see that similar problems are addressed in very different ways. Both of these areas have thrived in an intensely competitive environment by focus on key goals and simplifying their business process.

A paradigm of the past is that constructing basic, simple facilities may reduce capital costs but increase operating costs and decrease reliability. We now believe the opposite is true.

By reducing the complexity and amount of process equipment and eliminating spare machinery, we can:

- reduce maintenance costs (fewer things to fix);
- reduce the number of operators (multi-skilling is more possible);
- improve safety (fewer people exposed to safety hazards and plant is more easily understood by all);
- increase uptime (fewer things to break and fewer instruments to malfunction), and
- decrease environmental impact (smaller footprint, less emissions, less waste, higher reliability).

The Ferrari is more fun but the Chevy is fit-for-purpose.

Ability to Change

> *"The ability to change faster than your competitor may be the only true, sustainable competitive advantage."*

The story behind BP's re-thinking of development of marginal, or economically challenged, fields emerged from the thoughts of Joel Barker (futurist) - "The key to paradigm shifts is the answer to the question: what is impossible today, but if possible, would dramatically change the future of your business?" By seeking the answer to that question we have uncovered a fresh way of approaching North Slope development problems. One that is as much based on a state of mind and philosophy as it is based on engineering and design. Northstar was impossible a year ago, but possible today.

On Northstar we are committed to reducing the costs of development from $1.5 billion (the previous estimate based on studies by Amerada Hess) to around $300 million, a five-fold reduction. We are confident we can achieve this based on recent Badami studies where the costs of development have been reduced from about $800 million to below $400 million (and counting). In fact, our most recent estimate confirmed we have already identified 90% of the savings required. Most of these reductions have come from an alignment with new and existing contractor companies. This sort of alignment can only be generated if oil companies are willing to relinquish some control and re-invent the project management process.

> *"Younger people learn more quickly than older people. Not because they have a greater ability to learn, but rather that they have less to un-learn."*

Project management, in the traditional client-contractor model, is dead as we know it. The paradigm has shifted and we are "back to zero" discovering a new way of relating. That can only occur when the parties are not only willing to change, but actively seek out the opportunity to change. We have attempted to acknowledge and honor the past, while avoid being chained to it.

> *Insanity: to continue to do things in the same way, while expecting to achieve a different outcome.*

Therefore, previous project management techniques, designed to manage, control, and audit suppliers and contractors are inappropriate when the parties are truly aligned.

Technology

New technology will continue to be an important lever for improving our business. In the near-term, however, technology is more likely to produce incremental, continuous improvement in our business rather than step-change. The continued push to drill ever higher departures, horizontal wells and multi-lateral wells (a single hole from the surface, branching to many different well locations) will create new opportunities to increase oil recovery and lower development costs.

A larger near-term lever to improve performance is by borrowing technology from other locations or even from other industries. In the words of Woodrow Wilson: "We need not only all the brains we have, but all we can borrow."

For Badami we are borrowing cold, buried pipeline concepts from Canada and the ability to operate cheaply without roads from other offshore locations. In the process plant itself, we have a lot we can learn about unmanned operations, instrumentation and control systems from other, non-petrochemical process industries.

SUMMARY

The outlook for further new oil field development on the North Slope is bright. New types of relationships are being forged which create alignment of vision and purpose. With an aligned commitment, we will all share in the joint success - if we are prepared to change.

QUESTIONS AND DISCUSSION

Tom Newbury: Is it much more expensive to build and maintain a pipeline offshore than onshore? For example, what would be the relative cost of an offshore pipeline from Badami to Endicott as opposed an onshore pipeline?

Terry Obeney: That is a very tough question to answer. Mainly because I would have to really know a lot more than I do know about the development costs. One of the things that we are discovering as we look at these fields, is that we take our existing database and we make comparisons between alternatives. We come up with a preferred solution which we think is the cheapest, most effective solution. We then find, once we start giving our contractors more input into the design process, that the whole database changes. So we don't really know whether the scheme we selected was the best one so we go back to the beginning again. So we are in a continual process of reinventing the database, the cost database. My current feeling is that offshore pipeline construction ought to be quite cost effective, more cost effective than, perhaps, onshore locations. If you are looking at an onshore hot pipeline that you have to elevate out of the permafrost, for example, and if you are able to lay a pipeline offshore in something more than five or six feet of water depth where the permafrost doesn't exist, the key issue is going to be burial depth. That will vary from location to location even though you might be in relatively shallow water. It might be more prone to ice scouring in one location than another. So burial depth is going to be a big factor on pipeline costs. So unfortunately, there is no simple answer to that. I think, historically, the costs that we have carried for offshore pipelines have been way too high. But that is generally true of everything we are looking at now. There are simpler ways of doing things.

Tom Newbury: Thank you. Mr. Obeney, you mentioned alliances and cooperation. Would you briefly describe the federal and state agencies that are cooperating on the EIS for the Northstar Project?

Terry Obeney: On a federal level, most all of the federal agencies are involved in the EIS process: the U.S. Army Corps of Engineers, Environmental Protection Agency, Minerals Management Service, National Marine Fisheries Service, and Fish and Wildlife Service. State agencies have been involved; but there is still negotiation as to how the actual EIS process will play out. We are anxious to get all those negotiations to a close so that we can go through the bid process to get the EIS contractor in to do the work. The agencies are, in effect, having their own negotiations over the process. We are having them involved in the development planning process, independent of the EIS process. But when we actually get down to the nuts and bolts engineering, we want to do it concurrently so that there is only one set of studies done for actual design purposes of the facilities and alternatives comparison for the EIS.

KUVLUM UNIT - DEVELOPMENT OPTIONS

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INTRODUCTION

In the fall of 1992 oil was discovered at Kuvlum. Two offset wells were drilled the following year. Present efforts are directed toward understanding the distribution of the reservoir quality rock over the structure and formulating viable methods of development. The eastern Beaufort Sea/North Slope area has had a number of exploratory discoveries (Figure 1). These fields on a stand-alone basis are considered as either marginally economic or completely uneconomic to produce given the existing infrastructure. A joint development of the fields may be a viable development approach for this area.

The Kuvlum Field is located offshore of northeast Alaska in the Beaufort Sea. It is 60 miles east of Prudhoe Bay Field and 12 miles offshore. The average water depth is 105 feet. Kuvlum is a large hydrocarbon bearing structure with more than 40,000 acres of structure closure and a large oil column. Three wells have been drilled on the Kuvlum structure locating a good quality oil productive reservoir sand. The distribution of the sand is not adequately understood. This remains the subject of future seismic, sedimentological, and paleontological studies.

Concurrent with the effort to achieve a higher confidence level on the reservoir, the engineering focus is on low cost marginal development approaches that could be utilized in the Kuvlum arctic environment. A study of Kuvlum development undertaken in 1993-1994 focused on the use of a permanent bottom-founded production platform structure and a crude transport system consisting of a trenched pipeline. The results indicated the proposed production system was technically feasible but reserves in the 500-600 million barrel range would be necessary for a stand-alone development. Union Texas has investigated the application of a subsea development and the use of existing bottom-founded structures for developing Kuvlum. These low cost development methods and other leveraging technologies could lower the threshold field size to the 300 million barrel range. A joint development, sharing the cost of the infrastructure, could be the most leveraging concept for the eastern Beaufort Sea area discoveries and could lower the commercial reserve threshold even further.

BACKGROUND

Union Texas has in the past year focused on low cost marginal development approaches that could be utilized in the Kuvlum arctic environment. This paper will summarize the development approaches that have been considered and some of the leveraging technologies that may have application. The North Slope area has had a number of exploratory discoveries (Figure 1). Prudhoe and Kuparuk fields have driven the development of the infrastructure and have allowed the development of nearby fields, many of which would be uneconomic as stand-alone fields at current crude prices. As Kuparuk field has moved the infrastructure to the west, no stand-alone field has moved the infrastructure to the east where Kuvlum is located.

The Kuvlum Unit (Figure 2) is about 51,000 acres, of which about 47,000 acres are leased by Union Texas. The average water depth at Kuvlum is approximately 105 feet, and the area is in the multi-year sea ice zone. Kuvlum is a large hydrocarbon bearing structure with more than

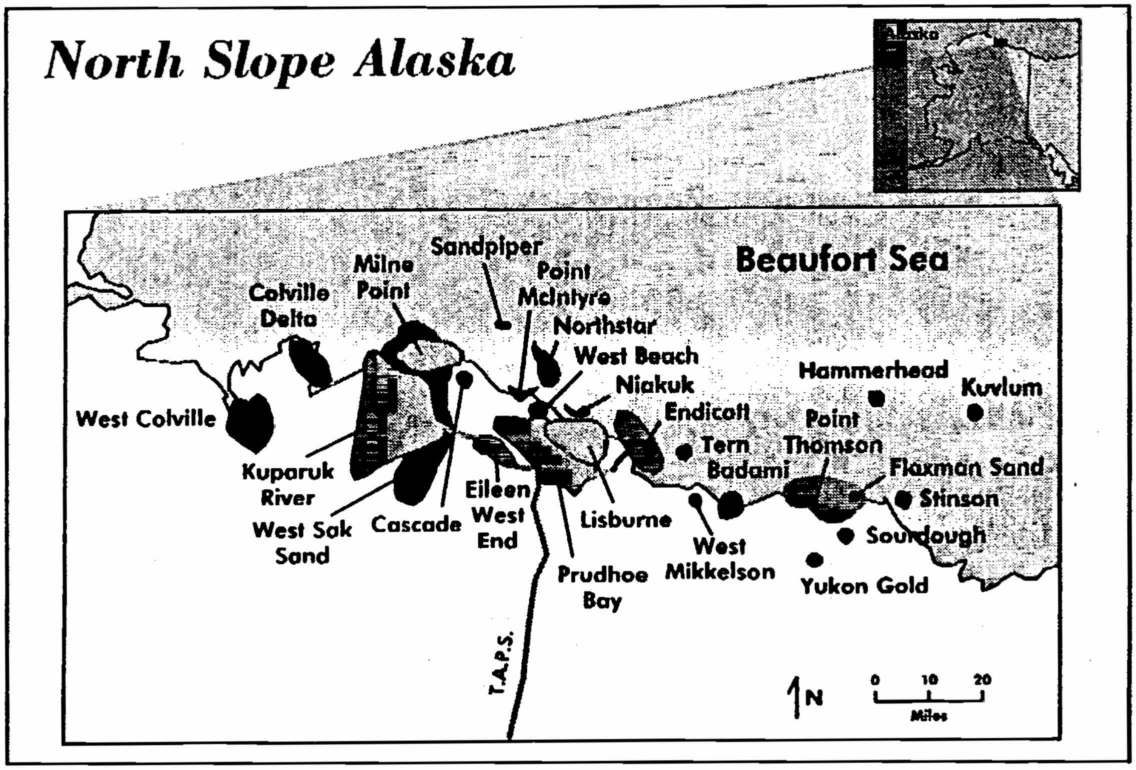

Figure 1. Discoveries - North Slope Alaska.

40,000 acres of structure closure and a large oil column. The discovery well, Kuvlum # 1, encountered good quality oil productive reservoir sand. Offset wells, three miles to the southwest and one mile to the north, had variable quality oil sands. A drill-stem test in the Kuvlum # 1 produced 3,400 barrels of oil per day of 34 degree API gravity oil. Reservoir analyses indicate that the sand is capable of producing quantities exceeding that drill-stem test. The major geologic risk is reservoir continuity. The Kuvlum reserves are noncommercial on a stand-alone basis.

A question that Union Texas needed to answer was "Why Retain Kuvlum?" The major reasons were as follows:

- Good Reservoir Sand and Large Structure
- Potential for Improving Infrastructure
- Improving Technologies
- Improving Fiscal Terms

The good reservoir sand encountered in Kuvlum # 1 and the size the Kuvlum structure are key in the retention of the Kuvlum Unit. However, there is a lot of uncertainty due to the variable quality of the sand and the difficulty of mapping the sand. This reservoir uncertainty causes a wide reserve range. The range is nine million to 350 million barrels of oil. There is a 90% probability prediction that the reserves are within that range. An improvement of the understanding of the reservoir continuity from future seismic, sedimentological, and paleontological studies will hopefully reduce the reservoir risk.

Union Texas feels that there is potential for improving infrastructure to the eastern area of the North Slope. The eastern Beaufort Sea/North Slope area has had a number of exploratory

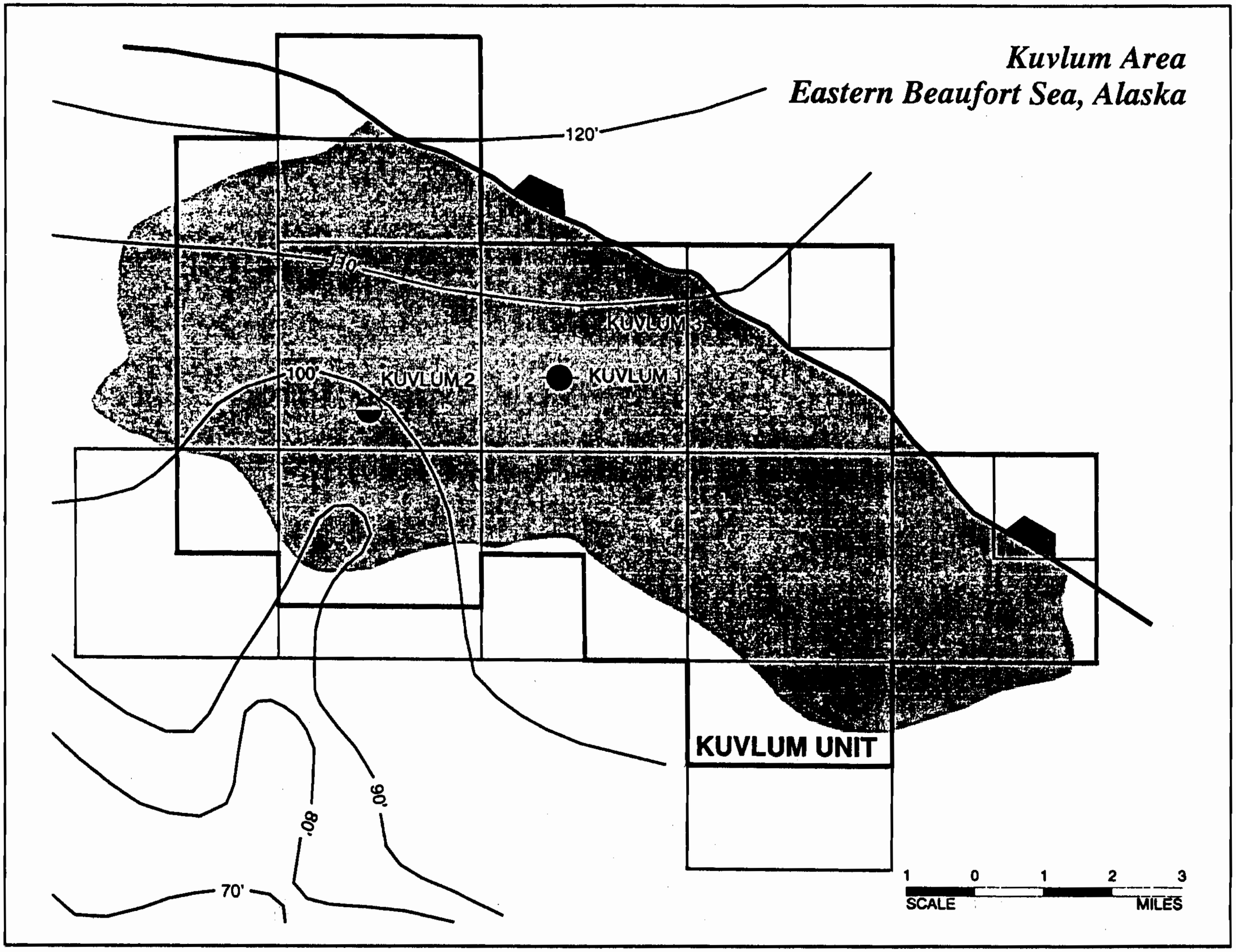

Figure 2. Kuvlum unit.

discoveries (Figure 1). BP has announced Badami as a potential development which would move the pipeline infrastructure approximately 28 miles to the east. There are a number of discoveries in the Point Thompson vicinity and a major reserve potential could exist in the Alaska National Wildlife Reserve (ANWR). Although these discoveries are marginal or uneconomic on a stand-alone basis, a new large stand-alone discovery or joint development of the existing accumulations may allow development of the area.

Union Texas is focusing on what can be done to develop smaller accumulations. Improving technologies may play a key role in achieving this objective by reducing cost and project risk. Some of the leveraging technologies for Kuvlum will be reviewed as a separate topic, but better contractor alignments, changes in design criteria and generally lower costs will need to be realized. A 100 million or 200 million barrel field cannot support the operating approach of a four billion or 13 billion barrel oil field.

There have been indications that the Alaskan Beaufort Sea fiscal terms could be enhanced. The recent modification of the Jones Act allowing Alaskan oil to be exported is a step in the right direction to improve the commercial aspects of Alaskan oil. Fields like Kuvlum in the hostile Arctic OCS should be able to obtain royalty relief to improve economics. This type of royalty relief has been given for Gulf of Mexico deep water marginal accumulations, and the same logic should apply for the Beaufort Sea. Furthermore, modifying the Jones Act to allow non-U.S. dredgers and other equipment to be readily used in the Beaufort Sea should enhance North Slope competitiveness by reducing the cost of development.

DEVELOPMENT OPTIONS

Union Texas is focusing on low cost marginal development approaches that could be utilized in the Kuvlum arctic environment. Three general development options have been reviewed:

1) Subsea
2) Existing Bottom-Founded Vessels, and
3) Purpose Built.

A study of Kuvlum development undertaken in 1993-1994 focused on the use of a permanent bottom-founded production platform structure and a crude transport system consisting of a trenched pipeline. The results indicated the proposed production system was technically feasible; however, reserves in the 500-600 million barrel range would be necessary for a stand-alone development. This purpose built option is not a viable option given the Kuvlum reserve range.

Subsea applications and the use of existing bottom-founded vessels were the focus of the investigation. The potential lower cost of these methods of development could allow a lower reserve range (i.e., 200-400 million barrels) to be viable. This work is still in progress so the results are preliminary. The expected arctic ice loads and potential ice scour depths were studied as they relate to the application of both the subsea and existing vessels options.

In drilling wells in the Beaufort Sea, a glory hole is dredged or drilled with a Tornado bit. For example, the Tornado bit will drill a glory hole 20 to 24 feet in diameter and a depth of ±40 feet. The purpose of the glory hole is to protect the blow out preventor (BOP) stack if a large ice berg approaches the well location (Figure 3). The potential scour depth would be less than the top of the BOP stack, so the integrity of the BOP stack would not be affected. This technique was used in drilling the Kuvlum wells.

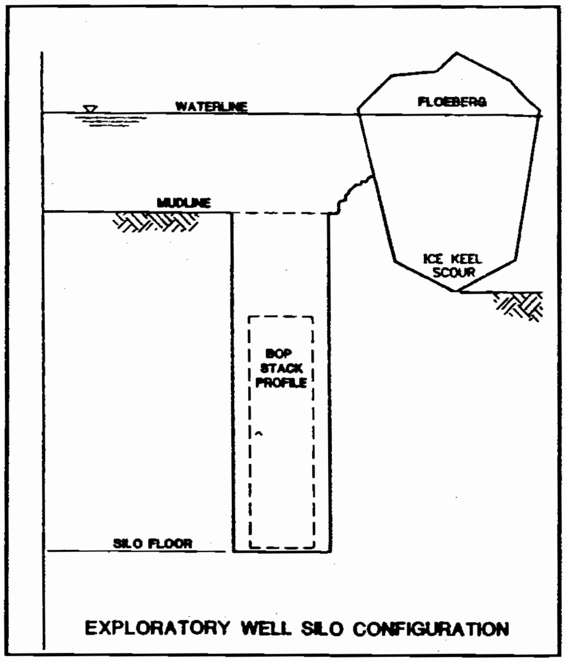

Figure 3. Exploratory well configuration.

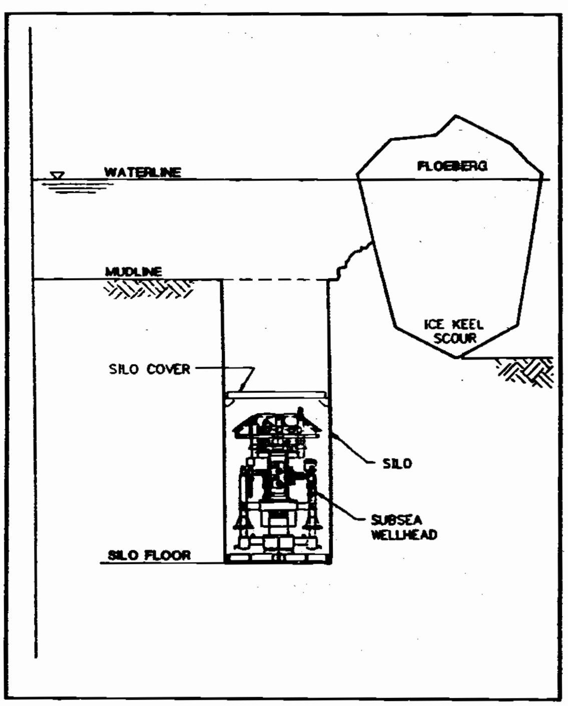

Figure 4. Completion tree in silo.

This same glory hole technique could be applied to subsea trees as shown in Figure 4. The thought of the use of the glory hole as a silo spurred a transfer of technology from the North Sea. Silos are used in the North Sea at times to prevent subsea trees being exposed to anchors, fishing nets, etc. Also, the advancing technology on subsea processing and pumping could be applied. For example, it may be technically feasible to place the subsea processing within the glory hole. All of the equipment could go down below the expected scour depth.

Kuvlum may require one to three wells to further appraise the field. In a marginal development the use of these wells for future production will be important to minimize development costs. One approach to utilize these wells would be to use the Tornado bit to provide a pathway from each individual glory hole. This could allow the wells to be interconnected using a "cookie cutter" technique with the Tornado bit (Figures 5 to 7). Although the "cookie cutter" approach could be feasible for individual glory holes, a dredger to lay out the area for the manifold and pipelines to shore would be better utilized.

Another marginal development approach investigated the use of existing bottom-founded vessels. The bottom-founded vessels considered were the Single Steel Drilling Caisson (SSDC) from Canmar, the Concrete Island Drilling Structure (CIDS) from Global Marine, and the Molikpaq from Beaudrill. All of these vessels are for water depths ranging from 50 to 80 feet. Since the water depth averages 105 feet at Kuvlum, a subsea berm is necessary. Berms and gravel islands of this size have been constructed; the Uviluk berm would be very similar. Figure 8 shows the development concept using the SSDC. The appraisal wells could be drilled prior to the berm construction and be utilized via a caisson rising through the berm. This concept also has a conduit for the pipelines on the sea bed. The conduit and caisson would be installed prior to dredging the berm and setting down the SSDC.

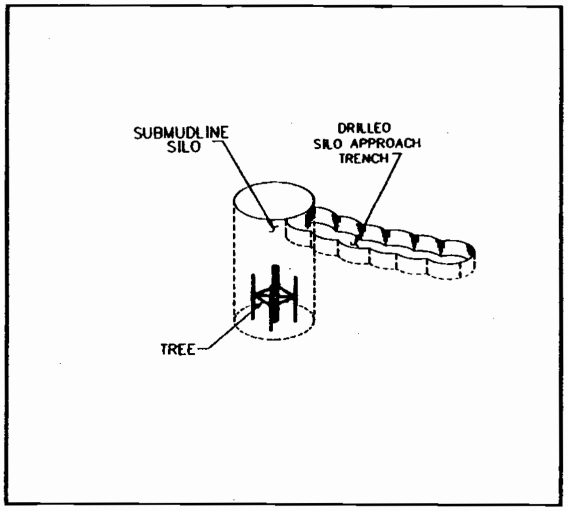

Figure 5. Single silo subsea completion.

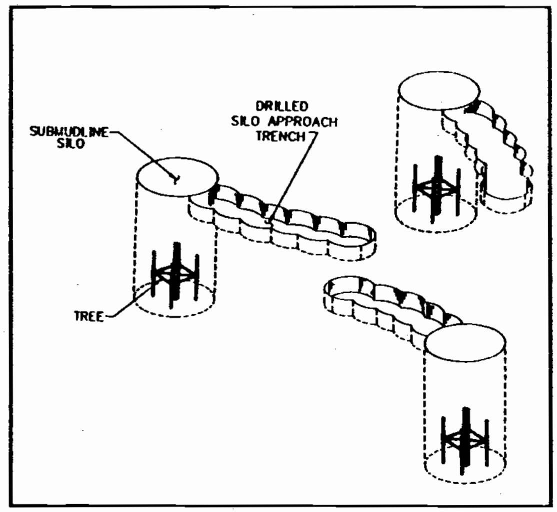

Figure 6. Multi-silo subsea completion.

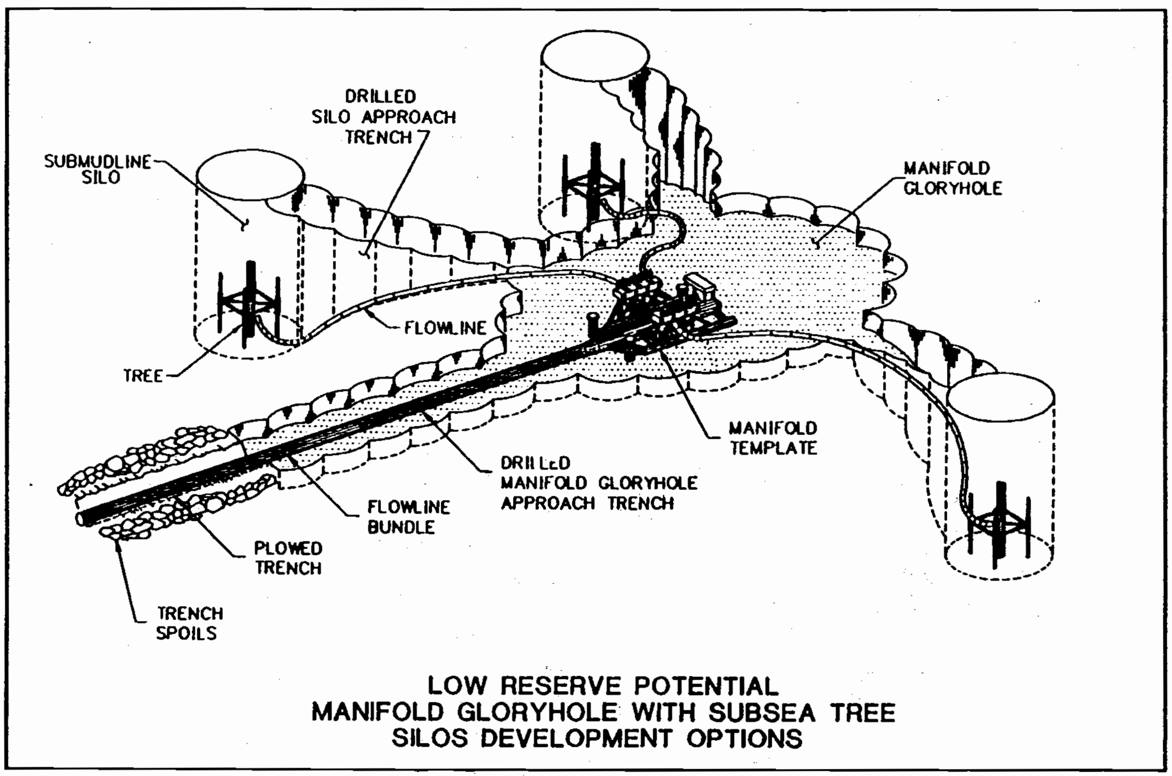

Figure 7. Subsea system.

The subsea and bottom-founded vessel options lower the capital costs because a new purpose built structure is not required.

KUVLUM SSDC DEVELOPMENT

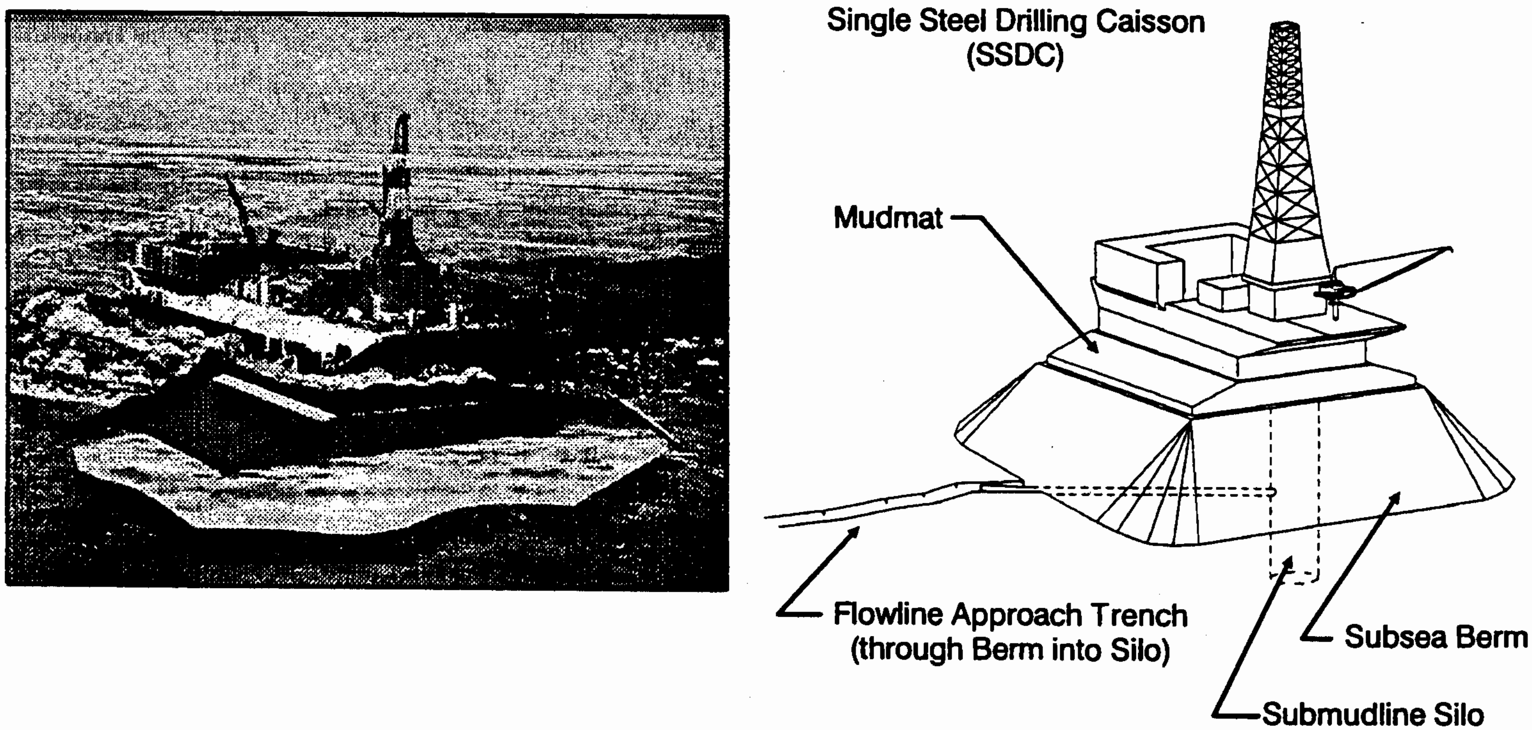

Figure 8. Bottom-founded vessel concept.

TECHNOLOGIES

As stated earlier, improving technologies may play a key role in achieving development of the smaller accumulations especially those in the Beaufort Sea. Given the basically flat oil price of recent years, the commercial goal can only be achieved by reducing cost and project risk. The application of technologies from around the world can be leveraging in reducing cost and risk. A few leveraging technologies that might have application for Kuvlum are:

- AVO
- High Departure Wells
- Downhole Splitter Technology
- Horizontal Well Technology
- Subsea Processing
- Partial Processing
- Multi-phase Pumping
- Normally not manned or minimally manned facility operation

The prime geological risk is reservoir continuity. The use of Amplitude versus Offset (AVO) is one technique that may have application at Kuvlum. Given the Kuvlum crude quality along with the sand quality, this technology may be applicable to attain better reservoir definition. Lowering this major risk could allow confidence to move further forward in the appraisal process.

The use of high departure wells is critical to lower development costs. To reach the entire reservoir from one location would require just one development structure. The structure cost is a major component of the total development costs. On the North Slope, a high departure well is normally equal to 2 to 1: that is, if the vertical depth is 7000 feet, the existing technology can reach to about 14,000 feet. The departures being considered for Kuvlum are 3-4 to 1. In some areas of the world, these departures are being achieved. As this technology develops on the North Slope in the next five years, it may have application at Kuvlum.

The use of a downhole splitter can also save drilling costs. This technology allows the upper well bore to be used for two laterals being deviated from different depths and/or directions in the reservoir. The splitter technology can substantially lower costs especially for the high day rates that are typical in the Beaufort Sea.

Horizontal wells can reduce the number of wells required to develop a field and have higher flow rates. The application is field specific. At Kuvlum, flow rates three times what would have been achieved from vertical wells might be possible. Also with improved drainage, fewer wells would be necessary. The application of this technology is very leveraging in reducing the costs.

Subsea processing, partial processing and multi-phase pumping are production facility related and could be utilized at Kuvlum. Subsea processing was touched upon in the subsea approach. Partial processing and multi-phase pumping could be applied in the subsea or bottom-founded vessel approaches. A partial processing facility offshore could separate enough gas to run the satellite facilities. The rest of the production could flow or be multi-phase pumped to shore where existing facilities could be used.

Normally not manned or minimally manned facility operation is important in keeping operating costs to a minimum. Since the Arctic is a tough environment, fully automated facilities will be utilized as much as possible.

SUMMARY

In spite of these technologies, the current accumulations in the eastern Beaufort Sea/North Slope are not large enough for stand-alone developments; that is, no one accumulation is large enough to support all the infrastructure. A joint development or shared cost approach may have commercial potential. A joint development is probably the most leveraging approach that can be used for development of the eastern Beaufort Sea area.

QUESTIONS AND DISCUSSION

Jeff Walker: Would you comment on the trade-offs for some of those technologies, such as subsea completion versus bottom-founded structures, and for horizontal versus vertical drilling technology? Where would one be more beneficial over another?

Jim Watt: Part of my career was as a production engineer, so I would say that ideally you want access to the well bore. That is an advantage of a bottom-founded vessel — where you can access the well bores and work them over as the productivity dictates. With subsea completions, if you have poor performance, you might have to shut in the well until you can move in at a later date and work over the well. That is the main trade off.

As for the horizontal versus conventional drilling technology, we don't see any real disadvantages with horizontal. It is a cost and performance question. It is necessary to attain adequate reservoir data and perform reservoir modeling, which will indicate the reservoir performance with horizontal or vertical drilling.

Tom Newbury: Are there complications that arise when oil from many reservoirs is combined in the same pipeline? You mentioned the existing pipeline infrastructure and its possible extension to Badami. What would be the complications if oil from Kuvlum or the Yukon Gold Prospect flowed into the same pipeline?

Jim Watt: You are going to have crude blends. So with proper design — in terms of volumes that would come from each field — the pipeline and pumping stations can handle those problems.

STATE OF ALASKA LEASING PROGRAM AND UNIT RESPONSIBILITIES

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Among its various duties the Department of Natural Resources' Division of Oil and Gas is responsible for conducting the state's oil and gas leasing program and for managing the exploration and production units that may eventually be formed from the leased tracts. Today's talk will provide an overview of the state's new five-year leasing program and of the existing units within Alaska's Arctic region.

Five-Year Oil and Gas Leasing Program

At the beginning of each new legislative session the Department of Natural Resources is required to present to the state legislature an updated five-year oil and gas leasing program. The five-year program presented to the legislature in January 1995 included 11 lease sales proposed through the year 1999. Since its issuance, the five-year program has undergone some revision (Figure 1), resulting in one sale being placed on hold (Sale 79, Cape Yakataga), the addition of a Cook Inlet sale (Sale 74W) and a rescheduling of two other sales (Sale 80, Shaviovik and Sale 85A, Cook Inlet).

Lease Sales in the Arctic Region

Currently there are five sales scheduled for Alaska's Arctic region, the first of which is Sale 80, Shaviovik. On September 6, 1995 the Director, Division of Oil and Gas, issued a decision to proceed with this sale, which is scheduled for December 5, 1995. Sale 80 consists of over 951,000 acres divided into 202 tracts, lying predominately between the Trans-Alaska Pipeline System (TAPS) and the Arctic National Wildlife Refuge (ANWR), with additional acreage around Gwydyr Bay, Foggy Island Bay, and between the Prudhoe Bay and Kuparuk River oil fields.

Sale 86, Central Beaufort Sea, scheduled for April 1997, is predominantly an offshore sale extending from the Canning River west into Harrison Bay. Sale 87 is an onshore sale that will make available for leasing nearly all unleased acreage on the North Slope. It could consist of approximately two million acres, making it the largest sale the state has ever conducted. Sale 87 is scheduled for March 1998. Two other offshore sales, Sale 83 and Sale 89, are scheduled for March and December 1999 respectively and will offer all unleased state submerged acreage in the Beaufort Sea between Point Barrow and the Canadian border. Depending on an outcome of United States v Alaska, Supreme Court, No. 84, Original, that is favorable to the state, lagoonal waters adjacent to ANWR and the National Petroleum Reserve Alaska (NPRA) will be offered in these two sales. If included, this will be the first time these lagoonal areas have been offered in a lease sale.

Public Notification Process

The Division of Oil and Gas has developed a public notification process that includes no less than four public comment periods for each regularly scheduled sale. According to state statute, a lease sale must appear on the five-year program a minimum of two years. Figure 2 gives the public notification schedule for each sale on the five-year leasing program. Sales located within the Arctic region of Alaska are highlighted.

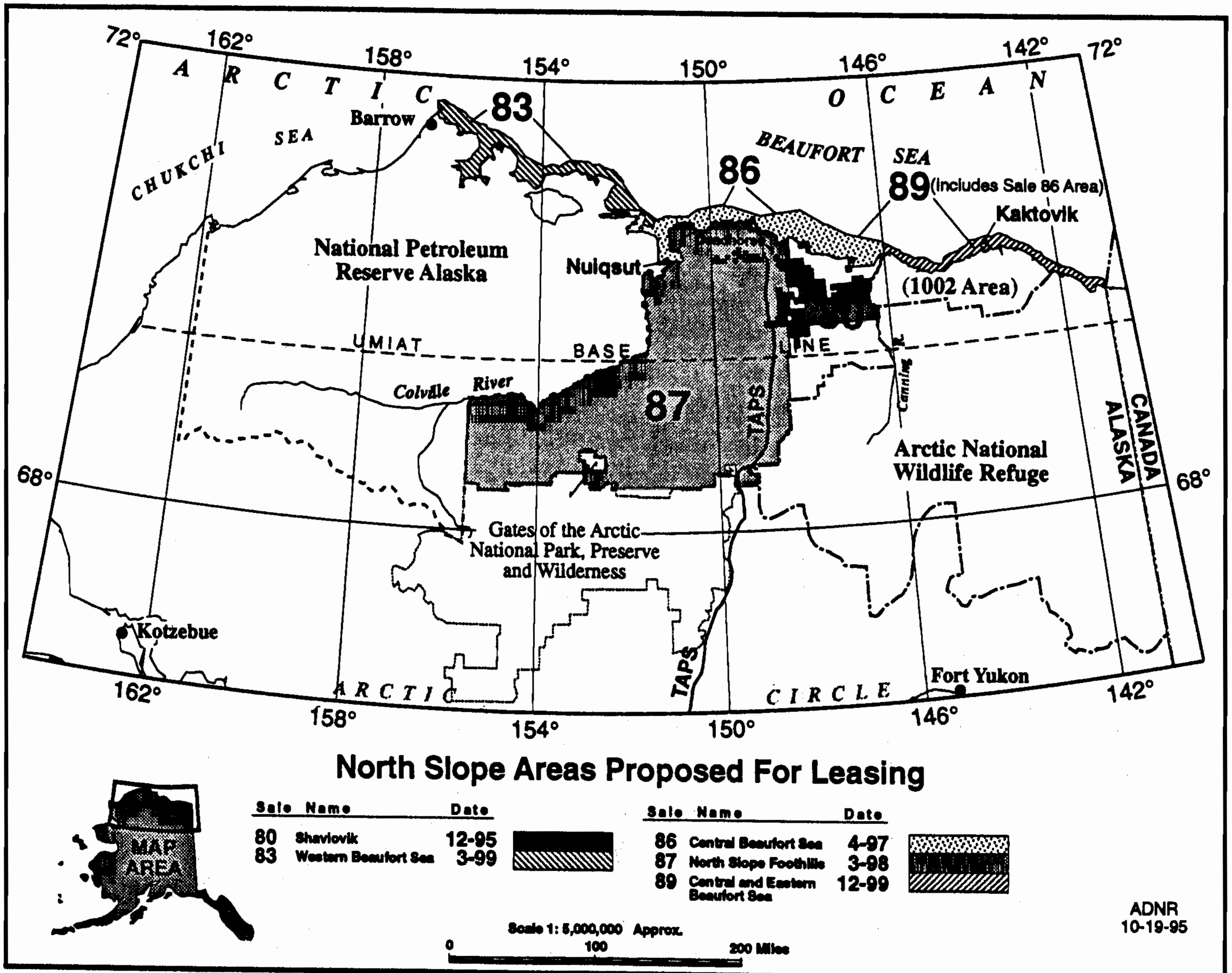

Figure 1. North Slope areas proposed for leasing.

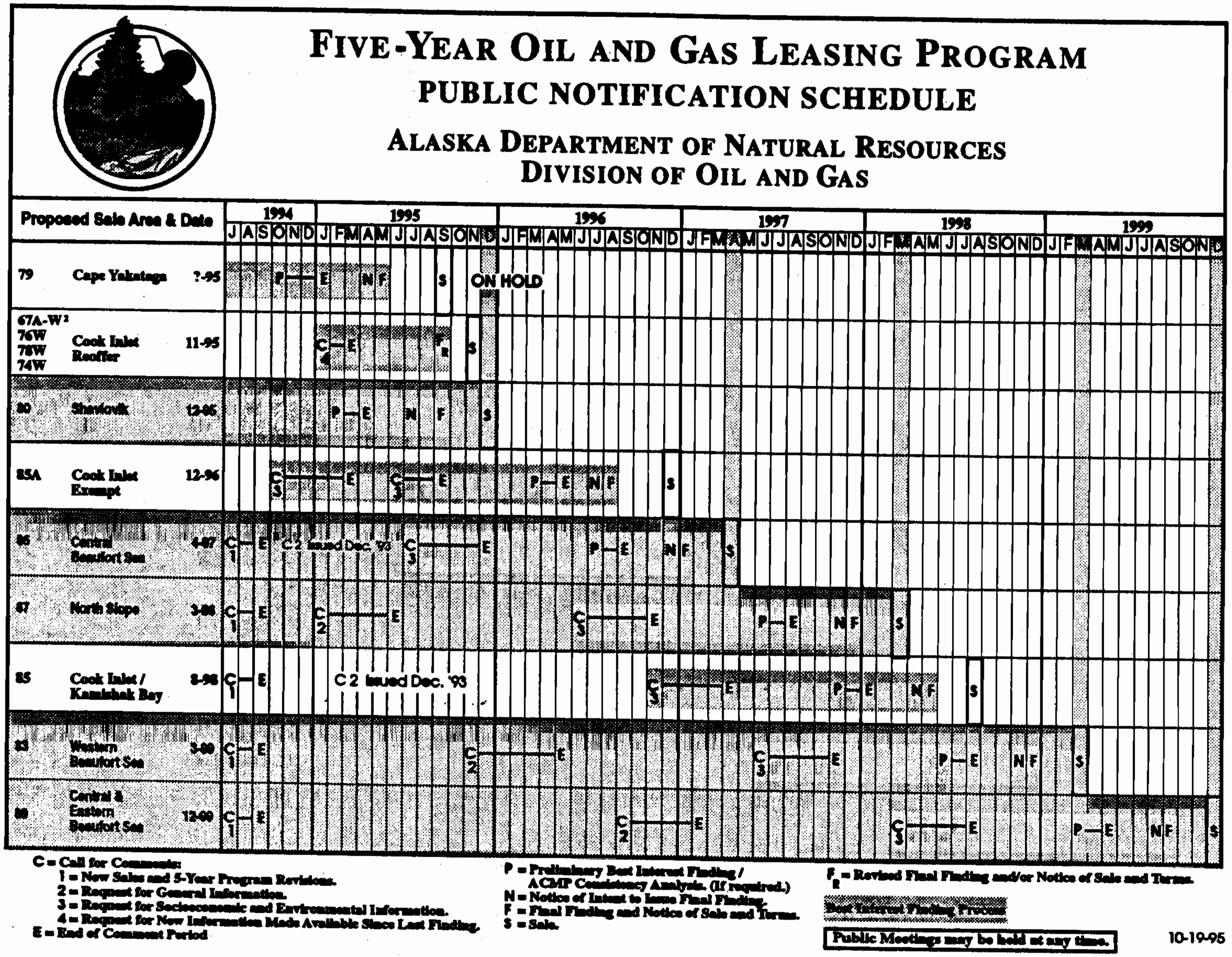

Figure 2. Five-year oil and gas leasing program public notification schedule.

Every two years, approximately nine months prior to adding lease sale areas to the five-year program, the division issues a Call for Nominations to industry requesting input on what acreage should be offered for leasing. Information provided by industry helps structure the leasing schedule. The needs of each company differ, and the division tries to accommodate those needs as best as possible. Recent changes to the public notification process has resulted in the division requiring more time to prepare for each lease sale. As a result, the division has had to reduce the number of lease sales it can offer. To compensate for this reduction in the number of sales, the division has proposed larger sale areas to ensure that all available acreage that is nominated for leasing is included in the five-year program.

After receipt of industry's nominations the division develops the new leasing schedule and, upon approval by the Commissioner of Natural Resources, issues a Call for Comments on these proposed additions. This Call for Comments normally occurs about six months prior to releasing the five-year program; the public has two months in which to comment on these additions. A Call for Comments has wide circulation. It is sent to many state and federal agencies, local municipalities and boroughs, representatives of the oil industry and the environmental community, Native organizations, and individuals who have expressed an interest in the state's leasing program. After a review of the comments received, necessary revisions are made and the new schedule is then made public.

Approximately three to three and one half years prior to a scheduled sale the division issues a second Call for Comments requesting general information on the sale area. This request is mainly to remind the public that a sale is being planned for that area. The public comment period following this Call is approximately five months. Within two years prior to the sale a third and final Call for Comments is issued requesting specific information on the sale area. The division requires information on various topics that, by law, must be discussed in a Best Interest Finding, including wildlife species and habitat, current and projected uses of the sale area, cumulative effects of oil and gas activities on the environment and local communities, and the fiscal effects on local communities. The public is given five months during which they may supply the division with information and comment on these and other topics.

This final call for comments begins the division's best interest finding process. State law requires that the director of the Division of Oil and Gas find that the lease sale is in the state's best interests before it may be conducted. This final finding and decision by the director must be issued at least 90 days prior to the lease sale. Six months prior to issuing the final finding, a preliminary finding is released followed by a 60-day public comment period. During this comment period the division schedules at least one public hearing, more if they are requested. Though this is the only time in which the division conducts its own public hearing, division representatives attend hearings conducted by local governing bodies throughout the public process.

An important component of the best interest finding is an explanation of the mitigation measures, which are designed to alleviate any adverse effects of oil and gas exploration and development. These mitigation measures, which must be consistent with the Alaska Coastal Management Plan (ACMP) and with local borough and municipal coastal management plans, are developed utilizing information received during the comment periods from agencies, local governing bodies, environmental groups and the oil industry, and from research by division staff members.

Exempt Lease Sales

The state may also offer acreage in an exempt lease sale, and attempts to satisfy the evolving needs of industry by proposing exempt sales whenever possible. "Exempt" means the sales are not bound by the provision that they must be on the five-year program for a minimum of two years. There are several provisions for qualifying acreage as exempt — being previously subject to a state or federal oil and gas lease, being contiguous to land already under lease, being adjacent to land on which a discovery of commercial quantities of oil or gas has been made, or being adjacent to land included in the federal five-year Outer Continental Shelf leasing program. If acreage that was previously offered, but was not leased, is re-offered within five years, only a revision of the original finding may be required. If there is insufficient information warranting this revision, the state can go forward with the sale based on the original finding. This is the case for the four Cook Inlet sales scheduled for November 1995.

Lease Sale Terms

Up until now, leases in the Arctic region have been given a term of ten years. Sale 80 will be the first sale in this region with a term of seven years. The leasing method is usually a cash bonus bid with a per acre minimum bid of $5.00 or $10.00 and a fixed royalty of 12-1/2 percent or 16-2/3 percent, depending on the location of the tracts being offered. The state also has the option of selecting other leasing methods, including net profit shares either as the bid variable or as a fixed amount and royalties as the bid variable. However, a cash bonus bid with a fixed royalty has been the established leasing method for the past ten years.

Unit Management

During the term of its leases a lessee may form an exploration unit which then extends the life of the leases. If it is determined by the operators of the unit that commercial production is feasible, then a production unit is formed. The division currently manages four exploration units and four production units on the North Slope (Figure 3). Forming an exploration unit requires a plan of exploration agreed to by the division. The division annually reviews these plans, or, if they are multi-year plans, reviews them just prior to their expiration to ensure activity is proceeding on schedule. Exploration plans generally require the drilling of at least one exploratory well along with the possible gathering of 2-D or 3-D seismic data. The division is responsible for ensuring that an exploratory unit encompasses the minimum area needed to carry out the proposed exploration plan.

Once the unit operators have made a decision to form a production unit, the commissioner must approve a participating area (the area of productivity). Unless circumstances warrant a delay in doing so, ten years after sustained production the unit area is contracted to include only the participating area. There is no subsequent contraction of the unit. It is also possible to expand production units. Expansion of a unit can only occur if it is determined that the participating area (i.e., the area of production) should be expanded. An example of this was the expansion of the Prudhoe Bay Unit to include the Point McIntyre field.

Summary

The Alaska Division of Oil and Gas, responsible for conducting the state's oil and gas leasing program, proposes the offering of essentially all unleased state acreage on the North Slope and in the Beaufort Sea by the year 1999. The division is also responsible for managing the units formed from oil and gas leases, and currently manages eight exploration and production units within Alaska's Arctic region.

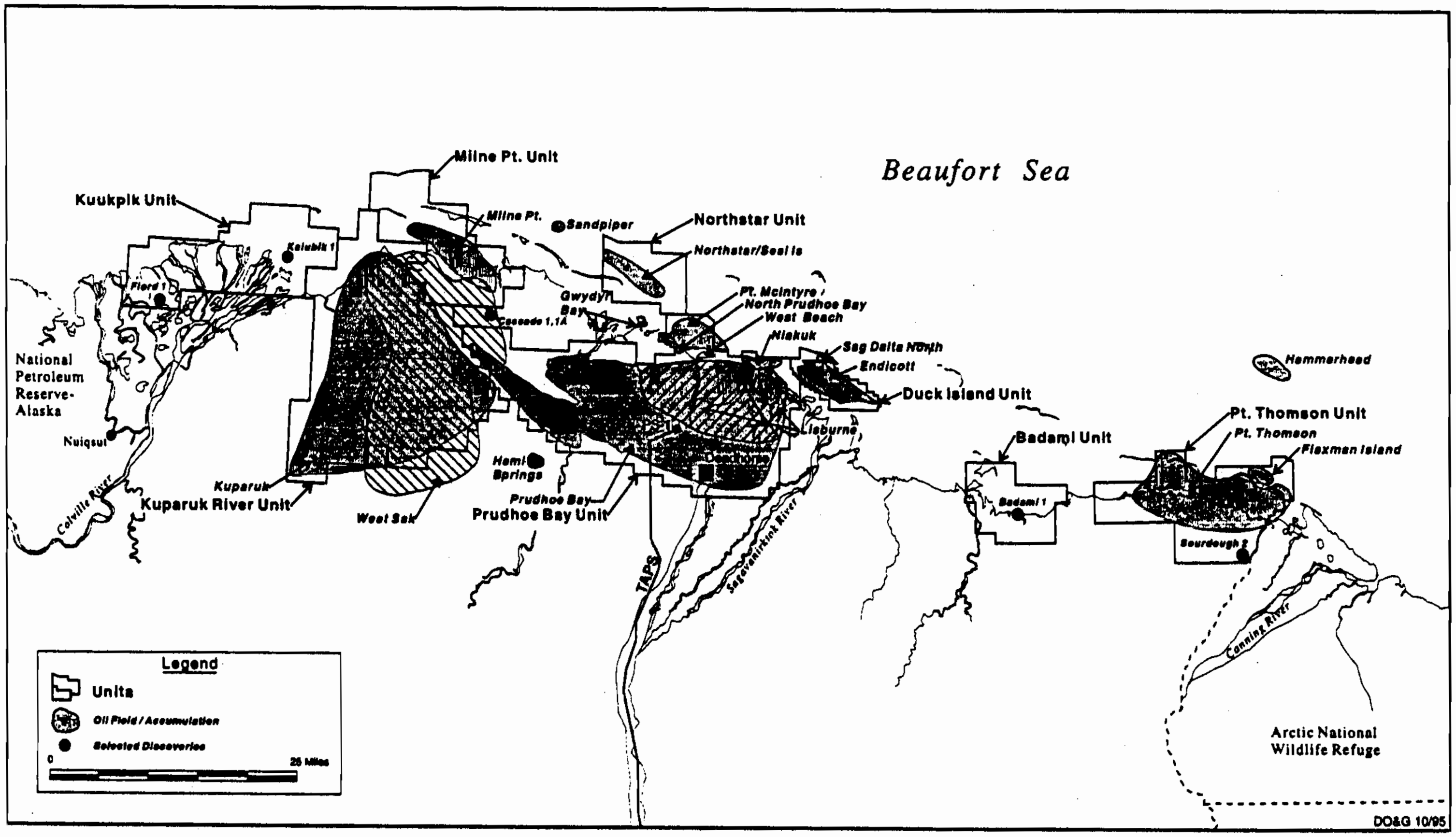

Figure 3. Central North Slope unit map.

ARCTIC OFFSHORE PRODUCTION: A CANADIAN PERSPECTIVE

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INTRODUCTION

During the past 20 years of exploration activities it has been demonstrated that year round safe and efficient operations can take place in the Arctic offshore environments. The significant database of expertise and technology that has been developed can be applied to production scenarios. The conclusion is that offshore development in the Arctic region can be economically attractive. This assessment is based on the fact that many changes have taken place especially with respect to design ice loads, structural concepts, and operating costs.

The technology is now available to develop a reservoir in the order of 200-300 million barrels located in the Beaufort Sea, using marine transportation to ship crude oil either directly to the market or via the Trans Alaska Pipeline System (TAPS). The following notes outlines the feasibility of this noted concept.

CANADIAN EXPERIENCE

Since 1976 a total of 73 wells have been drilled offshore in the North American Arctic using ice class floating drilling vessels, caisson retained islands, and bottom-founded drilling units. During this time a wealth of information has been gathered and analyzed. The analysis results in a significant improvement in the design requirements for offshore structures and transportation systems. For example:

Global Ice Loads:

- Full scale tests since 1980 demonstrate that the design for an offshore structure can be based on 100,000 tonnes load. This design load represents a reduction factor of 15, from the 1,500,000 tonnes accepted in 1980.

- The reduction in the design load will result in significant savings in construction costs of the production structure and site preparation.

- The footprint for the new structure is less than 2% of the footprint proposed during the 1982 Environmental Impact Hearings on Beaufort Sea Production. This will result in minimal disturbance of the ocean floor and increase flexibility to move the platform to another field.

Transportation considerations:

- A minimum of 1 billion barrels of reserves is required to justify a pipeline down the Mackenzie Valley which would tie in with other distribution systems. This option is therefore not considered in this paper.

- Arctic marine transportation using ice breakers presents a viable alternative to carry the crude oil to the market or for transshipment to TAPS. This conclusion is based on the following:

• Year round transportation of oil in the Baltic Sea. Similar shipments are also carried out in the Russian Arctic where escort support is available during severe ice periods.

• Operating experience of the Ice Breakers *Kigoriak* and the *Robert Lemeur* which were designed and constructed by Canadian Marine Drilling (CANMAR). The design of the *Kigoriak* demonstrated that with the unique bow construction an efficient displacement/horse power ratio is achieved for its class. The design of the *Robert Lemeur* represents a scaled prototype for an ice breaker/liquified natural gas (LNG) carrier.

• Demonstrated the structural integrity and the safe operation of both ice breakers after some 15 years of ice breaking operation under difficult conditions.

• Improved capabilities to monitor ice and other environmental conditions using on-site visual observations and the use of satellite imagery and/or airborne remote sensing techniques. Greater confidence levels in operational site-specific weather and ice forecasting support.

The *Arctic Shuttle* is the proposed mode of marine transportation. The *Arctic Shuttle*, a 40,000 DWT vessel, will incorporate the ice breaking capabilities and the safety and prevention features specified in the *Kigoriak* and *Robert Lemeur*'s design. The year round Arctic ice breaking experience will be applied to establish crewing level and competency standards to ensure safe operations.

BEAUFORT SEA PRODUCTION CONSIDERATIONS

The Beaufort Sea is an attractive area for development considering the above noted design and operational experience. Current technology and financial analyses provide additional evidence of the potential "prize."

A recent study conducted for the Canadian Government Panel on Energy Research and Development (PERD) identified that a world oil price of $11.10 per barrel would support a production project from a 350 million barrel field, using marine transportation. CANMAR's financial analyses for a 200 million barrel reservoir support these findings. Several such discoveries have been made in Canada.

Small scale production in the Beaufort Sea would result in a number of additional opportunities. For example:

• Development of a service industry and direct Northern Community participation.

• Linking development of other "small" field in both Canada and the Alaskan Beaufort Sea, thus creating a "String of Pearls."

• Opportunity to add volume throughput in TAPS.

WHAT NEXT?:

• Continue the dialogue with potential operators and regulatory agencies to demonstrate that such a proposal is viable and feasible.

• Communicate with Northern Stakeholders and the Inuvialuit to develop monitoring and prevention programs and encourage direct participation in any proposed project.

CONCLUSION

Beaufort Sea production can be conducted based on present technology, operational experience, and financial analyses. Such a project will be implemented in cooperation with Northern Stakeholders to ensure adequate protection measures are in place, business opportunities are provided, and sustainable community benefits are realized.

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QUESTIONS AND DISCUSSION

Grant Walther: Sir, are you aware of the Manhattan Project? There were some problems with that. More recently, of course, we have had the Exxon oil spill. As far as tanker technology goes in the Arctic, what contingency plans do you have to alleviate catastrophic oil spills? Specifically, how would you alleviate them? Of particular concern is oil coagulation in the Arctic. It doesn't decompose nearly as fast as it does in warmer waters. Would you please address those subjects?

Nick Vanderkooy: I don't have all the answers for you. As the interest is generated, we start developing the plans. I think we need to jointly look at those specific questions that you have and build on that. Then build the confidence that the type of structural integrity that you bring into an Arctic-class ice breaking tanker, that the shell is sound enough that it can withstand pressures, that it can run aground without puncturing the shell. We are operating in an environment where we don't have the "Pre-Cambrian" Shield sticking out that we can run on top. Along our entire combined coast it is relatively soft. You saw the structural integrity that was built into the *Kigoriak* and that was after 15 years of abuse. The shell is intact. That technology will be incorporated in the design of the outer shell. The cargo itself is all held in internal tanks, so that provides you with a double insurance that the cargo is secure in there. Contingency plans will be developed as they are with all facilities or exploration that is taking place right now. In Canada, we have to go through a very stringent review process as well. So some of these things will be addressed. From where I am standing now, and none of the detailed engineering work has been done on it, your concerns will be addressed and will be worked on jointly.

Jim Watt: I have a couple of questions. Does the Canadian Government offer any incentives to operators in the Beaufort Sea in terms of lower royalties or taxes, anything along those lines?

Nick Vanderkooy: At this point in time, there are no formal or official plans in place that would encourage that. If one had a "real life" project to present, one could go and negotiate. But with today's deficit problems of our respective governments, I don't think there is going to be a lot of support for giving money. There may be some leniency as to when those royalties kick in and how, but there won't be any handouts or major loan guarantees.

Jim Watt: One additional question. Does the Jones Act still impact your Canadian operations, say in U.S. waters? Would you care to speak to that?

Nick Vanderkooy: I am not sure what you are getting at. The Jones Act does impact our operations. With our vessels, we cannot trade between U.S. and U.S. ports. But the type of operations that we have had so far in supporting an offshore drilling facility, providing the anchor handling, the marine support, ice breaking management, falls well within the requirements of the Jones Act.

Jim Watt: I guess what I was trying to get at was does that have a negative impact on costs? Does it increase costs in your view or not?

Nick Vanderkooy: When you look at the "String of Pearls" where the *Arctic Shuttle* would come from Canada and deliver oil into the U.S., we are not trading between U.S. ports.

Unidentified Questioner: I think that what he is saying is that would your development platforms constitute ports in the definition of the Jones Act. If you are picking up oil from those...

Nick Vanderkooy: Oh yes, it would. But the picture that I showed was Canadian production oil brought into a U.S. port. You can do that legally. But I cannot pick up oil from a U.S. platform and deliver it to another U.S. port.

Unidentified Questioner: I was trying to get to the point to where your support vessels for U.S. ports, basically have to be U.S. vessels.

Grant Walther: What about submarine tankers? Have you looked into that? There was a lot of speculation on that in the 1960s, late 1970s.

Nick Vanderkooy: I don't think that, at this point in time, for the size of potential production, that this is a realistic way to go.

ARCTIC MARINE PIPELINES

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During the break, I was asked how many offshore Arctic pipelines I've put in and the answer is none; which isn't too bad considering there really aren't any. There are several onshore Arctic lines, but there is only one line that would qualify as an offshore Arctic line; it was installed in 1978 as a demonstration-of-technology in the high Canadian Arctic.

It is useful to consider what makes the Arctic, from a pipeliner's perspective, different than any other conventional area in the world. The answer includes: logistics, ice, permafrost, unique soils, and a unique sociocultural environment. Pipeline contractors will have to incorporate the expertise and the skill of the largely local and useful labor force.

Because there are no actual projects, I'm going to, by necessity, draw on a lot of the work that has been done around the world within the Arctic Circle.

There's been a fair amount of work in the Canadian Beaufort Sea and in the Mackenzie River Delta. That test pilot program I mentioned earlier was in this area. The Soviet Union, and now the Russians, for a long time, had a very active minerals development program in the Barents Sea and ship traffic out of Siberia. So from the standpoint of technology, there is a lot to be learned by looking around the world to see what cross-pollination can do for conventional and sometimes nonconventional marine pipeline installations.

It is interesting to note that from the standpoint of Arctic pipelines, the Alaska Arctic has been studied intensely for about 20 years, ever since exploration wells were drilled here offshore.

What is unusual is that in most frontier areas after 20 years of study, there frequently usually is something to show for it. There would be a pipeline in existence. One of the reasons is that there have been some ups and downs, some cycles in the oil and gas economies. It seems that just about the time we got ready to put one in, the bottom dropped out of the market. The reservoir didn't prove up. Conditions changed.

We may be looking at this year a prospect which, although shallow water, may be the actual first real Arctic operational pipeline just off Prudhoe Bay. I'm talking about BP's Northstar project.

Earlier studies that have looked at ways of transporting oil and gas out of the region have largely focused on tankers. In the mid- to late 1980s, a lot of research was done on Arctic ice-breaking tankers, trying to get transshipment terminals out of the Chukchi Sea area down to Point Hope; possibly an overland line to the Trans Alaska Pipeline; possibly ice-strengthened tankers down to Nome; A transshipment terminal and on down south to the lower 48.

These have fallen out of favor now in terms of risk and incidents, etc. The focus has shifted towards pipelines which have a significantly higher reliability aspect to them in terms of potential risk to the environment.

One of the first things we want to do is characterize the region not just from a construction standpoint but from a design standpoint as well. Open water conditions can be quite rough. Although designers and engineers have largely focused on the ice conditions, one cannot forget the hydraulic and the environmental loads; the more classical problems that we have to face.

Considering the ice, we can have light coverage; less than 10% part of the time. But it increases during a good portion of the year to something like 50% or more coverage. These conditions are not something under which we can do any meaningful construction.

To make an point, of a convoy of ice breakers, the 75 to 80 thousand horsepower category, among which is the *Leonid Brezhnev* — it used to be the *Arctika*, the nuclear breaker, largest in the world — and they're all locked in the ice north of Siberia. They were trying to get some of this convoy of lighter equipment through that side of the ice pack. When the wind blows to the west it exerts tremendous ice pressures. These vessels were actually locked in the ice; and one of them was crushed by the ice forces.

But we don't have that problem on our (the Eastern side). The wind blows and it tends to blow towards the west. We don't have the tremendous ice forces in the Chukchi on the Beaufort side, although we still have to contend with some substantial forces.

Now we get into the subject of design. But just before I touch on that I would like to say that, from a construction standpoint, the issues are largely environmental and economic. There is nothing from a construction technology point, as you will see shortly, that has not either been done or cannot be applied from other pipeline projects around the world.

But from a design standpoint, however, we don't have a precedent. We have, in some cases, similar circumstances to deal with, but we are in a situation where we must do thorough site investigations and surveying.

As I pointed out, a lot of this work has been done in specific Arctic areas in the expectation of a marine pipeline installation. But to date, we are still in the process of gathering additional data to try to improve our calculations, models, and our assessments of risk.

The big risk, of course, is ice scour. That's going to determine the depth to which we need to bury the pipe below the seabed.

The second one is the potential risk of permafrost. Although that's not typical offshore, we do find it. We also find discontinuous permafrost patches, relic permafrost at shallow enough depth locations and soils locations to pose a subsidence problem to a pipe.

The ice cover prevents us from doing the installation the way we would normally do it; and that is with floating equipment, conventional welding, dredging, etc. We have a very limited open water season.

And lastly, we have the soils and the soil mechanics issues which are not necessarily unique to the Arctic but have to be considered.

The first step in the design process is to gather information along the seabed. We can support this with aerial photography to characterize ice features. The only sure way is to use side-scan acoustic survey techniques to map the existing scour characteristics of the seabed.

With side-scan surveys, you can see ice keels which have passed through an area, but one cannot determine the depth of the incision of those keels. All you can determine is the general orientation, the relative magnitudes, and by using repetitive mapping year after year after year, we can determine the frequency of re-scour. This, as it turns out, is a very useful parameter in assessing risk. In other words, how many new keels would contact the seabed along a given length of pipeline each year?

There can be areas which have lots of repetitive scour but the scour incision depths aren't so deep. Or there can be areas which have only occasional scour, but when they do get scour, the keel is of such magnitude that it can create quite a deep incision.

One of the early stages of survey work is to gather soil borings and try to assess the presence of permafrost. One example of this was done in the Pechora Sea in Russia where we were interested in locating the presence of any permafrost in the marine portion of the route. As it turned out, the permafrost layer was just about at the mean high water mark, so we didn't have marine permafrost to deal with in that particular case. Quite a number of soil borings were taken to be certain.

We can gather quite a bit of information about ice using aerial and satellite imagery, which can show the characteristics of the ice sheet. This becomes important when we look at construction methods.

For reference, we characterize the ice as floating, land-fast, and bottom-fast ice. Land-fast and bottom-fast ice gives us a construction platform from which we might wish to work. It also has distinct effects on the depth of scour that we expect in that area.

We have an extension of ice which is not necessarily bottom-fast, but which is still land-fast and relatively stable. It turns out that the Seal Island prospect essentially falls in land-fast ice zone. It's not perfectly stable or bottom-fast. It does have some movement but it's manageable.

Further out we have the active shear layer which is that section between the fast-ice region and the offshore pack ice, which is mobile.

In the Canadian Beaufort on the East Amauligak project, we did find permafrost in the marine section and it had a depth below the mud line of about ten meters. But there is an active layer, one which is seasonally frozen, which corresponds to about the water depth where the ice contacts the bottom in winter. So at about the 1 to 2 m water depth, we have a seasonally frozen active layer. Both of these types of permafrost do present an issue for pipeline design. We want to protect against differential settlement and thaw strains which might come into play if this permafrost were to melt.

As it turned out in these areas, we did not find permafrost near the surface but relatively low, down around 20 to 25 m. Then it came up right up in here. It was about 18 m below the mud line and then dropped off very quickly once we got out into the full water depth, which was at 20 to 30 m.

Step two in the process, after we've gathered the information — soils, ice scour, ice gouge information — is to design the pipeline to be safe against ice scour damage. There is almost no way to get around the requirement of a deep trench, at least in these areas.

If there is permafrost, we may have to insulate the pipe. We may not have permafrost or it may not be thaw-stable material, it may be granular.

We have to consider the effects of currents and waves; the normal marine offshore pipeline type of design characteristics.

Concrete weight coating is one design consideration. That is very diameter-dependent. For diameters of 12 to 14 inches and less, we're better off using extra steel and making the pipe heavy by virtue of that steel and also stronger at the same time. For larger diameters, that concrete weight coating is sometimes a necessity just to hold it down.

I'm going to spend some time discussing how we approach ice scour risk and how it can be manageable, and to give you some idea of where we are in doing this for the Northstar project.

As mentioned earlier, we have the bottom-fast ice zone, the floating-fast ice, the grounded or the transition zone which forms usually around early to mid-winter, and then the floating extension, which is mobile.

The tendency is for the deepest scours to form underneath this ridge and occasionally a little bit to seaward of that. So if we do have keel contact, we may see scour depths in the range of 4, 5, 6 ft. Inshore of this, we will see more frequent scours, but they will tend to be of less magnitude as far as depth of incision is concerned. In water depths less than 50 to 60 ft, you can see fairly frequent echo sounder records showing lots of reworking, remolding of the seabed in this shallower water. But the design or the type of incision depths we are seeing are not too great.

As we get into deeper water, this tends to spread out a little bit. But when we do get scours, they can be a little more severe. In 150 ft or so, in the very deepest regions, we can get a relatively flat seabed but when we get scour it is significant.

The trick now, of course, is to determine when scour features originated. Scour may be hundreds or thousands of years old. The deposition rates in deep water are relatively low, provided you are not near one of the river deltas. So they can retain their shape for many years.

Now, we're dealing with water depth in the range of 40 ft for the Northstar prospects, so you can get an idea. But as we go out, we can see it would become a more increased trench depth or scour depth limitation. Incidently, the deepest water depth in which scours that have been seen to my knowledge are in the range of about 160 to 180 ft, except off Labrador where you have large icebergs which can ground, making it a little deeper.

So in gathering this information, we attempt to characterize the area on a map showing the isolines of mean scour depth. As we get farther offshore, the mean scour depth gets up to 4 to 6 ft. There are a couple of areas where you have bathymetric relief which has caused some deeper keels and deeper scours. As we get in shallower water, it's only 2 to 4 ft.

So these numbers aren't particularly unnerving from a pipe trenching standpoint because we routinely trench pipelines down to 3 or 4 ft deep below the seabed. But this isn't the whole story.

We then have to add to this picture the frequency of re-scouring because this now tells us how often we might get a new scour formed along the pipeline route each year. And we, as designers and statisticians, have to take into account, as the point was mentioned this morning, when you have a little bit of data and you're extrapolating that, you have to err on the conservative side.

So we want to be a bit conservative about how we apply this data. Since we don't have many years of repetitive mapping data, we have to apply safety factors, which I'll mention in a moment.

In the shallower sections where you have bottom-fast ice, scour contact depths are very small. In fact, you don't even record any because it is less than the echo sounders can discern. As we get into deeper water, we have been able to count more and more of those scours. So we have a high scour frequency coupled with a relatively deep incision depth. That would give us the worst case, or the deepest requirement for trench depth.

One of the safety factors that we have to consider is if we had a perfect model of the ice scour excavation mechanism along the seabed, we still might have some damage to the pipe caused by a zone of soil disturbance. This is the so-called ice-soil-pipeline interaction zone which is a branch of study which has been conducted for about ten years with continuing debate within the industry on the effect on pipe.

But it appears as though most soils would give us about another 2 or 3 ft of clearance necessary to avoid secondary damage to the pipe if the keel were to pass directly overhead. That does depend on the soil strengths and the strength of the pipe.

What this effort produces is a set of curves. The curves were prepared for the Canadian Beaufort and the eastern side of the Chukchi Sea using two statistical data sets — one being the number of keels which cut to a certain depth and the other being the frequency of re-scour.

When we get into about 100 ft water depth, that's the worst case for a marine pipeline. These data sets resulted in a required trench depth of just over 15 ft. That does give us a problem from a marine construction standpoint because that is five times or so to what we would normally trench a pipeline.

However, in shallow water, the picture is a little better. Given that we are inside the barrier islands in many cases, we're in the land-fast zone. Now inside of the 65 ft contour, we're down to about 6 to 9 ft trench depth. Now, this is a reasonable first step to take for pipelines which would be largely in the land-fast ice zone and corresponds roughly to the kind of figures that we are seeing in the Northstar region, although this particular area is somewhat more favorable than either of these two example sites.

Another issue which I mentioned but which needs to be elaborated is the permafrost effect on the pipelines. What we are concerned about is that we originally lay the line flat and straight on the seabed but suppose it has a permafrost boundary which is below that pipe and it's not even? There is a tendency for permafrost boundaries to be continuous or discontinuous; they're not just horizontal and flat. If the pipeline is hot, it will, over a period of years, create a thaw radius around it, which will melt and degrade the permafrost. If that is the type of material that is thaw unstable — in other words, if it is silt or silty sand as opposed to gravel and gravely sand — then this may create settlement or an eroded boundary. That, in turn allows the pipe to settle unevenly.

These types of problems have been observed on onshore pipelines. It is a very important aspect for buried onshore pipelines. A bit less so for marine lines but still the damage to the pipes, or the potential risk to the pipe, could be viewed as more important for marine line which is harder to get to, particularly in winter, than an onshore line.

So we want to find out what, if any, permafrost effects might have on this line and what the strain profiles might be. This is showing typical strains of between 2 and 2.5% for the kind of strains you might get in a differential settlement situation. Onshore, we can use Vertical Support Members (VSMs) and just simply lift the pipe up. This particular aspect can be applied in shallow water, possibly. It is one solution that is being considered in very shallow water if permafrost is found in the Northstar development.

A more likely approach to the problem will be to prepare a specially designed trench which has a thaw stable material or a gravel bedding layer which acts as a thermal buffer to the permafrost that may be below it and allows the pipe to retain its position even if there is some slight settlement.

As an option, back fill can be applied or the use of other techniques such as freeze back. This has been used one time where the soil is actually frozen around the pipe by using a refrigeration line and pumping refrigerated glycol through this. This is not a common method but it could be considered in some shore crossing areas to protect permafrost if you have very severe problems. Others that would just use the gravel without not necessarily building a trench. These would be only useful in sub-Arctic areas or areas where you don't have much ice to contend with.

Insulated pipe is another option. There aren't that many insulated pipelines in the world. There are probably 20 or 25 by now. They are very expensive. The technology is improving. It gives you an almost thermally perfect carrier, which means that the inner fluid may be transported at 150° F, and the outer surface of this is down around ambient soil temperature about 30 to 35° F. So you get very little heat loss.

Alternative systems include filled elastomers. That's a little cheaper to use and install but probably not likely to be used in the Arctic.

Those are the two critical design parameters. There are several others but I would like to move into construction techniques so we can see how these things might blend together.

Well, we don't really want to try to bring in tankers in this type of environment and we can design the pipeline to be safe if we engineer it properly. But let's take a quick look at where the costs are because ultimately that's one of the reasons why there aren't any marine pipelines right now.

The big expense is dredging and excavation. That's an upshot of the ice scour risk. Another one is materials. That is the line pipe itself and the support equipment. Getting it up there. Logistics. The pipe installation itself is less of a cost factor. Engineering, construction, management, although not a significant factor, is more expensive than conventional because of the extensive planning for contingencies.

So as construction engineers we try to see if we can't come up with some novel ways of reducing the cost of dredging, excavation, and logistics and maybe the cost of any work in shallow water. I would love to spend about two hours going through some of the designs that have come up over the last 20 years in how to excavate deep trenches in the Arctic, but I'll just be able to discuss a few.

Just for reference, what we are trying to get to is a trench with a pipeline in it. The depth of the trench being in the range of 9 to 12 ft with stable side slopes such that it doesn't cave in before we put the pipeline in the bottom. And of course, the depth here is such that the ice keel won't contact the pipe if it plows or bulldozes over it. The bottom width can depend on the type of method used and the number of pipelines we might want to consider in there. These have been some earlier studies where multiple lines were considered possibly in the same trench.

The big dredges, like the *Aquarius*, a cutter suction dredge, can move massive amounts of material and aren't too noisy when they're operating. Some points were made on that this morning. It is not necessarily your most environmentally-friendly equipment. It has to discharge the spoils and it's rather expensive to get in the Arctic; although they have been used up here in the construction of exploration islands. There are several dredging contractors that have had experience working up here.

And certainly, in the conventional area, this would be the way you'd approach it: just go in and dig the trench and then demobilize the barge. It is very expensive for us to do that here because of the time it takes to get the dredge up here and slow production rates for a deep and narrow trench. The reason is that these tend to cut back and forth. They're not really designed to cut long, narrow trenches.

Some contractors have come up with some heavy duty bucket wheels to cut through permafrost or frozen soil. This might have some application in limited areas if you had hard material to cut through.

Another dredge that never was built, but saw a lot of sketches done on it, is a so-called linear dredge. The principle being somewhat similar to the cutter suction dredge, but in this case, the arm doesn't swing left and right. It simply goes along in a narrow trench, and it would be built specifically for Arctic pipeline trenches. It's a good idea but very expensive and the infrastructure isn't quite there yet to support this kind of dredge. Maybe some day in the future, but not yet.

Another dredge which has been used up in the Arctic, the *Geopotes* was mentioned this morning. It's a trailing hopper dredge which can move massive amounts of material. It's not very good in hard soils. It tends to excavate like a vacuum cleaner. But it has had some work in ice.

One way to get around that is to consider the use of the trailing hopper dredge to get a broad section cut down to about 5 or 6 ft and then use a more surgical tool like a clam shell dredge to excavate the remaining 4 or 5 ft. This is a procedure which has been used in some cases to get a deep trench without having to move too much material.

But from the standpoint of cost reduction, these trailing hopper dredges are still fairly expensive. They would require wintering over in a season or perhaps two, so it's not our first line of defense.

Neither is a mechanical trencher. It's quite useful in short sections or maybe a couple of miles. Tending to be used in deep water and it is the first of a series that I'll show that is a post-trenching device. In other words, the pipe is laid on the seabed and then another tool is lowered on top of the pipe and is dragged along it, and the cutter excavates. It's a submarine dredge, if you will.

It has good application, but it's probably not one we would use here in the Arctic. You can't get a deep enough cut. Moreover, we're faced with a situation if we put the pipeline down and for some reason fail in getting it down to the design trench depth, the next winter we may have a good chance of losing the pipe. So a pre-excavation as opposed to a post-excavation approach is warranted.

There is one pre-excavation tool, however, that does bear mentioning because of its raw speed, and that's the marine plow. This became quite the matter of focus for Arctic marine lines in the mid- to late-1970s. In fact, that one pipeline that was installed in 1978 off Drake Point was post-trenched using a marine plow. And that was a very short line. It was less than a mile, so it went quite fast and it worked quite well. (Trench depth of 3 to 4 ft.)

One of the risks we have here is getting the pipe trenched in the season. If there is any mistake in the design of these tools, the soils will very often play havoc with the contractor. We have worked on several projects where the plows worked perfectly and they can excavate the trench 2 miles per day without any trouble and several where the plow failed to work at all. Finally the contractors had to start over again and try something entirely different.

A small plow has been used in the Gulf of Mexico. It will get about 2 to 3 ft of trench depth. Bearing in mind that we need 10 ft, you can extrapolate the size. The biggest one that has been built to date is about a 320-ton plow about three times the size of this and it was able to get between 3 and 6 ft, off Australia. But they're very heavy. They require a fairly large piece of equipment just to pull the plow itself.

The installation method for the pipe itself is not the most expensive part. In fact, once the trench is dredged or somehow excavated, getting the pipe in it can be done by a number of approaches.

Starting with the most conventional, you won't see this in the Arctic for a long time to come and certainly not in the Northstar prospect, a third generation semi-submersible lay barge. These are for deep water. It is the classical method of laying pipelines where the pipe is welded in joints, 40-foot joints welded together. Usually, automatic welding is used, and then the pipe is laid off a stinger.

The barge has a pair of large, horizontal tensioners, which maintain upwards of about 200 tons of horizontal tension to hold the pipe in the correct geometry. These have a working draft of about 45 ft, so we won't be able to use these in the shallow water.

With an eye towards optimism, back in the 1980s, one of the shipyards, Valmet in this case, came up with a dedicated Arctic pipe layer which would have high speed flash butt welding. It was a technique developed by the Paton Institute in Russia for joining pipelines. McDermott had worked on it and perfected it. This would use flash butt welding to make up pipe at about three or four times the speed normally found in conventional lay barges to enable her to get in and get out in one open water construction season.

Another method is the reel ship, the *Apache*. This is a very fast method and this enables us to spool up pipe like wire on a drum and then pay it off as the vessel steams down along the right of way. The vessel was built in the late 1970s. It's been active ever since. It's an excellent piece of equipment which has seen a lot of service. The only limitation is that 14-inch, 16-inch diameter is about the largest diameter pipe the *Apache* can spool up. And that particular vessel is getting on in age now and probably will be superseded by something about twice the size in the next three years.

More relevant to Arctic work though is what we can do with smaller, locally-available equipment. One installation option, commonly referred to as the bottom tow or bottom pull, is where we make up the pipe on land in strings that are about two or three thousand feet long. Stationed just offshore, a pull barge, which has a linear winch which is capable of exerting about 400 tons of pull load on a cable. It literally yanks the pipe off the beach and slides it along the bottom and then they weld on the next string and repeat this process as the barge moves forward after each 3 or 4 pulls.

It is very cost effective, but It doesn't work for very long lines. You run out of pulling power after about ten miles or so. But for anything less than ten miles in length, this type of technique could be used. It's largely an open water marine operation, but the winch equipment that's used could, in theory, be put on the ice. This pulling could be done from the ice through a slot in the ice.

In the bottom-fast zone, and perhaps even somewhat into the land-fast zone where the ice is, in mid-winter, frozen to the seabed — this is about five-foot water depth — a very interesting solution appears to be just straight through excavation, cutting the ice with a ditch witch or Vermeer trenchers, a pair of them, then using a backhoe, conventional equipment, to excavate the trench. And then lay the pipe into it.

There are a couple of options as to how we get the pipe onto the ice. One is to weld it up on the ice using a heated welding tent to maintain weld parameters and so forth. Side booms or winches would be used to lower the pipe.

That concludes the general view. I'd like to quickly just go through some of the specifics that have become of interest in the Northstar work just lately. The prospect is a total distance of about 5 or 6 mi offshore in fairly shallow water, 40 ft at Seal Island.

Now, ice gouges. Since I made such a big deal about ice gouges, I better say something about where we are on this. Based on work by Harding and Lawson in 1983, 1984, and 1985, the maximum gouge depth that we saw was a little over a foot. So that's not too severe. It was a lot of work by Harding and Lawson's specialists to go through and match up scours year after year over a period of three years and determine the number of new scours that took place each year. But they were able to do that and it wasn't as severe as some of the other areas that we're dealing with. Ultimately, that led us to this conclusion of risk. If we look at Site 3-only data and we take a risk during the entire operating life of the line of one chance in ten thousand, or one chance in a hundred thousand, the design keel depth would be about 6 ft.

Now, allowing for about another 3 ft or so for the secondary factors I mentioned, we're looking right now at a scour depth of about 10 ft based on this information. Again, a little bit better than if we used regional data.

For the soils that we see along the route, to date we don't have enough soils data to say for certain, but we have not seen evidence of thaw unstable permafrost. We do have mainly silty, clays here, sandy clays here. More sands, a tendency toward sands down here and then a layer of fairly thaw-stable materials, sands and gravels, at about 10 ft below the mud line.

What we're going to be doing this winter is to get more bore holes and soils information, along here, to establish the validity of this stratigraphy.

This slide is a demonstration of pipeline strength. For the kinds of pipe we'll be using in the Arctic, they're going to be stronger than most marine lines. In fact, I would say the wall thicknesses will be a factor of two greater.

We have done a lot of tests. Actually, the work here that you see was done by the Centre for Frontier Engineering Research in Edmonton, Canada. This is a 26-inch diameter pipe with a 1 5/8th inch wall thickness. We have already collapsed it with hydrostatic pressure and now we were bending it back over on itself to see at what point we could cause a rupture or cause failure. We had not yet caused a breach of that pipeline. It is a very strong, very tough pipe and can withstand quite a bit. You'll lose flow production in this pipe before you will have a breach in the pipe.

Question from the audience: What pressure is required to collapse that pipe?

Seven thousand psi external. We had to build a chamber specifically for that. In fact, it's now the biggest in the world. It goes up to 9,000 psi, because that's the largest pipe that's ever been collapsed hydrostatically and bent.

A construction technique that we might look at for working on the ice is a big clam shell digger. Obviously, with the amount of material we have to remove, the largest bucket we can get the better. This is, of course, a marine-based operation but the loads, particularly in the nearshore, inshore of the 25-foot contour, that we would put on the ice are suitable for on-ice construction work with a little preparation. It's a typical shore approach and may be similar to what we'd use here.

The technique that is a personal favorite of mine, at this point, for the Northstar installation is a pre-dredged trench with a slot cut in the ice. The pipe is made up in strings and towed out on the ice and lowered through the ice slot using a combination of buoys and lowering cables. We may or may not need pipeline tension. Probably not in this case except perhaps in the very deepest water. The reason I like this is it makes excellent use of local technology and relatively small equipment. It's a very controllable and manageable installation technique in these water depths at least. We would have the benefit of having a pre-dredged trench which we would be certain is already meeting specifications. As it turns out, an installation like this has been done recently in Canada in one of the lakes.

A summary of the approaches that we see are essential for marine Arctic lines include: a good understanding of the limit states, the structural strength of the pipe, ice gouge protection, and permafrost; construction activities which have to reflect the sensitivity of the environment and the regional specifics; and lastly, operational reliability, which is what we're left with after the pipeline is installed. And that, of course, feeds back and comes directly out of the design integrity, which is done early on.

QUESTIONS AND DISCUSSION

Tom Newbury: Is oil always pumped through pipelines under pressure? Is it ever sucked through so that there is negative pressure in the pipeline?

David McKeehan: No, the oil is always under pressure. Typically 800 or 900 psi and occasionally more than that. But in the event of damage, back suction and things of that nature could be applied. It would be part of an emergency response program, not normal operations though.

Audience Member: You mentioned directional drilling or boring...

David McKeehan: Boring or directional drilling are both being looking at. Their restriction is distance. At this point, directional drilling would be possibly an approach to the island or to the facility, and it can reach about a mile to a mile and a half. We think we could just make the 25-foot depth contour if we started from Seal Island and directionally drilled inward.

I will say, having been on a number of directionally-drilled projects though, it's a little iffy. It depends very much on the soils and you have to have lots of good soils for the pilot string to find its way and hit the target. You also have some muds disposal issues to deal with and you still have to pull a section of pipe back into the hole. So it has got some advantages but it's not something we'd want to stretch the technology too far on that issue.

Audience Member: If you dig a trench five or six miles long and ten feet deep, you're going to end up with a lot of soil that you pulled out. How would you anticipate handling that?

David McKeehan: That's a real good question. Right now, we're anticipating spreading it out on the ice uniformly or dispersing it uniformly. But actively in consideration is use of that spoil to dump back in the trench as a backfill medium. There are some issues associated with that. Mainly it's the liquefaction of that material. When a pipe is in a trench and you put native soil back in the trench, if it's not granular and fairly stable, it can actually liquify and lift the pipe out of the trench, which would be a real problem because then you have the pipe sitting on a liquified soil layer.

We're looking at ways of getting around that by making the pipe heavy with additional wall thickness, which we may end up just putting the soil back in the trench.

Audience Member: I'd like to follow up on that question. What kind of resources do you have to fill up that hole? Like gravel? Do you have any access to these materials to fill with?

David McKeehan: Yes, that's a very site-specific study. I assume you're referring to Northstar? There are enough gravel resources to fill that up. It's a cost issue, which amazingly enough, didn't come out to be as much as I thought it would be. But it's evidently available to do that.

Audience Member: Should an on-ice system where you were using conventional excavation techniques, and you had spreaders there it looked like, probably just to keep material from flowing from one section to another. But we learned the other day that the pressure of ice moving could be a hundred thousand tons. How would you anticipate keeping the ice separated when you have a long cut through it?

David McKeehan: Excellent question. It's one that we're really struggling with. In bottom-fast ice, we don't think we're going to have too much of motion characteristics. The trick is to get out beyond the bottom-fast limit, because that only gets you out to 5 or 6 ft and that leaves four miles of heavy duty construction. We'll probably use some form of ice thickening to press the ice down and make it bottom-fast part of the way out to mitigate any ice movement.

But having done all of that, we still will be faced with the problem. We plan this year — this is still in the early stages — to do a test slot to see what lengths of slot are susceptible to ice movements because of ice pressures closing in on them. Clearly at a very short length, we probably have some reasonable working window before you get a wind that blows and causes the ice pressure to close that slot. The ice experts that are working on the job say they don't think it's a big problem. It's something we need to verify. If that's the case, we may resort to less of a slot than a hole in the ice or a traveling hole which is more resistent to those closures. But that's one of the very key questions that we hope to shed some light on this year for this area.

Audience Member: You indicated that the pipe would be 5 to 7 mi long and there's an island between the site and West Dock. Which side of the island are you going to go on from the mainland?

David McKeehan: That's not a question I can answer in any final sense but the present route goes just to the west of that island, between that island and the mainland. It travels to the west of that island. There are several routes being considered. Earlier routes that were looked at back in 1990 actually went to the eastern side of the island and directly to West Dock. So I don't think it's a final routing.

Audience Member: I assume that seismic earthquake activity is not a primary concern here in Northstar? But is it possible other areas of the Arctic or sub-Arctic where that may be a concern? How would you deal with that with a buried pipeline as opposed to marine VSMs?

David McKeehan: Marine pipelines in seismic areas are fairly common. The techniques that you try to use, of course, are not to bury it and not to back fill it, which goes counter to what we probably have to do here. So it's probably fortunate that we don't have to deal with both of those challenges at the same project at the same time.

However, in case we would have to, or in areas where we do have sizeable amount of shear motion, the best way to do it is to get to a very thick wall pipe. Now, I'm referring to D over T, diameter to wall thickness in the range of 15 to 20. That type of pipe is extremely resistant and it behaves like that one piece of pipe which I showed here. It will shut in production automatically before it ruptures. So, in the event that you had the worst combination of a seismic, shear slips, and faults with a buried line with compact, competent soil and it caused bending of the pipe, the pipe would probably survive it. Having said all that, there still would be some risk if you had that case though.

Audience Member: You concluded that shipping oil in the Arctic through tankers is environmentally not sound. Is that correct?

David McKeehan: I didn't quite say that. I think it's not the favorite solution at this point.

Audience Member: Are you familiar with the international North Sea route program?

David McKeehan: No, I'm not.

Audience Member: Anyway, Norway, Russia and Japan are involved in this effort and they're spending a lot of money — mostly Norway and Japan are spending the money — to investigate a North Sea route using large ice breakers. It seems like it's predicated on, in some of the documents I've read, shipping oil from some of those Arctic fields in Russia.

David McKeehan: I think I know what you're talking about. There is a strong political reason for that. In Russia, the western companies want to get the oil out. Of course, the Russians want to keep it in. There is a real focus to get things moved by shipment terminals. In fact, a lot of the work we're doing is looking at how we would build a shipment terminal and get it out.

Also the ice conditions there along those routes are much less restrictive than they are here on the U.S. side because of the presence of the Gulf Stream that goes up there. And actually, some of those areas remain ice free even all winter long. So it's a little easier of a problem plus the political aspect of it is really driving a lot of that, I believe. Because the Russians want it all coming into their pipeline system.

MMS STAKEHOLDERS TASK FORCE EFFORT

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The success of the OCS program and specifically the Alaskan portion of the program is contingent not only on the technical advancements and efforts by the industry to look at making marginal fields economic and partnershipping with their contractors but also deals with the ability of the government to improve our relationship with our stakeholders and to deal with issues and concerns and resolve potential conflicts. The Alaska Regional Stakeholders Task Force is unique to the Alaska Program. It was formed by the OCS Policy Committee, which advises the Secretary of the Interior on the MMS offshore program, to make recommendations on the proposed Five Year Oil and Gas Leasing Program which would cover the period from 1997 to 2002.

The overall objective of the Task Force was to provide an opportunity for local stakeholders to have early input into our planning process for lease sale decisions. It is the first time that there has been a process that provided for stakeholder input before putting out a proposal for formal public review and comment.

Membership on the task force was diversified to represent the Native, subsistence, and the environmental community, commercial fishing, the development community, the oil and gas industry, local governments, federal government, state government, gubernatorial appointees, coastal districts, and coastal resource service areas. Taking a state the size of Alaska and coming up with 20 representatives that can represent everybody in Alaska was a tough chore.

Task Force members met and developed what they call "Evaluation Criteria." These criteria categorize all the issues and concerns that would be used in debating and making decisions and recommendations on the proposed Five Year Program. These evaluation criteria include: prospectivity, which was inclusive of both industry interest and resource potential; existing infrastructure; technological capabilities and limitations for drilling, exploration, production, and oil spill clean up; local and tribal government and community interests; subsistence and socioeconomic and cultural interests and environmental concerns and values. Under each of these evaluation criteria, there is a whole list of additional concerns, issues, conflicts, and problems that were identified, which are summarized in the Stakeholder Task Force Report.

The Task Force met twice; and local community meetings were also held in some of the key communities: Barrow, Yakutak, Kodiak, and Kenai. Following discussions and input from the local stakeholders that they represented, the Task Force came up with the following recommendations:

- Use the "Evaluation Criteria" in considering the Five Year Planning Areas;

- Include the issues and concerns identified as scoping issues to be put in and evaluated in Environmental Impact Statement (EIS).

- Schedule sales to be included in the next five year schedule so that they would be held one per year, and there should be order and predictability in the lease sale schedule.

• Continue to analyze and prove alternative energy sources and their implications to lease sales.

• Include five planning areas in the Five Year Program: Beaufort Sea, Chukchi Sea, Hope Basin, Gulf of Alaska, Cook Inlet-Shelikof Strait.

• Identify critical habitats and sensitive areas as scoping issues prior to determining the areas of the sale in the EIS.

• If the sale goes forward and lessees are not allowed to develop their leases, the government should buy back those leases to compensate.

The draft program that is now out for public review has followed these Task Force recommendations. The five planning areas are included in the proposed Five Year Program. They are one sale per year proposed, consistent with the Task Force recommendations.

One of the other recommendations that the Task Force made was the need for the OCS Policy Committee to be made better aware of the subsistence values and significance of traditional subsistence economy in Alaska. Among all the planning area evaluation criteria that were discussed, the need to better appreciate and recognize Native subsistence ways of life, Native knowledge and traditional and indigenous knowledge in the decision making process was critical to the Native community and environmental community that participated in the Task Force process. Delbert Rexford, who is a special assistant to the mayor of the North Slope Borough and who is on the Task Force, was invited to go back and address the OCS Policy Committee. Ms. Judy Gottlieb, Alaska OCS Regional Director, has made it her priority to incorporate indigenous knowledge into our decision making process. This effort is actively underway within our office; to meet with the Native population community leaders and other Native organizations, both to identify where we can get information and how to incorporate it into our decision making process.

It is important to recognize that while the Task Force worked hard to reach consensus, there was a multi-diverse group of individuals, and there was not always consensus by the Task Force on the recommendations made. The Task Force did provide an opportunity for open discussion of concerns. Everyone on the Task Force was pleased with the process and welcomed the opportunity to table issues and concerns early in the process before the government was set in a decision. The recommendations reflect interest and support for including these five planning areas in the proposed Five Year Program for further analysis. There was a minority report submitted that reflected that the Task Force and the recommendations are not consistent with continued opposition by communities for individual lease sale activities. The Alaska OCS Regional Office is continuing with outreach programs and working with communities to resolve concerns and issues for these individual lease sales.

The OCS Policy Committee did accept the recommendations of the Task Force and the Secretary of the Interior used these recommendations in developing the draft proposed Five Year Program. The OCS Policy Committee has also recommended that Task Forces similar to this continue to be used where all parties agree that it is a worthwhile effort. The Alaska Regional Stakeholders Task Force will continue through the completion of the Five Year Program. The Task Force is in the process of adjusting its membership so that the five planning areas that are included in the draft program have appropriate representation. There will be new representation from Cook Inlet, both Native, tribal, and public interests; new representation of the academic community; and new representatives of tribal and subsistence interests from the North Slope.

Sociocultural Session

AN OVERVIEW OF NORTH SLOPE SOCIETY: PAST AND FUTURE

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INTRODUCTION

Human cultures (or as termed for purposes of our session, sociocultural systems) are patterns of thought and behavior communicated through language and other symbolically meaningful forms. They are constructed and modified to provide people with a way to survive in a given environment and structure a social system, i.e., a set of relationships among people. Individual human beings acquire self-identities, self-esteem and motivations for culturally appropriate behavior through successful forms of cultural transmission — the passing of culture from one generation to the next. Culture thus provides for continuity and change — a foundation for psychological equilibrium and a logic for choice and innovation. Rapid culture change produces culture shock, personal and social pathology, and a decline in the welfare and quality of life of cultural members. This is especially true if people are relocated from traditional lands or forced to cease traditional activities.

In opening this session today, I wish to provide an historic overview of the emergence and characteristics of the Inupiat culture with an emphasis on those values, behaviors, and institutions that made it successful in the high arctic. Then, the substantial changes that have occurred on the North Slope in the past 100 years will be outlined noting the especially rapid changes that have occurred since the discovery of oil at Prudhoe Bay in 1968. Particular attention will be paid to the North Slope Borough as an institution — political, economic, social, and educational — that has effectively mediated many of the changes for the Inupiat people allowing a positive identity to be maintained and transmitted. Finally, perspectives on the direction North Slope society will take in the future raised by the National Research Council study, *Environmental Information for Outer Continental Shelf Oil and Gas Decisions*, will be discussed in regard to the need for specific kinds of research to address the key issues.

INUPIAT SOCIETY - ADAPTIVE INSTITUTIONS

Present archeological information indicates that human beings began utilizing the North Slope region as early as 10-12,000 years ago (Mesa site) (Table 1). That initial utilization seems to have been oriented toward terrestrial, possibly supplemented by river and lake resources; evidence for the utilization of marine resources, particularly seals, begins about 4,200 years ago (Anderson 1990). Important technological developments, such as the toggling harpoon head, made possible winter sea-ice hunting of seals at blow holes thus beginning the shift toward use of marine resources in the region.

Although evidence of whaling can be dated to 3,400 years ago (at only one site), it disappears for sometime and begins again in the archeological record about 2,000 years ago on Sivuqaq (St. Lawrence Island) and about 1,500 years ago throughout coastal northwest Alaska from Bering Straits to the vicinity of Point Barrow. Beginning about 1,000 years ago, the complex of cultural elements called the Thule tradition, with its broad flexible subsistence technologies and its success in hunting large marine mammals, made possible large Eskimo villages at a number of key coastal locations in the North Slope region. In addition, the Thule tradition, also successfully adapted to the interior of the North Slope and the Brooks Range, emphasizing

Table 1. North Slope cultural chronology.

PERIOD	DATE	SIGNIFICANT ACTIVITY
Traditional	12,000 BP	Earliest human occupation and use of the North Slope
	4,200 BP	Early use of marine mammals on winter sea ice
	3,400 BP	Earliest evidence of whaling
	2,000 BP	Beginning of dependence on large marine mammals
	1,800 BP	Founding of Tikiqaq (Point Hope)
	1,000 BP	Emergence of Thule culture-ancestor of Inupiat culture-large communities, coordinated cooperative marine mammal hunting
Historic	1750s	Trade with Siberian peoples for Russian goods-tobacco, iron
	1831	First European appearance at Point Barrow
	1850s	American vessels begin commercial harvests of bowhead whales
	1880s	Shore whaling stations established with first non-Native residents
	1890-1910	Epidemic diseases reduce population; bowhead whales seriously depleted; missionaries and schools arrive
	1930s	Reindeer herding introduced; fur trapping for cash; subsistence whaling sustained
	1940s	Military and construction experiences for many Inupiat men
	1950s	Defeat of tuberculosis and extension of medical care produce "baby boom"
Statehood	1960	Statehood and Barrow Duck-In
	1968	Discovery of oil at Prudhoe Bay
	1972-1974	Formation of North Slope Borough
	1977	Ban on bowhead whaling and creation of the Alaska Eskimo Whaling Commission
	1979	Completion of the Alyeska Pipeline
	1980-1986	Capital Improvement Program upgrades housing and public facilities
	1994	Opening of Dalton Highway to public
	1995	First non-Native mayor of Barrow; repeal of alcohol ban; reported decline in caribou numbers in pipeline area

caribou hunting as the primary subsistence strategy. This archeological culture is seen as the direct antecedent to the Inupiat culture being practiced in the early 1830s when whites began exploration in the area that included both coastal and interior adaptations.

Traditional Inupiat culture of the North Slope was made possible by a melding of social behaviors and institutions that balanced the individual and competition with the group and cooperation. Whaling was central to the life of the people as a source of food and material, as a focus for spirituality and ritual, and as a focus for joy and celebration. A high degree of cooperation was developed among the men of a hunting crew and between the men and women in the processing and distribution of the catch. Each crew, however, also competed with each other to be the first to sight and strike whales. It is in the landing of the whale and the processing that the cooperation occurred. Critically important to the success of whaling was the formula worked out for distributing whale among the striking and assisting crews — this formula assured rapid response from other crews to the site of a struck whale. Thus competition and cooperation were fused in the hunt which better provided for all.

The technical and economic aspects of whaling were embedded in a set of spiritual beliefs and practices which emphasized respect for the whale and that whales, as sentient beings with spirits cognizant of human activity, chose to give themselves to worthy human beings. The spiritual cleansing and ritual engaged in by the "umealik" (captain of the whaling crew and owner of the boat and equipment) was to make he and his wife and their crew worthy of the whale.

Social ceremonies of celebration and cohesion were core elements of Inupiat culture. Foods were distributed by the successful captains and crew to the community while song, dance and competitive games provided a focus for physical activity in the extreme cold and darkness of the winter. There is evidence that privation and even starvation periodically affected the Inupiat population but the constellation of institutions, values, ideas and behaviors allowed for a vigorous people and culture whose persistence and increase in one of the most extreme environments in the world is testament to their success.

HISTORICAL CHANGES

In the late 18th century, premonitions of change began to be felt in the region as new materials such as iron, tobacco, and perhaps alcohol began to be acquired by the Inupiat through trading patterns which linked them through Native peoples around Bering Straits to Russian trading posts at the mouth of the Kolyma River in northern Siberia. The first European exploration reached the Point Barrow area in 1831.

In the 1850s, American whaling vessels from New England passed north through the Bering Straits in pursuit of the bowhead whale. This began the process of contact with American culture. At first the contacts involved relations primarily of trade with Americans providing technical items such as guns, pots, pans, stoves, and iron as well as unfortunately alcohol, and Inupiat providing skins, garments, whale "bone" (baleen), labor and environmental expertise (Bockstoce 1986). Relations were often not amicable.

In the 1880s, the whaling industry took a new direction as shore stations were established by companies to be able to gain access to whales during their spring passage through the leads between the shorefast and offshore ice. Many Inupiat were employed seasonally by the whaling stations and some Americans, such as Charles Brower, Fred Hopson and George Leavitt, elected to settle on the North Slope and take Inupiat wives. By the 1890s, several Inupiat entrepreneurs had entered the commerce organizing as many as six crews and hiring whites to work for them.

As the industry declined, both due to the loss of a market for whale products (oil and baleen) and depletion of the whale population, white companies and personnel withdrew returning whaling completely into the hands of the Inupiat once again and reverting it to the subsistence practice seen today.

There were two critical legacies for the Inupiat from the commercial whaling enterprises. First, the commercial slaughter of the whales in a matter of four decades reduced bowhead numbers to approximately 10% of the original level (Bockstoce 1986:252). This threatened the very foundation of the culture and made life exceedingly difficult. Second was the effect of epidemic diseases, influenzas were particularly devastating, which spread rapidly due to the Inupiat lack of biological resistance as well as poor housing and sanitation. The introduction and impact of sexually-transmitted diseases also contributed to the decline in Inupiat population. By 1910 the decline in population had reduced the Inupiat to 20-25% of their number in 1850 and had virtually depopulated the interior of the North Slope occupied now by the remnant population of Anaktuvuk Pass (Fortuine 1989).

By the 1910s a modified Inupiat adaptation had developed. Christianity and schooling introduced in the 1890s had been accepted by many Inupiat. Still, subsistence was the core of the culture and whaling had returned to its essential subsistence and social position in Inupiat culture although its spiritual content had been revised somewhat (Chance 1990). Despite the declines in harvest numbers, Inupiat persisted in this core cultural activity out of survival necessity. Contacts with American society now came from furs trapped in the winter months and sold to traders. An additional element was reindeer herding which grew to substantial proportions in the 1930s only to decline and virtually disappear by the 1950s (Chance 1990).

The governmental explosion in Alaska precipitated by World War II was felt in numerous ways by the Inupiat of the North Slope. Perhaps most influentially, Inupiat men became familiar with the nature of American society and its standard of living through service in the armed forces and employment at various construction sites. They became familiar with foods, appliances, clothing, housing and many other technical amenities of American life. Some chose to remain in this new environment. The majority, however, returned to their North Slope homes with an interest in improving the quality of life in their home communities.

The extension of medical care for infants and the suppression of tuberculosis in the 1950s led to a "baby boom" throughout Native Alaska and a rapid increase in family size among Inupiat. Coupled with limited availability of local wage labor and a collapsed market for furs, the North Slope Inupiat were among the most impoverished Americans when the federal government began its "War on Poverty" in the mid-1960s.

OIL DISCOVERY AND THE NORTH SLOPE BOROUGH

In 1968 oil was discovered at Prudhoe Bay. In 1969, Eben Hopson decided to pursue Fred Paul's idea for the incorporation of the North Slope Borough as a regional government with the power to raise revenue through taxing oil development facilities at Prudhoe Bay (McBeath and Morehouse 1980:77). After significant struggle in the courts with the State of Alaska and with oil companies who sought to halt or severely limit its powers, the North Slope Borough was finally formed in January, 1974. It is at the same time, the largest municipality in terms of space and the smallest in population.

It is interesting to note that elsewhere in the United States, Native American populations in proximity to major resource development projects have rarely benefitted and in almost all cases been harmed by such development. To date on the North Slope, that has not happened because the Inupiat had the vision to seize the reins of governmental authority and the will to use that authority to protect themselves. Barrow, for a number of reasons, looks and feels different from Nome, Fairbanks, Juneau or Dawson — communities that also developed around Native settlements in response to resource extraction development (McBeath and Morehouse 1980:79).

The key point that I wish to highlight about the North Slope Borough is its positive impact on the lives of North Slope Inupiat. It has served as a vehicle to 1) improve the general quality of life of the North Slope Inupiat and 2) to mediate and provide leadership internally in channeling culture change as well as externally in protecting the possibility for Inupiat culture to continue. This is evident in three areas: economy, subsistence and identity.

Economy

Through tax revenues, the North Slope Borough upgraded schools, housing, and other facilities throughout the communities of the North Slope. This was accomplished through the Capital Improvement Program (CIP) which created substantial wage-labor jobs in construction that spread the wealth widely to Inupiat families and others hired to assist in the improvement of the quality of life. The bureaucracy formed to oversee the vast territory and responsibilities of the new government also provided wage opportunities for men and women to maintain households with improved amenities. In addition, and of great importance, the Borough created policies for vacation and leave which allowed time off for the pursuit of subsistence activities. This is a critical innovation that allowed households to appreciate what might be thought of as the best of both worlds — sufficient income to live comfortably and sufficient time to pursue subsistence hunting, fishing, gathering, and the cultural ceremonies which celebrate these traditions. This melding has been made possible through an elected Inupiat leadership with a different view of the meaning of life from the efficiency experts of the corporate world.

Subsistence

The North Slope Borough has provided the platform for the protection of Inupiat subsistence interests in a variety of ways. It has established an environmental protection office, a Department of Wildlife Management, a Coastal Zone Management Plan and a Geographic Information System (GIS) program to minimize the impact of industrial activities on critical habitats, animal, bird and fish populations and transportation corridors used by subsistence hunters.

The North Slope Borough has used its revenue base to challenge legally and politically actions of state and federal agencies and private companies which the leadership has viewed as detrimental to the continuity of subsistence species and the habitats they require. The cases of the Dalton Highway and offshore exploratory oil drilling are examples of its efforts in this area.

One of the most impressive results of North Slope legal and political activity is the protection and enhancement of the bowhead whale hunt, which as we have seen is central to Inupiat culture and individual well-being. A crucial innovation was the creation of the Alaska Eskimo Whaling Commission (AEWC) in 1977 when the International Whaling Commission called for a total ban on bowhead hunting. In addition to managing the bowhead hunt through the allocation of strikes and kills between communities, the establishment of rules for the hunt and criteria for captainship, the AEWC has developed a state-of-the-art scientific plan for the censusing of whales. Through this institution scientists and Inupiat whalers have gradually developed a relationship of trust that I hope will result in Inupiat models of science in which rigorous methods are applied to problems and issues of importance to the Inupiat. Inupiat valued and directed scientific studies are important to the future of the North Slope because their knowledge and sense of homeland gives them a particularly large stake in the protection of that environment.

Identity

The North Slope Borough has directed some of its revenues to actively promote the retention of Inupiat culture and language. Through the Office of History and Cultural Heritage, it has made possible the recording and transcribing of personal histories, cultural activity descriptions, and other observations of the elders. The NSB has provided funds for annual elders meetings and for conventions of youth and elders where the cultural traditions can be passed on. It is presently in the process of developing a museum to preserve and demonstrate elements of the traditional culture.

Control of education and the availability of advanced education locally were significant aims of Borough organizers. The Borough made possible the formation of an Independent School District which has moved to develop bilingual programs in support of the Inupiat language and courses in Inupiat history, culture as well as courses on land claims. It has also funded local aides in the classrooms providing role models in classrooms for children.

Although there have been shortcomings as well as successes in the operation of the North Slope Borough, it is not difficult to visualize how different and dismal life for the North Slope Inupiat over the past 20+ years would have been without it.

THE FUTURE - FINDINGS OF THE NATIONAL RESEARCH COUNCIL

In 1992, the National Research Council at the request of the Congress of the United States and through invitation of the Minerals Management Service (MMS) undertook a study to review the adequacy of environmental information for leasing of offshore lands in Alaska. Due to the likelihood of exploration and development in the Beaufort and, to a lesser extent, the Chukchi Sea, the convened committee elected to focus its attention on Arctic offshore waters.

It was the view of the committee (and I as a member) that the requirements of the Outer Continental Shelf Lands Act (OCSLA) requires the MMS to study and manage the effects of OCS activities on the "human environment" broadly defined to include "the physical, social and economic components, conditions, and factors which ... determine the state, condition, and quality of living conditions, employment, and health of those affected, directly or indirectly, by activities occurring on the OCS" (NRC 1994:129). This is a clear and unambiguous mandate for MMS to study and manage broadly defined effects on social and cultural systems.

In its general conclusions, the committee found that environmental information for the lease and exploration phases in the Chukchi, Navarin and Beaufort Basins was generally adequate, "**except** in the case of effects on the human environment" (NRC 1994:187). The committee determined that baseline studies of socioeconomic and sociocultural conditions were generally adequate except that the characteristics of and impacts of enclave development on the welfare of non-Native migrant workers was poorly analyzed. However, the report went on to note that studies dealing with changes due to development and the impacts of those changes on socioeconomic and sociocultural conditions were absent.

In regard to local North Slope conditions, the report found that insufficient research had been done on the effects of pre-lease anticipatory and speculative activity as parties react to impending developments as threat and/or opportunity (NRC 1994:145-146; Table 2). Specifically, does such activity significantly affect later developments in social and economic sectors?

Table 2. National Research Council findings and recommendations concerning the human environment in oil and gas leasing decisions (NRC 1994).

FINDINGS
1. Environmental information for leasing and exploration generally adequate, "**except** for information on the human environment."
2. Insufficient research on the opportunities and threats perceived and acted upon prior to leasing.
3. Subsistence studies of baseline conditions adequate but not sufficiently longitudinal nor used effectively in EIS projections.
4. Social indicators study culturally relevant elements but absent are indicators allowing the tracking of social pathology and stress.
5. Research on "enclave" employment and impacts on non-Native migratory workers lacking.
RECOMMENDATIONS
1. Research long-term impacts of all phases of OCS activities in terms of revenues, employment, income distribution, subsistence and social and cultural health.
2. Research sociocultural adaptations to change as indicated by social indicators of well-being in addition to cultural measures.
3. Research through quantitative assessment the impact of cumulative oil development activity on significant subsistence activities in terms of spatial distribution and harvest levels.
4. Research and analyze the means and degree to which impacts on subsistence from development can be mitigated.
5. Research on impacts of demographic growth and population mix on political control, public policies, and revenue allocation.
6. Secure and maintain adequate funding and experience social scientific staff to carry out necessary studies.

The committee found that MMS studies had produced substantial documentation of the scale, timing, and spatial distribution of subsistence activities on the North Slope. However, those studies had not been satisfactorily utilized in identifying impacts of additional oil development in a detailed quantitative and spatial fashion. Single word assessments of likely impact as low or moderate in the 1992 EIS were unsatisfactory. More importantly, such assessments are of no use in determining what if any kind of mitigating measures, such as alternative siting, environmental protections, and limiting access, might be taken to protect subsistence activities. Given the present and continuing importance of subsistence activities to the cultural and personal well-being of members of North Slope society, such assessments are of vital importance. They are also particularly well-suited to new partnerships involving Inupiat, scientists, government agencies, and oil companies in truly collaborative efforts to address the implications of gradual, but cumulatively significant, changes likely to take place in the environment on subsistence activities.

The committee was unable to find evidence that the Social and Economic Studies Program (SESP) had dealt in a systematic manner with long-term or permanent socioeconomic or sociocultural changes that are likely to result from OCS development (NRC 1994:146). In particular, no apparent attention had been paid in EIS projections to the potential impact of changing demographic ratios of Natives and non-Natives on political control of the North Slope Borough and its policies. Neither had the long-term impact of declining revenues on the Borough and its residents been assessed. It was suggested by the committee that overadaptation, either to the Borough as a mediating institution and/or to revenues from oil development, could result in a radical bust scenario should new technologies or cheaper energy sources lead to abandonment of the North Slope. What are the implications of these scenarios for the facilities, employment, and resident population dependent on them?

While the committee noted a regionally relevant set of Social Indicators had been developed for monitoring long-term changes in North Slope conditions, it pointed out that missing from these indicators were evidences of social and personal well-being (NRC 1994: 145). Standard measures of crime, education levels, dropout rates, and social pathology indicators related to violence and drug and alcohol abuse were notably absent. It is interesting that these measures have loomed large in the recent debate over legalization of alcohol possession and consumption on the North Slope but have been ignored in MMS studies.

The committee was also concerned that relatively little attention had been paid to the social and cultural aspects of employment on the North Slope. Nor had the impacts of the "enclave" model of development on the non-Native migrant workers been addressed. Evidence indicates that there has been a very low rate of employment of Inupiat in the Prudhoe Bay oil patch and most of that has been through Native corporations acting as contractors to the oil industry in the service sector (NRC 1994: 144). Little attention has been paid by MMS to this issue which potentially could be of critical importance in the future.

In light of these findings, the committee found that in order to adequately project and satisfactorily manage change, a research program of both greater breadth and specificity was required. Six (6) recommendations with several subrecommendations were made (Table 2). The most important, in my view, called for:

1. Research on long-term impacts of all phases of OCS activities in terms of revenues, employment, income distribution, and subsistence.

2. Research on sociocultural adaptations to change as indicated by social indicators of well-being in addition to cultural measures.

3. Research through quantitative assessment the impact of cumulative oil development activity on significant subsistence activities in terms of spatial distribution and harvest levels.

4. Research and analyze the means and degree to which impacts on subsistence from development can be mitigated.

5. Research impacts of demographic growth and population mix on political control, public policies and revenue allocation.

CONCLUSION

As oil development in Arctic offshore waters continues, the critical question for those directly affected is not whether cultural change will occur because it always has and it always will. The questions are, rather, what will be the nature of that cultural change? To what extent will the affected people benefit from or be harmed by the change? And, to what extent will the affected people be able to determine the nature of those changes and in that way decide their own futures? The answers to these questions can exert a powerful influence over the degree to which the resultant change will, on balance, provide for fulfilling lives or lead to cultural disruption and social pathology.

The National Research Council identified an atmosphere of mistrust over OCS development among the involved parties and suggested that trust through experience would be necessary to create the opportunity for meaningful collaboration. In addition, the National Research Council's report raised serious issues related to the socioeconomic and sociocultural future of the North Slope. It also identified the research necessary for MMS to conduct to meet the legal mandates of OCSLA for projecting and managing change in the human environment. As an examination of the program for this synthesis meeting will reveal, the NRC's call has gone unheeded by the Congress and perhaps by the MMS as research of this nature is not reported at this session. When the stakes are so high for the future of North Slope society, the lack of funding and priority for consideration of these issues suggests at a minimum indifference to the future of North Slope Inupiat culture and society.

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HISTORY OF WHALING BY KAKTOVIK VILLAGE

Joseph Kaleak
Whaling Captain
Kaktovik, AK 99747

Today, I am going to try my best to give the history of subsistence whaling for the Kaktovik area (Table 1). In 1937 and 1940, two whales were landed. In 1964, the people of Kaktovik returned to whaling. There were only about three or four captains at that time. In 1973, only one whale was landed. I think that was due to bad ice or water conditions during that fall whaling time. In 1977, before we had a quota imposed by the International Whaling Commission, five whales were landed. That was a good whaling season that year. In 1985, no whales were landed. That was due to the fact that there was a drill ship located about 18 miles east and ten miles offshore of Barter Island. So it was a bad year because of that ship. In 1987, no whales were landed due to bad weather. From 1992 to 1995 we had a very good whaling season because there was no seismic survey activity and the whales were close to shore.

After the whaling season, everyone puts their boats away. If we get the whale subsistence quota early, then we go hunting on land. On Thanksgiving and Christmas, we always share what we have caught with the community. The captains always share when whales are landed. We share with our friends.

Figure 1 is a map showing the harvest locations since we started whaling. The numbers 33 and 39 are in areas where the oil industry is active. The Outer Continental Shelf (OCS) is very calm, nothing active is going on right now. Since we started whaling, these are the locations where we have caught whales. I hope it is going be to like that for a long time (whales close to shore); that way we won't have a hard time searching for bowhead whales. Sometimes we have to go very far offshore. We have to go back and forth every day. In 1994 and 1995, the whales were close to shore and we didn't have to go out too far. I hope it is going to be like that for a long time.

Table 1. Bowhead whale harvest data for the Village of Kaktovik.

Number[a]	Whaling Captain	Year	Number[a]	Whaling Captain	Year
3	Archie Brower	1964	27	Joseph Kaleak	1986
4	Herman Aishanna	1973	28	Nolan Solomon	1986
5	Herman Aishanna	1974	29	Archie Brower	?
6	Herman Rexford	1975	30	Isaac Akootchook	?
7	Herman Aishanna	1975	31	Tommy Agiak	1988
8	Archie Brower	1976	32	Tommy Agiak	1989
9	Archie Brower	1977	33	James Killbear	1989
10	Alfred Linn	1977	34	Joseph Kaleak	1989
11	Nolan Solomon	1977	35	Herman Aishanna	1990
12	Tommy Agiak	1977	36	Jimmie Soplu	1990
13	Joseph Kaleak	1977	37	Daniel Akootchook	1991
14	Joseph Kaleak	1978	38	James Lampe, Sr.	1992
15	Joseph Kaleak	1978	39	Daniel Akootchook	1992
16	Nolan Solomon	1978	40	Joseph Kaleak	1992
17	Alfred Linn	1982	41	James Killbear	1993
18	Tommy Agiak	1982	42	Herman Aishanna	1993
19	Alfred Linn	1982	43	Joseph Kaleak	1993
20	Isaac Akootchook	1983	44	James Killbear	1994
21	Nolan Solomon	1983	45	Herman Aishanna	1994
22	Tommy Agiak	1983	46	Edward Rexford	1994
23	Herman Aishanna	1984	47	Tommy Agiak	1995
24	Isaac Akootchook	1984	48	James Killbear	1995
25	Nolan Solomon	1984	49	James Lampe, Sr.	1995
26	Alfred Linn	1986	50	Isaac Akootchook	1995

[a] = Number refers to locations on Figure 1, not numbers of whales landed.

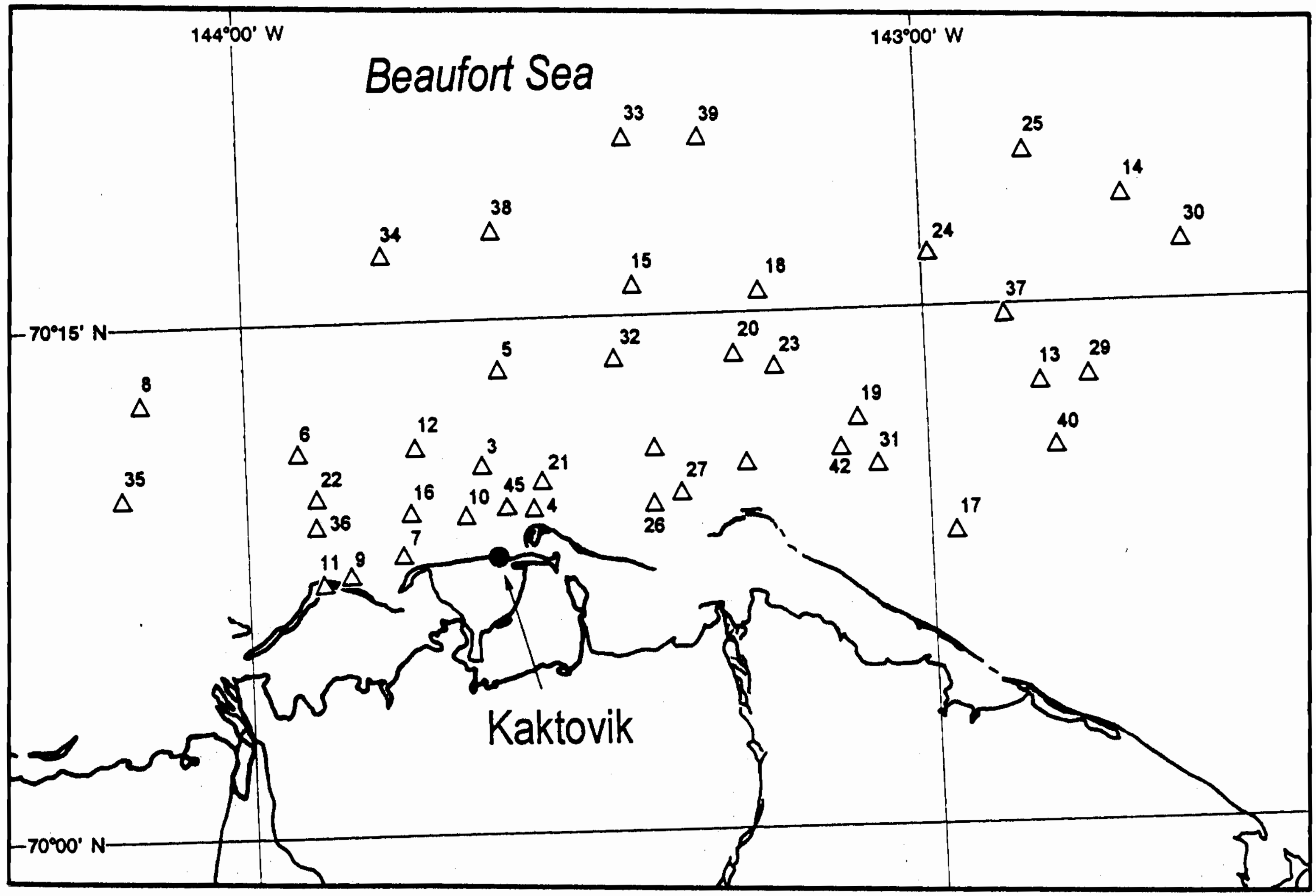

Figure 1. Whale harvest locations near Kaktovik (adapted from Dept. of Wildlife Management, North Slope Borough, 1993 map).

HISTORY OF SUBSISTENCE WHALING BY NUIQSUT

Frank Long, Jr.
President
Nuiqsut Whaling Captains Association
Nuiqsut, AK 99789

It is a pleasure to be in a meeting as important as this with the Minerals Management Service. I am a whaling captain from the Village of Nuiqsut and also the president of the Nuiqsut Whaling Captains Association. I have participated in whaling for a number of years. I began when I was nine years old. The first time I ever went out was at Point Hope. After moving to Barrow, I participated in whaling there. In 1973, I moved to the Village of Nuiqsut to reestablish the community. We lived in the tent city during the winter. Actual whaling started in Nuiqsut in the fall of 1973. But before that time, centuries back, whaling by our Native people, had been conducted in the Cross Island area, which is near Prudhoe Bay. I don't think that there is anything that would stop our whaling because it is not only part of our life and our culture, it is the nature of the whales that we live with.

Nuiqsut is a unique whaling community. We go down the Colville River and across the ocean to our base camp at Cross Island — a distance of about 94 miles. Even though we have fast outboards with 200 hp, it takes about eight hours to go that far. After basing there, we hunt in the area to the north, northeast, and east of Cross Island. There are numerous industrial activities that also take place in that area.

I am very surprised to be here, but I am glad I am here to not only speak about my way of life also the way that we whale. Whaling has been active for as long as I can remember. I am glad and proud to be one of the whalers. It not only gets into your bones; it also gets into your blood. Whales think like we do. If there is a lot of controversy among whales and the people, it is very difficult to hunt and catch the whales. There are people, like Mr. Rexford, who have been whaling for many years. It is important to us that we come from people who subsist on the bowhead whale.

We go to Cross Island during the first week of September. When there was no industrial activity in the area or to the east of Cross Island, we would be successful, landing our quota. Since 1973 we have had a quota, today our quota is four whales. It is very difficult to find even one bowhead whale when there is a lot of industrial activity. The whales not only pressure us, they pressure industry also. We both want to do our thing, but I think that there is a way for both oil exploration and whaling to be successful.

I have been told from the time that I can remember that a whale will be startled or scared by a little sound. Even tapping on a boat will cause a whale not to surface. It will go further out and leave you behind for sure — way, way out there.

The main thing that I would like to talk about is the interaction of subsistence whalers and the involvement of industry. A lot of times there is controversy between the whalers and the oil industry. There was controversy about Kuvlum, Hammerhead, and Galahad on the east between Barter Island and Cross Island. As I stated before, when there is industry activity, we have to go very far out for whales — about 44 miles straight out from Cross Island to catch whales. It takes hours and is dangerous when you go that far out. A few years ago, we were caught by a bad storm. We lost a whale and a crew boat, but everybody was found and we returned to Cross Island safely. It is hard to see far with the little boats that we have; the biggest one is only 26 ft. We know that whaling is dangerous, but it is our livelihood. We have to supply our community's nutritional needs for the winter. The captain doesn't get the whole whale; after it is harvested, it belongs to the whole community. We share it, like Mr. Joseph Kaleak said earlier; we share during Thanksgiving, Christmas, and "Nalukataq" — a time that we share and give away most of the catch. Everybody in the community, regardless of whether they are a small kid or a senior citizen, gets a portion of the whale muktuk and meat.

It is important for us to know that it is a challenge — not only for me but a challenge for the industry to get to know the Natives and why we subsist on whales. I know that what they have to do, drilling exploratory wells, is important. We also do what we have to do. So, in turn we have to learn to work together, or if we don't, we will fall into another lawsuit. A couple of years ago, the Nuiqsut whalers filed a lawsuit against the industry and the federal government. In my opinion, I think it is not necessary for us to do that against each other. Both will gain if the Native subsistence whalers and the oil industry learn to work together — there is nothing to lose. I always hope that one day we will learn to work together.

The map (Figure 1 and see also Table 1) here shows where we live in Nuiqsut to the west of Cross Island about 70 air miles west of Deadhorse and Prudhoe Bay. I said it takes about eight hours to go from our village to Cross Island. When we do our hunting and there is industrial activity taking place in this area, we go straight out about 44 miles at the most. We go in many different directions searching for whale. We also go along the Barrier Islands. The closest whale that was caught this year, when there was no industrial activity, was two miles off Cross Island. When there is pack ice, it covers the area near Cross Island. About four years ago, there was a tourist ship near Cross Island; due to heavy ice, they couldn't go beyond Cross Island. Once that ice is packed, it doesn't move north or east; it stays the whole year.

A little sound, east of Cross Island, where the Kuvlum Prospect, Hammerhead, and Galahad development units are located, will affect the bowhead whale. There is a lot of argument between the industry and the whalers. I will argue as long as I have a voice. I know that we, as subsistence hunters, weren't taught to argue over an animal; we were taught to harvest and to feed our people. But when industrial activity takes place and the arguments get heavy, it is very hard to even look at people like the meeting attendees. The federal government will argue against us. The International Whaling Commission will argue against us. And maybe the local people will argue against too. However, I am glad that I could be part of this meeting.

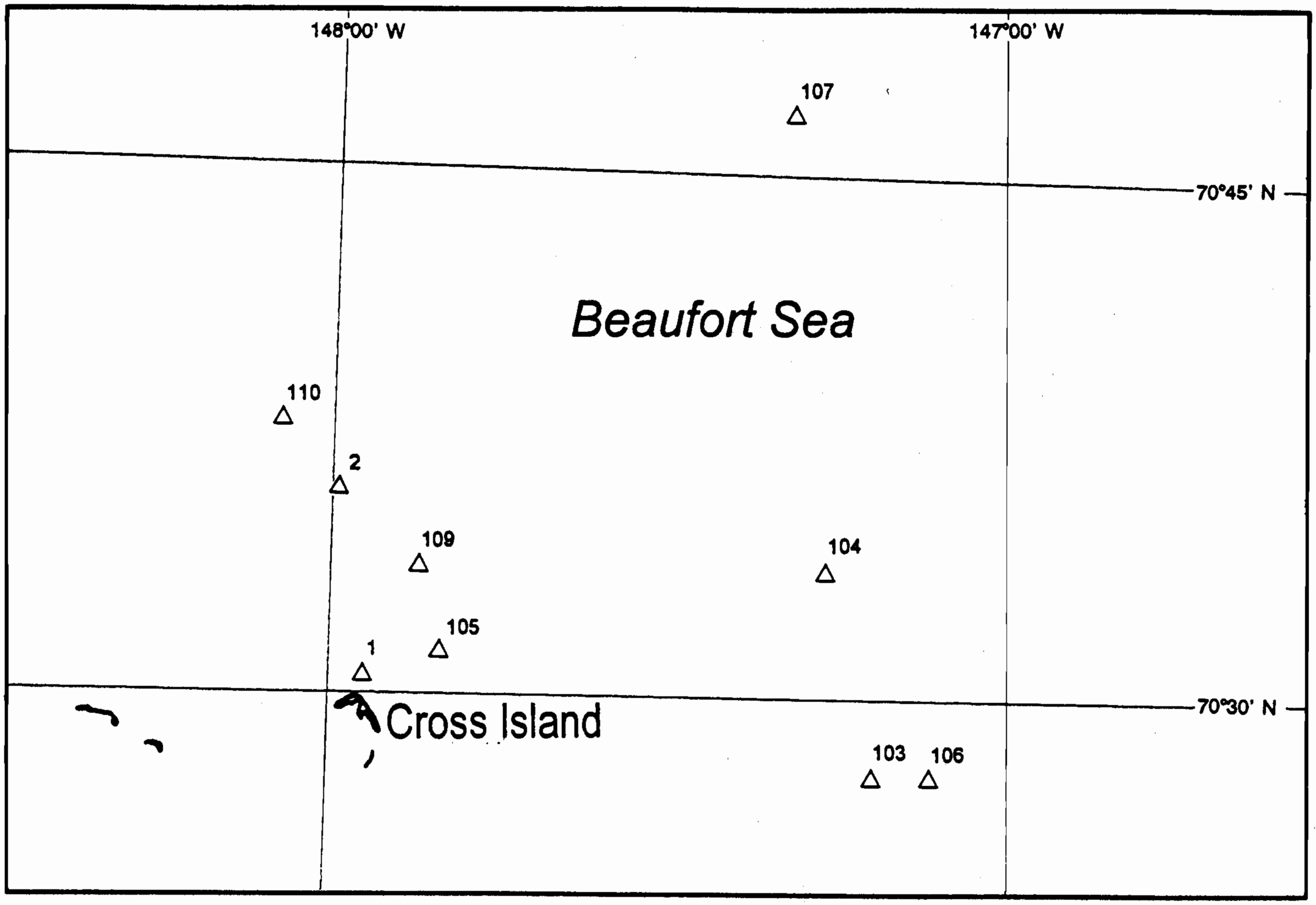

Figure 1. Whale harvest locations near Cross Island (harvest locations 101 and 102 were located farther east) (adapted from Dept. of Wildlife Management, North Slope Borough, 1993 map).

Table 1. Bowhead whale harvest data - Nuiqsut.

Number*	Whaling Captain	Year
1	Taaqpak	1937
2	Taaqpak	1940
101	Thomas Napageak	1973
102	Thomas Napageak	1982
103	Billy Oyagak	1983
104	Lloyd Kittick	1985
105	Patsy Tukle	1986
106	Thomas Napageak	1990
107	Archie Achiviana	1991
108	Billy Oyagak	1991
109	Roxy Oyagak	1992
110	Patsy Tukle	1992

* = harvest locations in Figure 1, not numbers of whales landed.

THE ALASKA ESKIMO WHALING COMMISSION AND HISTORY OF SUBSISTENCE WHALING OFF POINT BARROW "NUVUK"

Burton Rexford
Chairman
Alaska Eskimo Whaling Commission
Barrow, AK 99723

ALASKA ESKIMO WHALING COMMISSION

The Inupiat and Siberian Yukpik Eskimos, living in northern and western Alaska, have been hunting the bowhead whale for thousands of years. As the International Whaling Commission (IWC) has acknowledged, "whaling, more than any other activity, fundamentally underlies the total life way of these communities." The entire community participates in the activities surrounding the subsistence bowhead whale hunt, ensuring the tradition and skills of the past associated with their cultures will be carried on by future generations. Each whale provides thousands of pounds of meat and "muktuk" (blubber and skin), which is shared by all the people in the community. Portions of each whale are saved for celebrations at Nalukataq (the Blanket Toss or whaling feast), Thanksgiving, Christmas, and potlucks held throughout the year.

Subsistence whaling has been the mainstay in our culture since time immemorial, and the activities associated with subsistence whaling serves as a tradition that binds our communities together.

In September 1977, the Alaska Eskimo Whaling Commission (AEWC) was formed to unite whaling captains against the ban that the IWC put on all types of whaling, including subsistence whaling. The AEWC, in cooperation with the National Oceanic and Atmospheric Administration (NOAA) signed a Cooperative Agreement in 1981. So, for the past 18 years, the AEWC has worked with the federal government, successfully, in the management of the bowhead whale. Through this cooperative agreement, NOAA delegated authority to the AEWC to manage the subsistence whale hunts. Under this agreement, the AEWC also adopted a Management Plan which governs the actual aspects of the hunt. We have found that this system of management has worked since the inception of AEWC. The local responsibility of joint management of any type of resource is vital and has been proven to be successful.

The management guidelines for our hunts are set out in a management plan approved by NOAA. In addition, our hunt is subject to an IWC-imposed annual whaling quota. This quota has been established at a level close to our people's needs after many years of effort by the AEWC, with the support of the North Slope Borough, and working with the United States Congress, the U.S. Department of Commerce, the environmental communities, and the IWC to do scientific research. Since 1977, representatives of AEWC have attended every annual meeting of the IWC — and every year scientific research on the bowhead whale conducted through the efforts of AEWC, the North Slope Borough, and NOAA is provided to the IWC Scientific Committee. The information gathered and the positions agreed upon at this meeting form the basis of the presentations made to the International Whaling Commission at its annual meeting.

As a result of our excellent management record and our diligent efforts on behalf of our subsistence whalers, the AEWC has gained international recognition and respect as a model local resource manager. Today, the AEWC exists as a tax-exempt, non-profit corporation whose purpose is to:

1. Preserve and enhance a vital marine resource, the bowhead whale, including the protection of its habitat;

2. to protect Eskimo subsistence bowhead whaling;

3. to protect and enhance the Eskimo culture, traditions, and activities associated with bowhead whales and subsistence bowhead whaling;

4. to undertake research and educational activities related to bowhead whales.

The AEWC carries out those purposes outlined above through the establishment of the following goals:

1. ensure that the hunt of the bowhead whale is conducted according to the AEWC Management Plan in a traditional, non-wasteful manner;

2. promote extensive scientific research on the bowhead whale so as to ensure the continued health of the bowhead whale stock;

3. communicate to the outside world the facts pertaining to the subsistence bowhead whale hunt, the manner in which it is conducted, the Eskimo's knowledge of the bowhead whale, and the centrality of the hunt to the cultural and nutritional needs of the Eskimo.

The members of the AEWC are the registered whaling captains and their crew members of the ten whaling communities: Little Diomede, Gambell, Savoonga, Wales, Kivalina, Point Hope, Wainwright, Barrow, Nuiqsut, and Kaktovik (Figure 1). The AEWC is directed by a board of ten elected Commissioners; one from each whaling village. The members of the AEWC are afforded a public forum to speak on issues that affect them and to set quotas at the Whaling Captains' Convention held in mid-winter. At this meeting, the 150 whaling captains negotiate their demands of the whaling captains on priority issues affecting their subsistence whaling activities in their respective village. Invited participants include the United States Commissioner to the IWC, NOAA personnel, AEWC Commissioners, AEWC staff and legal counsel, the Mayor of the North Slope Borough (NSB), the staff of the NSB Department of Wildlife Management, and the AEWC Cooperating Scientists. Every four years, a bowhead quota for our aboriginal subsistence whaling is set. The whaling captains, at the convention set a quota for each whaling community, based on historical, cultural, and subsistence nutritional needs.

THE BOWHEAD CENSUS

Significant additional research, the bowhead census, was launched in 1993 by the AEWC through the NSB Department of Wildlife Management. The census was a great success which documented a tremendous increase in the bowhead stock.

As all who know our people, the bowhead hunt is a vital component of our culture in the bowhead subsistence whaling communities. Because the hunt and the Native exemption that protects our rights to continue hunting are so important to our people, the AEWC takes sole responsibility for representing all of the ten bowhead subsistence whaling communities.

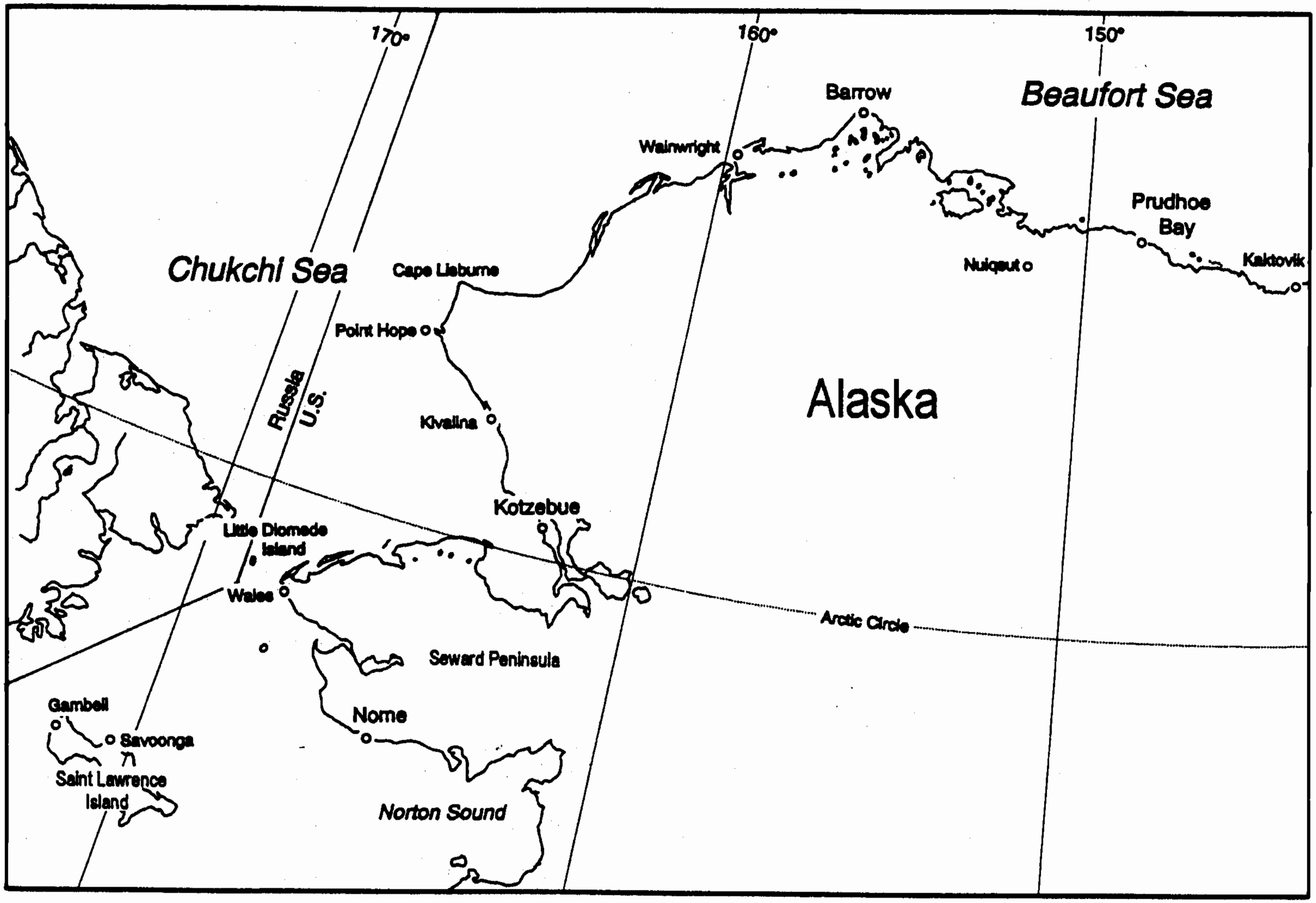

Figure 1. The whaling communities which are members of the Alaska Eskimo Whaling Commission: Little Diomede, Gambell, Savoonga, Wales, Kivalina, Point Hope, Wainwright, Barrow, Nuiqsut, and Kaktovik.

HISTORY OF SUBSISTENCE WHALING OFF POINT BARROW "NUVUK"

I was born at Point Barrow "Nuvuk," Alaska on January 12, 1930. Unlike other boys in the village of Barrow, my observation of sea animals began at the early age of six years old. My grandparents were the last residents of Point Barrow "Nuvuk," Alaska. My aunt and I would hunt daily for food, such as snipes, along the beach shoreline of Point Barrow "Nuvuk." Often we would observe fall migration of belukha and bowhead whales about 25 yards from the beach shoreline. I was ten years of age when my father introduced me to the spring migration whale hunt at Barrow, Alaska. We didn't have dog teams to assist us in transporting our whaling equipment and necessary supplies. The results are very clear, that manpower is used to pull 30 ft Boston Whaler, a wooden hull boat, over the ice pressure ridges.

During the early 1940s (1943), I was one of the crew members of the late Mr. Anthony Weber of Point Hope during the spring migration bowhead whale hunt. After the whaling season, we moved to Kotzebue, Alaska until 1948. While a resident there at Kotzebue, I would observe belukha whales localized 10 to 15 yards from the beach shoreline. In 1948, we returned to Barrow, and I didn't waste any time. I made crew member to Mr. William "Enugruak" Leavitt, Sr., the son of the Yankee whaling ship captain, Mr. George Leavitt, Sr. I have been an active participant whaling captain since the mid-1950s in the fall migration hunt of the bowhead whale.

During some recent years, oil industry seismic activity has been conducted in our hunting grounds of the bowhead whale. In the vast Beaufort Sea, the seismic area — with parameters clearly identified as approximately 20 to 30 miles northeast off Cape Simpson "Tulimanik" and approximately 20 to 30 miles north of Point Barrow "Nuvuk" — extended through migration routes and natural habitat areas.

Since time immemorial, Point Barrow "Nuvuk," Alaska has been both a staging area and strategic location for our fall bowhead whale hunt. The Eskimo elder bowhead whalers have clearly identified the natural habitat areas where the bowheads congregate as:

1. Point Barrow "Nuvuk"
2. Eluitqauk Island
3. Taupkaluk Island
4. Cooper Island
5. Martin Island, and beyond east of Martin Island

The migration routes are unpredictable due to nature's conditions. When the oil industry was doing seismic work during the fall migration, my two colleagues and their crew members completely searched these above locations and beyond. The entire month of September was spent in our attempts to locate bowhead whales, resulting in nothing. Not only were there no bowheads, there also were no belukhas nor gray whales to be seen. My same two colleagues and their crew members, along with my crew, repeated this same process years later and again came up with zero results. After going through this same process, we have never experienced such a low morale in our lifetime as when there were no whaling activities. After a thorough coverage of what used to be our whale hunting grounds, my colleagues and their crews attempted to go beyond the parameters of the seismic work area. In spite of the endangerment of human life, these attempts were executed repeatedly, and still the end results were the same.

I share the honor, dignity, and humiliation that my colleagues and their crew members have inherited from those seismic boat experiences. Throughout my 55 years of whaling in Point Hope, Barrow, and Nuvuk, I have observed, like many other whalers, the impact of underwater noise on bowhead whales. My honor and dignity as a Whaling Captain are of the utmost importance to my peers and colleagues in the Barrow Whaling Captains Association and the Alaska Eskimo Whaling Commission. Without honor and dignity, a whaling captain loses face with the whaling community and loses the respect and prestige one attains through many years of involvement as a member of the whaling community.

Thank you for the opportunity to speak at this meeting.

SOCIOCULTURAL SESSION

GENERAL DISCUSSION

Burton Rexford: As we talk about seismic activity, it is bad news for the whalers to have a distribution of the whales so far away from the hunting grounds. It is dangerous to take a crew out that far in the Arctic Ocean. Thank you.

Abigail Dunning: You mentioned, Mr. Rexford, that you were introduced to whaling at 10 years of age. I wondered if you, or any of the panelists, would address how you are passing on that tradition to your young people in the whaling villages?

Burton Rexford: Unfortunately, I was lucky to go out at that age. It wasn't allowed, but I went out early. Today, we have the availability of fast moving transportation. We are allowing the ten-year-olds to go out to the whaling camp. We are allowing women, too, today! That never used to be allowed in my days, when I was young.

Tom Newbury: Mr. Rexford, I appreciate very much that you brought the maps. Mr. Kaleak, Mr. Long, and you talked about the specific sites where you have harvested whales. That is a great help to us. In the past, the MMS has heard about the general harvest areas, but we've not known about the specific sites. I thought you made a good point when you said that while the sites show where whales were harvested, the sites aren't the only places where you hunted. I understand that you hunt in the general area.

I want to note also that you talked about the response of whales to slight noises in the whaling boats. There will be a subsequent session on the responses of bowhead whales to underwater noise.

I want to respond to a similar, specific comment by Mr. Kaleak. He mentioned that no whales were landed during the year that a drill rig was located near Barter Island. Previously, I had heard about the correlation, and was concerned. So I looked through the data from the Bowhead Whale Aerial Survey Program (BWASP), checking to see if whales were sighted near the island. What I found was that during part of 1987, when a rig was being towed into position at the Aurora Prospect near Barter Island, no whales were sighted near the island. But once the rig was left in position — it was left "idling" but not drilling during the migration — and the tow boats were gone, then the whales were sighted by BWASP near Barter Island. The BWASP data indicates that whales were displaced by the towing operation but not by the idled drill rig. This general subject — the effects of underwater noise from vessels, drill rigs, and ice breakers — will be discussed further in the next session.

Burton Rexford: To quickly respond to your comment on monitoring: we have been following the monitoring programs for several years with the North Slope Borough scientists and AEWC.

Tom Newbury: Also, I want to explain that MMS has tried to mitigate the biological consequences — of noise effects on the whales — with monitoring requirements. We realize that we need more data to quantify the effects. However, it has been more difficult to mitigate the sociocultural consequences; the effects on subsistence. We have tried to do it by requiring industry/whaler coordination.

During the lease sale process, an environmental impact statement (EIS) is prepared. There is a draft EIS which gives the whalers time to comment on the proposal, and to express your concerns. However, during the next step (exploration) there isn't time for a draft document

— time to review and to comment on the documents. So we have a special requirement for coordination.

It is a special stipulation that has been attached to leases that requires the exploration company to contact the potentially affected communities. It requires the company to discuss the potential conflicts; to describe efforts that are being made to assure that the activity is compatible; and then, significantly, to discuss unresolved conflicts.

I wanted to explain again that during the leasing process, there is a draft and a chance to make comments. During the exploration phase, there is just a single document and a requirement to coordinate. In the next phase — the development phase which we have been discussing at this meeting — we are preparing a draft EIS. There will be a chance to comment on it.

A question that I have is: has the industry/whaler coordination helped you? I realize that it hasn't always worked; there was a time you mentioned when the coordination broke down and a lawsuit was filed. Is there anything more that we could do through this coordination process that would make it more suitable?

Burton Rexford: I guess the reason for filing the lawsuit was to put the federal agencies on notice that we were not satisfied with the monitoring program. We are subsistence people; we observed the poor quality of data that was coming from the monitoring programs. Whenever there is any industry activity out in the sea, the whales are distributed way out from the beach. We argued that point. We got an adverse ruling in the court, but we benefitted even from filing the lawsuit.

Tim Holder: This is a question for Mr. Long. Have you gone to Cross Island for many, many years, or is that a fairly new place where you set up whale camp?

Frank Long: It is a former whaling island. Taaqpak and people before him had whaled on it. There are some whale bones out there. The oldest recorded whale is 1937, but there are bones that are older than that out there. I don't know exactly how old, but when we were conducting a history and culture survey for the North Slope Borough in 1980, there were five whalebone heads. So, I would say that whaling had been going on for a long time. I think that the whalers left the island in 1940s when the federal government required the Natives to attend school. All of the people from that area either went to Barrow or to Barter Island.

Tim Holder: When you catch a whale do you bring it up on the island or do you bring it back to the mainland shore and pull it up there?

Frank Long: We bring it up on the island. We've a winch that we use. We butcher it there. Then when we are all done, we try to take it all home by boat if we can. If not, then we either go to West Dock or Endicott, and have it trucked to Oliktok Point near Nuiqsut (Figure 1).

I also would like to respond to the question about young people participating and learning the activity of whaling. In our community, we take out young people. All of my boys have been exposed to whaling — not at the age that Burton and I started — but we do try to teach them about our hunt and the area in which we hunt. I first took my youngest boy when he was ten years old. He loves to go out. He is anxious to go fall whaling, although he recognizes that there is danger. There is not only danger, but a challenge. It becomes part of you to be a whaler. It becomes your nature, your life, and your way of breathing. So whaling is very important to us. In each community, I think we have different views of it, but we teach our children and young

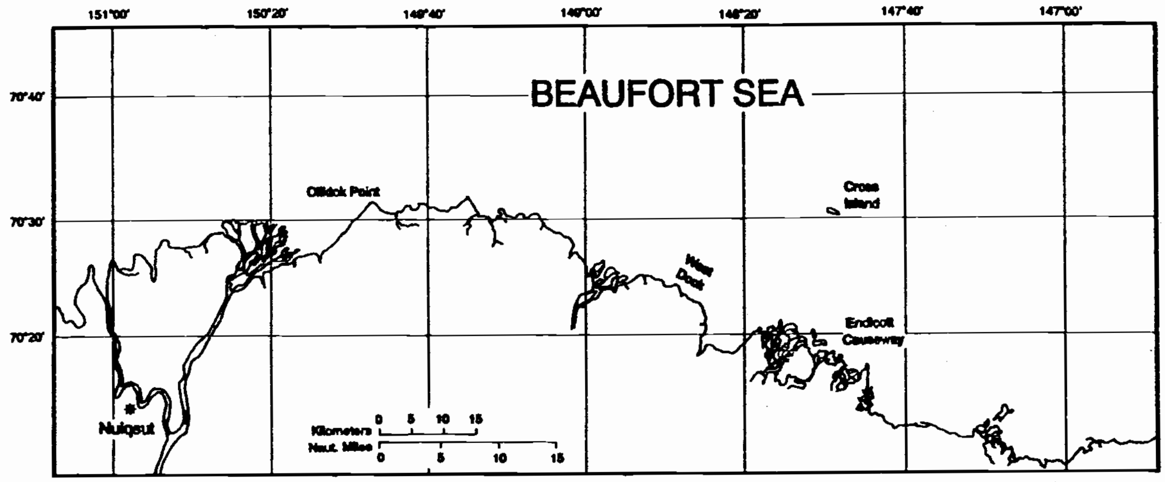

Figure 1. Possible whale landing sites: Cross Island, Endicott, West Dock, and Oliktok Point.

adults who are interested in whaling.

Joseph Kaleak: I would like to comment on what Mr. Long said. We've have about five or six kids who go out with us all of the time during fall whaling. The kids always make an excuse to get out school during fall whaling time. The school lets them go and we train them. They like to go out and look for themselves and train themselves in how we do the subsistence whaling. Even when we land a whale, they are always trying to help cut the whale, so that they can do it themselves later on. We appreciate it when the students go out with us during fall whaling.

Burton Rexford: My recommendation for the Cross Island area and the whalers from Nuiqsut, would be to insist on no seismic activity after September 1st. We have done that before; we have shut down the seismic activity. If I can do anything for Nuiqsut, that is what I would recommend — September 1st.

Tom Albert: A couple of interesting things have happened during this session. One of them is that you have heard from some very senior Eskimo people who have spent their whole life hunting in a rather dangerous environment. Mr. Long said that now they go out 40 miles in a very small boat — not <u>four</u> miles but <u>40</u> miles. The thing that I have heard for years, and years, and years, is that seismic noise scares the whales away.

Somebody asked what can be done to make the coordination process better. When there are draft EIS public hearings, or industry coordination meetings in the villages, it is like a repeat of a very brief movie that over the years is attracting fewer and fewer participants. Fifteen years ago, when I participated in such early meetings, the rooms would be packed; people would come in and testify. The MMS, industry, whoever, would sit there, nod, and take notes — but nothing would happen. Over the years, as these meetings have continued, the number of people who give up an evening to come out and comment on these things is declining. MMS personnel were kind enough to come to Barrow not long ago for a meeting. It was unfortunate how few people showed up. But it signifies something — "what is the sense?"

The main issue, as I see it after years of listening to the whalers, is either they are all lying or the scientific data (that we will discuss in the next session) on the seismic effects on bowhead behavior are wrong. Some scientific studies indicate that most whales will respond at 7.5 km. We will hear that tomorrow, and I am not trying to upset Dr. Richardson unduly. He and I have been through this before. That is the "scientific conclusion." But for the Eskimo hunters on the water, it is an entirely different story. I have heard this for years. They pound on my desk saying, "We were out hunting all over the place for the past week and we can't find any whales. Aren't even any gray whales. What are you going to do about it?" So there is something wrong.

When we discuss what needs to be done in the development phase, we've got to get the truth to this question. What is the effect of seismic noise on these animals? There is a stronger response than the avoidance that is seen within 7.5 km. There is displacement. Even though the observers in the survey aircraft can sometimes see whales in these areas, for the hunters at sea level, there are so few whales that they don't find them. So when seismic activity is conducted, there is a scarcity of animals. Although the airplane observers find some, they have the advantage of traveling 150 mph and looking down. There is something wrong here.

Since the Director of the MMS is here and these are days of budget cutting, I hope that the Environmental Studies budget will somehow be enhanced to take into account the design of studies that can resolve this difference. There is a problem — and it is not going to go away.

As Mr. Rexford pointed out about the lawsuit, that may be the only recourse we have. If the monitoring plans are not good — and unfortunately a lot of them have not been good — we are going to run into lawsuits which is not good in itself. As Mr. Long pointed out, people want to get along, because there are too many other problems. But here is a problem and it has to be solved. Somebody asked the question, "How can we do it better?" A good study, properly funded, I think will help us get there.

OVERVIEW OF RECENT SOCIOCULTURAL STUDIES IN NUIQSUT AND KAKTOVIK, ALASKA

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INTRODUCTION

Community studies discussed here are part of a three-year study entitled "An Investigation of the Sociocultural Consequences of Outer Continental Shelf Development in Alaska." These studies were conducted by the Division of Subsistence, Alaska Department of Fish and Game (ADF&G), under a cooperative agreement with MMS, Alaska OCS Region, Social and Economic Studies Unit, in Anchorage, Alaska.

The primary purpose of the three-year study was to investigate the long-term social and cultural consequences of the development of the resources of Alaska's Outer Continental Shelf (OCS), especially as these affect the subsistence uses of fish and wildlife.

A major focus of the research was the sociocultural consequences of the *Exxon Valdez* oil spill of March 1989 on Prince William Sound, Kenai Peninsula, Kodiak, and Alaska Peninsula communities (17 in all) affected by the spill; four control communities in the Arctic region (Kotzebue and Kivalina in the North West and Nuiqsut and Kaktovik on the North Slope) were included in the study to strengthen the application of the findings to broad questions of sociocultural change related to development of resources of the OCS and to update baseline sociocultural information for these communities useful in the preparation of area environmental impact statements, leasing plans, and in assessing OCS related impacts.

Project purpose, procedures, and pertinent survey instruments for Nuiqsut and Kaktovik were reviewed and approved by the city council in each study community prior to survey start-up. Councils were kept informed of project progress and project staff met with council members whenever requested (as in Kaktovik). Draft reports were reviewed with each city council and copies of the final report were distributed to study communities and corresponding regional organizations.

Data collection took place through voluntary face-to-face interviews using two instruments: a harvest survey questionnaire modeled after the division's standard community baseline survey tool (which collects data on household demography, involvement in the cash economy, resource harvests and uses, and assessments of changes in subsistence harvest and use patterns) and a "Social Effects Questionnaire" (addressing changes in social and community organization which could be affected by OCS development) patterned after research tools developed in prior Social Indicators research funded by MMS.

Two rounds of North Slope community fieldwork took place. Kaktovik surveys were carried out in mid-1993 and fieldwork in Nuiqsut was completed in early 1994.

All North Slope fieldwork was led by Division of Subsistence staff in participation with staff from MMS, North Slope Borough (NSB) Departments of Planning and Wildlife Management; and with the support of locally hired survey assistants who helped with the fieldwork in both Kaktovik and Nuiqsut.

This presentation summarizes major findings for Kaktovik and Nuiqsut. The full report, Fall and Utermole 1995, was submitted to MMS, in six volumes, organized by study community.

COMMUNITY INFORMATION AND FINDINGS

KAKTOVIK

This small community is located on Barter Island, about 160 miles east of Prudhoe Bay, on the northern edge of the Arctic National Wildlife Refuge (ANWR). It is a predominately Inupiat community of about 220 persons in 63 households (1993). The local economy in Kaktovik is best characterized as "mixed cash-subsistence," with subsistence harvests of local resources forming the central thread in the economic, social, and cultural fabric of the community.

Fieldwork was carried out during July 1993, and the study period was July 1, 1992 through June 30, 1993. The survey approach was to obtain a household census for the 63 eligible households. Our final household survey tally was 47 households for the harvest portion of the survey and zero for the social effects survey (due to a request from the city council that we forego that part of our planned survey work). Relevant survey findings from Kaktovik are presented in Table 1.

NUIQSUT

Located on the west bank of the Nechelik Channel in the Colville River Delta, Nuiqsut is about 150 miles southwest of Barrow and 60 miles west of Prudhoe Bay. The community was resettled in 1971 and has experienced steady population growth since. During the study period the community was predominantly Inupiat with about 350 persons in 100 households. The local economy is best characterized as "mixed cash-subsistence," with subsistence harvests of paramount economic, social, and cultural importance.

Fieldwork was carried out in February 1994, covering the period January 1, 1993 through December 31, 1993. The survey approach in Nuiqsut, due to the larger population size, was to take a random sample of 60 households. Our final household survey tally was 62 households for the harvest survey and 60 households for the social effects survey. Relevant Nuiqsut findings are presented in Table 2.

SOCIOCULTURAL STUDY SUMMARY

Survey findings from both Kaktovik and Nuiqsut show an increase in local subsistence harvests since previous division baseline harvest surveys, with a particularly strong marine mammal and estuarine fish component. These two resource categories now make up over 60% of the estimated annual harvest (by weight) in Nuiqsut, and over 70% in Kaktovik.

Concerns regarding possible negative effects of OCS leasing and development was clearly expressed in the Nuiqsut Social Effects survey results. Over 80% of sampled households in Nuiqsut believed that marine mammal and fish resources would decrease as a result of OCS development, and over 66% of the sampled households were not in favor of either searching for, or development of, OCS oil or gas resources. Their main concern expressed was that there would be adverse impacts, such as decreased resource population levels and contamination, on local harvesting activities and disruption of resource migration patterns. These concerns cannot be taken lightly, particularly when seen in the light of the overall findings of the larger three-year study summarized below.

Table 1. Summary of Kaktovik survey findings.

Cash Economy			
	Employment		
		79% of Kaktovik adults had some form of employment in the study year.	
		average number of jobs held was 1.4 per adult	
		average length of employment was 7.9 months per adult	
		44% of adults had year-round work	
		leading source of jobs was in local government (53%)	
	Income		
		per capita income was $18,176 from all sources	
		average household income was $55,688	
		about 70% was earned income	
	Cost of Living		
		estimated at over 200% above Anchorage, AK	
Subsistence Economy			
	Resource Harvest		
		Total estimated community harvest:	170,940 lb
		Total estimated household harvest:	2,714 lb
		Per capita estimated harvest:	886 lb
	Harvest Composition		
		Fish:	13.4%
		Land mammals:	16.9%
		Marine mammals:	67.7%
		Other:	02.9%
	Harvest Participation		
		Mean number of resources used per household:	16
		Mean number of resources harvested per household:	8.6
		Mean number of resources given away per household:	7.7
		Mean number of resources received per household:	10.5
		Percent of households harvesting any resource:	89%
		Percent giving away any resource:	83%
		Percent receiving any resource:	92%
Social Effects			
	No measures: The Kaktovik City Council did not support this survey.		

Table 2. Summary of Nuiqsut survey findings.

Cash Economy			
Employment:	81% of Nuiqsut adults had some form of employment in the study year.		
	average number of jobs held was 1.6 per adult		
	average length of employment was 8.8 months per adult		
	42% of adults had year-round work		
	leading source of jobs was in local government (39%)		
Income:	per capita income was $14,301 from all sources		
	average household income was $56,743		
	about 86% was earned income		
Cost of Living:	estimated at over 200% above Anchorage, AK		
Subsistence Economy			
Resource Harvest			
	Total estimated community harvest:		267,817 lb
	Total estimated household harvest:		2,943 lb
	Per capita estimated harvest:		742 lb
Harvest Composition			
	Fish:		33%
	Land mammals:		33%
	Marine mammals:		32%
	Other:		01%
Harvest Participation			
	Mean number of resources used per household:		20
	Mean number of resources harvested per household:		11
	Mean number of resources given away per household:		11
	Mean number of resources received per household:		12
	Percent of households harvesting any resource:		90%
	Percent giving away any resource:		92%
	Percent receiving any resource:		98%
Social Effects			
OCS Development			
	on fish:	decrease numbers	80%
		no effect	11%
	on marine mammals:	decrease numbers	87%
		no effect	10%
In favor of OCS search for oil:			
		no	67%
		yes	28%
In favor of OCS development and production of oil:			
		no	68%
		yes	25%
Opinion on OCS development and production of oil:			
		more jobs in community	2%
		technology to do it right	2%
		in favor of onshore development instead of offshore	2%
		adverse impact on subsistence	52%
		pollution concerns	18%
		in favor if done carefully	10%

Research by the division in the Prince William Sound area before and after the *Exxon Valdez* oil spill documented major impacts of the spill on subsistence uses and the sociocultural systems which they support. In addition, there was a definite geographic pattern to spill effects, reflecting the degree of oiling and the persistence of oil in the environment.

Over the three years of this study further evidence of this geographic pattern developed. Respondents in communities close to the spill report that their subsistence harvest levels are still low, sharing of wild foods since the spill has decreased, and that children's participation in subsistence activities has been negatively affected. Study findings show that people living in close proximity to the spill area were most likely to report that they liked living in their communities less during the study years than before the spill.

In the third study year subsistence harvest levels appear to be rebounding from the low levels of the first and second post-spill years, and pre-spill harvest levels have been approached in all but the most severely impacted communities, i.e., those close to the spill origin, where harvest levels remain well below pre-spill averages. In some of the most heavily affected communities (Tatitlek and Chenega Bay) harvest declined further in the third study year, and there are important shifts in the composition of subsistence harvests. For instance, marine mammal harvests are much lower than before the spill, and a larger proportion of the harvest is now fish.

In 1989 negative spill impacts on resource uses by spill area respondents focused on fear of oil contamination; by 1993 households reporting spill effects on their subsistence uses cited reduced resource populations as the cause of the decline. This viewpoint was especially strong in Prince William Sound communities where a large majority of respondents said that populations of deer, harbor seals, sea lions, sea ducks, salmon, halibut, and clams were down since the spill.

Fear of human contamination from specific resources, though substantially reduced from the first post-spill years, still persist among a significant number of households in communities near the spill site.

It is important to note the finding that many households in the spill area reported that they had not received adequate information about the safety of subsistence foods, and despite lingering contamination concerns they returned to using subsistence foods. Economic and cultural necessities of relying on subsistence foods compelled Alaska Natives of the spill area to resume subsistence harvests in the face of increased costs of time, money, and health concerns.

In the view of many of the people interviewed as part of this study, and especially in Prince William Sound and among Alaska Native people, the spill caused fundamental changes to natural resource populations and the natural environment overall that have yet to be adequately explained. This uncertainty has had profound effects on the outlook for the future that people expressed in communities close to the spill site. This remains an important long-term impact of the spill.

Another long-term impact of the spill is the prolonged litigation over damage claims. The lack of judicial sensitivity to, and recognition of, the cultural importance of subsistence to the Alaska Native communities of the spill area and, the injury that this culture suffered, continue to be contested in federal court. Rulings in federal court which made ineligible claims by the Alaska Native Class concerning injuries to their way of life were especially disheartening to the people whose subsistence uses had suffered demonstrably from the spill. In some cases, these rulings even served to discourage people from participating in further documentation of their losses.

Litigation, and narrow definition of subsistence injuries, must be given due consideration in impact assessments for future OCS development in Alaska.

Relevance of major study findings to Nuiqsut and Kaktovik lie mainly in the area of marine resource harvests. In both communities a large portion of their subsistence harvest is from the marine environment, and nearly all of the marine harvest areas for the two communities lies in, or in close proximity to, former and present (Sale 144) federal lease sale areas in the Beaufort Sea. As such the two study communities (but really all but one NSB community — Anaktuvuk Pass) appear as vulnerable to industrial activity mishaps as Prince William Sound communities, with a high probability of the same kinds of sociocultural impacts as were documented in those communities.

The single most important lesson learned from the Exxon spill, relevant to other regions where the economic and cultural necessity of using subsistence foods is compelling, is that prevention is the best cure! We recommend this principle be employed in all development proposals we now review. In order to attain this goal we need to improve cooperation and coordination between agencies responsible for formulating applicable rules, conditions, and mitigation measures; incorporate broadly-based sociocultural monitoring and evaluation procedures as a standard set of requirements; seek a broader level of involvement of regional and local authorities in planning and monitoring of permitted activities; and finally, we need to find institutional mechanisms that responsibly improve the working relationship between government, industry, and the public.

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QUESTIONS AND DISCUSSION

Tom Newbury: Would you repeat the conclusions you listed at the end of your talk?

Sverre Pedersen: We recommend this particular principle: improve coordination between agencies responsible for formulating applicable rules, conditions, and mitigation measures. We need to incorporate broadly-based sociocultural monitoring and evaluation procedures as a standard set of requirements. We need to seek a broader level of involvement of regional and local authorities in planning and monitoring of permitted activities. We also need to find better institutional mechanisms that responsibly improve the working relationship between government, industry, and the public.

Cleve Cowles: A major portion of the findings that you talked about this afternoon was regarding perception of impacts. I was wondering if there was anything in your work that would help direct the government, in terms of what types of information could be provided, to better achieve a level of understanding of effects in areas where there may not be sufficient information flow?

Sverre Pedersen: This is a complicated area. I am no expert on this. But having worked on the North Slope for some time, I do have opinions on what needs to be done. I am not sure that these are necessarily the mechanisms that will work the best. But in my experience, the best approach would be to take time in the communities; to share the information that you have on whatever activity that is proposed. I don't mean calling a meeting between 8:00 and 10:00 pm one evening and then at 11:00 pm everyone leaves on a plane and goes back to where they came from. I am talking about people spending time in the community, getting to know concerns, maybe on a one-to-one basis and developing better lines of communication with individuals. Very often, in my experience, meetings, particularly in Nuiqsut and Kaktovik, often are best after all of the government people have left. Because government people don't spend enough time in the communities. So that is an ingredient that I think is very important here. Take the time to explain projects to people. That means spending a couple of days, maybe a week, in the community. In fact, maybe even visiting with households and talking about the issue. Meetings are not the best mechanism for sharing information in my experience. Talking to people is. That is how I get my information. If I were to try and get information from just a meeting, I would feel very uncomfortable. So this is one avenue where I think we can all work on a little bit more and perhaps it will pay off. I think it will.

As I was talking to Dr. Langdon earlier, one of the big problems on the North Slope is time. That currency is a problem in many locations, it not unique here. Time is a very important ingredient. That is allow people to get time. First you present the problem for them to think about it, consider it, and then formulate opinions or positions on what you presented. Because it cannot go at the rate that often we go now. It may seem to us that three months for them to think about this would be plenty. But that is probably not adequate, it probably needs to be more time there. As I was telling Dr. Langdon, perhaps what we need is about one generation, in terms of time, to allow people think about problems. Because we are presenting sophisticated problems to people in ways that they have a difficult time relating to. So even though they have had a couple of days to think about something, they may not make the best decision. They need more time. That is my "pat answer"— time. With more time we will get better results.

Steve J. Langdon: I would like to make a brief comment about that question as well. In examining our past policies, it appears that the only currency unfortunately that is present for mitigation is financial. That is why Mr. Pedersen and the Subsistence Division have turned to the issue of prevention. The reason they have returned to prevention is that these are incommensurates. People cannot be financially compensated when valued subsistence elements of their life have been destroyed. That is a fundamental finding. It is a very serious thing for people to think long and hard about.

Now having said that with regard to subsistence activities and the importance of subsistence resources to the continuity of the culture, I would make the second point which is that the entire framework of this decision, in terms of power and in terms of the allocation of resources, is so totally skewed as to make it impossible for people to weigh these consequences. There is no way that they can perceive, at present, any benefit. There is no calculus that shows them how financial resources will flow to the North Slope Borough. There is no guarantee about the siting of facilities with regards to the continuity of tax revenues. There are no plans in place with regard to employment circumstances. Residents of the North Slope shoulder substantial costs associated with these kinds of decisions with no indication of potential benefits. How can anybody possibly embrace an activity over which they have such little influence and such an extremely uncertain and incalculable possible benefit? Nobody can make decisions in those kinds of contexts without fundamental reallocations of the resource revenues, which we see debated heavily in the Arctic National Wildlife Refuge (ANWR) where the state is upset that its share is likely to be reduced from 90-100 to 50-50. What is demonstrably going to be received by North Slope Borough (NSB) and NSB communities by OCS activities that may take place completely outside of their boundaries? That is a very significant issue.

Grant Walther: What is the viability of the State of Alaska being able to monitor the situation? I think we find ourselves in a awkward position. I think the *Exxon Valdez* spill demonstrated that. The State of Alaska, in essence, is an oil company. It receives royalties. It receives funds. It receives profit every time a drill goes down and oil comes up. It is very difficult to monitor your neighbor when you are both doing the same thing or when you are the big brother or the little brother.

When you talk about these surveys and the questions that are asked up north, how much value does the input from these people really matter? What can they say that would make any difference, in reality? It seems to me that we have heard a theme today. The gentlemen who were up on the panel earlier (the subsistence whalers) said that they have problems when there is seismic activity in the Arctic and can't obtain the whales that they do otherwise. The "studies" seem to always say a different story. Is their input of any value? Is their input of any value regarding ice scouring, subsea pipelines, possible development? How much value does what the Inupiat community really have to say. Does it matter to the oil industry? Or is it just a matter of going through the motions because we are going to do it regardless? It doesn't matter if it takes us two weeks, two months, six years. We are going to do it and we are going to do it the way we have done it in Texas, Louisiana, Oklahoma, and Saudi, and we are going to do it that way. We don't care what else happens. Okay, we will play along with a little bit of it. In the State of Alaska, Governor Knowles openly says that we are going to partner with the industry. I thought that was very interesting; to come in as a democrat, liberal candidate and the next day he is in office he comes forth and says we are going to partner with industry. I thought his position, coming from that party, was to be somewhat of a monitoring position, to tell industry that we need to think things over. I am not saying that I am associated with either party or have any particular partisan belief. But I do believe that the State needs to critically examine its role in this situation dealing with oil development, both onshore and offshore. It is a very difficult position to be in.

Sverre Pedersen: That is an interesting question. All I can say to you is in the work that we do, we employ methods that are recognized by the scientific community. We present this information. We just make sure that this information gets considered. There is an entirely different process that takes over from there on. We do the best that we can to provide information that should be useful in thinking about these problems.

Grant Walther: Don't you need a baseline study? Your studies are old, if I understood that correctly. Are you getting funding for new studies?

Sverre Pedersen: I haven't seriously sought those funds yet.

Grant Walther: May I suggest that you seriously seek them?

Bowhead Whale Session

THE BOWHEAD WHALE MIGRATION OF FALL 1994

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INTRODUCTION

From 1979 to the present, the Minerals Management Service (MMS) has funded annual monitoring of endangered whales in arctic waters. Since 1987, MMS uses agency personnel to perform field work and reporting activities for the Beaufort Sea on an annual basis. Previous survey reports are available for inspection at the MMS library in Anchorage.

GOALS

The present goals of the ongoing program are to:

1. Provide real-time data to MMS and NMFS on the general progress of the fall migration of bowhead whales across the Alaskan Beaufort Sea, for use in implementing overall seasonal drilling restrictions and limitations in geological/geophysical exploration. (The study provides immediate information to management for day-to-day decision making.)

2. Monitor temporal and spatial trends in the distribution, relative abundance, habitat, and behaviors (e.g., feeding) of endangered whales in arctic waters;

3. Provide annual analysis of long-term interyear trends in the median depth of the migration axis of bowhead whales. (This addresses the question of whether whales are swimming in deeper water from year to year.)

4. Provide an objective wide-area context for management interpretation of the overall fall migration of bowhead whales and site-specific study results. (A recent site-specific study at Kuvlum showed a high-resolution map of whales in the vicinity of the drillsite. Our report for the same year provided a contrasting picture of the entire sweep of the migration as it moves across the Beaufort Sea.)

5. Monitor behaviors, swim directions, dive times, surfacing patterns, and tracklines of selected bowhead whales;

6. Record and map belukha whale distribution and incidental sightings of other marine mammals; and

7. Determine seasonal distribution of endangered whales in other planning areas of interest to MMS.

STUDY AREA

The annual survey program is based on a design of random-field transects within established geographic blocks in and adjacent to the Beaufort Sea and Chukchi Sea sale areas offshore of Alaska. The study area includes Beaufort Sea Survey Blocks 1 through 12 (Figure 1) between 140° W and 157° W longitudes, south of 72° N latitude.

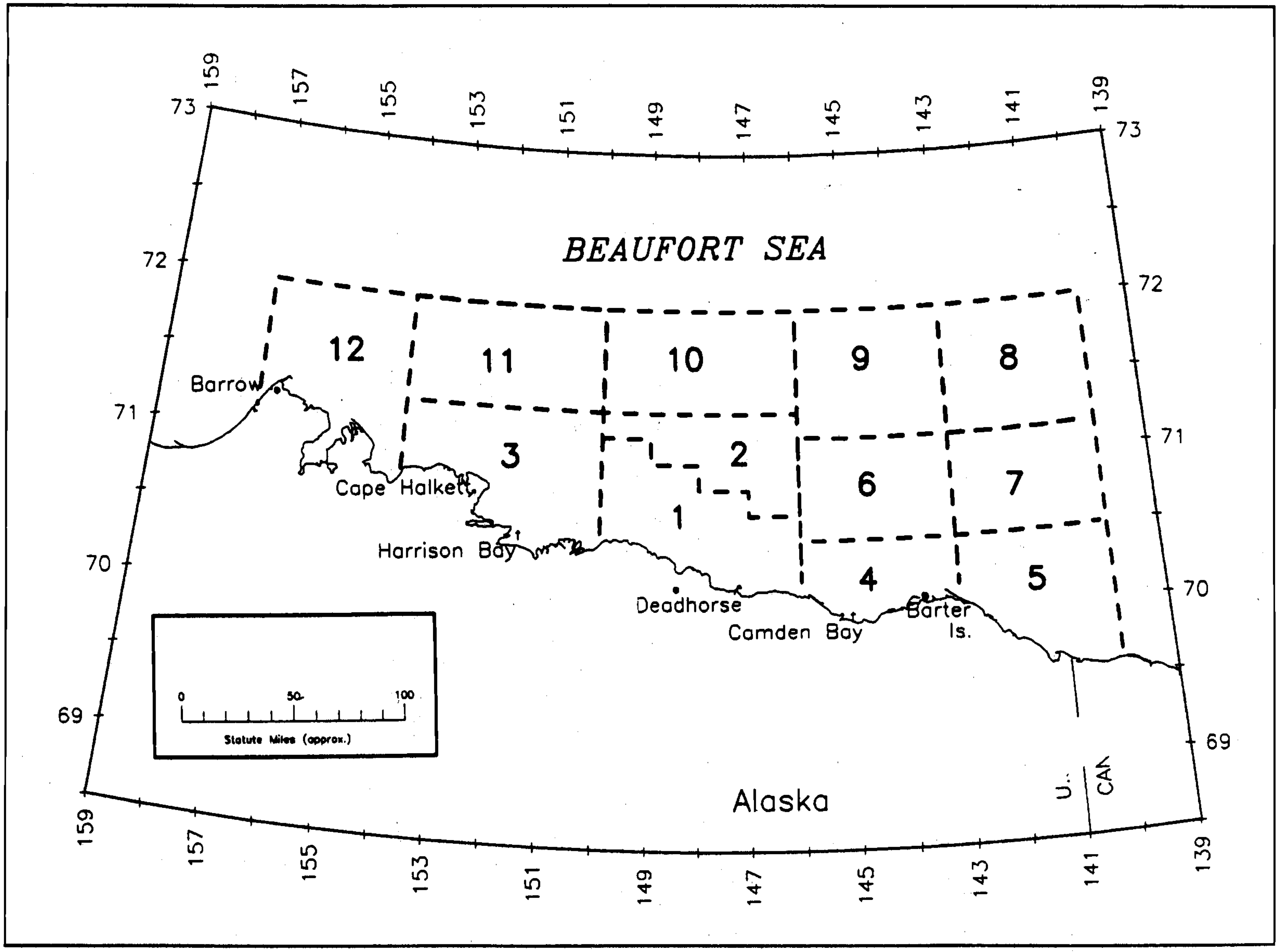

Figure 1. Fall 1994 study area showing survey blocks.

Addressing our major goals requires a sample design covering the entire area. We rely on other more site-specific studies for analysis of high-resolution behavioral effects.

AERIAL SURVEY DESIGN

Aerial surveys were based out of Deadhorse, Alaska, from 31 August through 18 October 1994. The field schedule was designed to monitor the progress of the Fall 1994 bowhead whale migration across the Alaskan Beaufort Sea. All bowhead (and belukha) whales observed were recorded, along with incidental sightings of other marine mammals. Particular emphasis was placed on regional surveys to assess fine-scale shifts in the migration pathway of bowhead whales in this area and on the coordination of effort and management of data necessary to support seasonal offshore-drilling regulations.

RESULTS

Environmental Conditions

General ice coverage in the Alaskan Beaufort Sea was relatively light during the Fall 1994 surveys. Ice coverage ranged from >0-25% in August to >75% concentrations throughout October. By the end of October, the Alaskan Arctic Ocean was essentially covered with very heavy ice from Icy Cape to Banks Island, Canada. The open-water conditions during Fall 1994 generally provided for good observation of subsurface whales, although associated high sea states sometimes reduced the ability of observers to spot whales near the surface or at great distances from the transect centerline. Cloud ceilings over portions of the study area were often lower than the target-survey altitude of 458 m. Overall, environmental conditions were considered favorable most of the time, permitting 33 flights in 48 days.

Bowhead Whale Observations

One hundred five sightings were made for a total of 204 bowhead whales observed during Fall-1994 surveys in the study area, not counting repeat sightings. Three of these whales were identified as calves, resulting in a seasonal calf ratios (number of calves/total whales) of 0.015.

The day-to-day timing of the bowhead whale migration was calculated over the entire study area as a daily sighting rate, or sightings per unit effort (SPUE), and an index of relative abundance, or whales per unit effort (WPUE). Of the 105 observed sightings of bowhead whales, the first bowhead whales were sighted on 31 August. The data for daily sighting rates showed a peak of 7.30 SPUE on 2 September, followed by a second peak of 3.81 SPUE on 9 September.

Of 204 bowhead whales sighted during Fall 1994, 160 (78%) were in shallow water (0-50 m deep), 42 (20%) were in waters of transitional depth (51-200 m), and 1 (1%) was sighted in deeper water (>200 m).

Belukha Whale Observations

Although the study area and survey altitude were designed to record the fall migration of bowhead whales, belukha whales, which undertake a somewhat parallel migration, were always counted and were considered suitable for selected analyses. Over the Fall 1994 field season, 92 sightings were made for a total of 514 belukha whales. Sightings of belukha whales were distributed between 140° W and 156° W longitudes, south of 72° N latitude.

ARC/INFO APPLICATIONS

In recent months, we have incorporated bowhead whale sightings into a single database within ARC/INFO Geographic Information System (GIS). Most of our bowhead data (1974-present) include whales that were sighted from research ships and airplanes or sightings made during offshore drilling operations. In the ARC/INFO database, we are currently developing metadata for each selected bowhead whale data set. We recently acquired data on bowhead whales whose movements were tracked by satellite. Future data from successful satellite-tagged whales should prove useful for delineating general migration patterns and for evaluating the behavioral effects of industrial activity on bowheads.

Sea ice is one of the most critical physiographic elements when observing the movements of the bowhead whale in the Beaufort Sea. Sea-ice maps for the Beaufort and Chukchi Seas have been digitized for the 1994 fall season and incorporated into ARC/INFO. These coverages provide useful overlays for comparing sea ice with bowhead whale sightings.

Simplified integration of bathymetry and regional ice coverage, incorporating bowhead whale observations, suggests there may be some general relationships between sea ice, bathymetry, and bowhead whale movements. The data also suggest that there may be other physical and biological variables that need to be incorporated to better understand the movement of the bowhead whale.

We hope to integrate additional information from earlier years, especially in those years where offshore drilling has occurred. This will include data from satellite-tagged bowhead whales, visual ice observations near drill-site locations, weather information, and other variables.

QUESTIONS AND DISCUSSION

Tom Albert: Do you foresee this program continuing? I know, at least from the North Slope Borough perspective, we think this is an important program. Do you foresee this continuing?

Steve Treacy: I think so. As you know, the Federal government is belt tightening everywhere. But I think that this program has a value in that it provides a third perspective. The industry has their site-specific studies and the whalers have their own knowledge of what they see out there each year. The perspective of this study is the larger sweep of the fall bowhead migration across the Beaufort Sea. I think it is almost necessary to the proper interpretation of results of some of the site-specific studies. BP, which will be talking later today, I think, will come closest to maximizing the use of some of our collected data in their study. So it does have value to industry and to the whalers, and I think it will probably hang in there.

Anne Dalley: I think you mentioned that you said you saw 204 different whales. Those were different sightings, but how many different individual whales do you think you actually saw?

Steve Treacy: The 204 represents the total number of whales counted in 1994. And, of course, that number varies each year. I was going to give a little update on the 1995 Fall migration, too. We just finished our field season and brought people back on the 20th. During the month of September, we had good weather and we saw 413 bowhead whales. That's not to assume that the population has doubled in one year. It just has to do with sighting conditions. In October, the sighting conditions were terrible. With high winds, we only saw 15 whales there. So there was quite a difference between months in 1995.

Anne Dailey: Are those, perhaps, multiple sightings of the same whale over and over?

Steve Treacy: We do what we can to avoid that. Certainly within the same day we come close to guaranteeing that they're not the same. If we go out the next day, and the only place we can work is just to the west of where we were the day before, yes, we could be seeing some of those same whales. But where they're swimming relative to known isobaths or the actual water depth they're swimming in would still be of interest, even if some of them did happen to be the same whales as the day before. It would still show the sweep of the migration as it moves across, so it doesn't really mess up our data.

TRACKING THE HABITS OF BOWHEAD WHALES WITH SATELLITE-MONITORED RADIO TAGS

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Following a tag and attachment development phase, this project resulted in the successful tagging and tracking of two species: North Atlantic right whales in 1989, 1990, and 1991 (Mate et al. 1992, Mate and Nieukirk 1993) and bowhead whales in 1992. This presentation covers the monitoring of 12 radio-tagged bowhead whales in the western Arctic. The satellite-monitored Argos radio tags were applied between 30 August and 1 September 1992 in Mackenzie Bay, NWT, Canada (Mate and Krutzikowsky 1995). Locations and sensor data were obtained through the Argos Data Collection and Location Service (Fancy et al. 1988). The tags transmitted according to a pre-set transmission schedule and only when at the surface. The tags summarized data on dive durations, dive depths, and time spent at the surface/underwater for eight periods each day.

The stainless steel cylindrical tags (192 mm long x 54 mm diameter) were applied with a crossbow at close range from a 13.7 m diesel-powered fiberglass boat. Two tag types were used: duration/depth (n = 10), which transmitted each time the whale surfaced and duration-only tags (n = 2), which transmitted for a 100 min period every 12 h. Two or more messages were necessary in a 10-min orbit to achieve a location, which is calculated from Doppler shift data. Location accuracy increased with reception of additional transmissions. We received transmissions from all 12 tags but useful locations were obtained from only eight whales. Three tags with poor attachment or placement provided the least amount of data. One was heard from only five times but provided the longest documented tag attachment (49 days). Utility status messages were received from only six tags (depth/duration). Five of these reported low battery voltage toward the end of their operation suggesting that they quit due to battery exhaustion from frequent transmissions (every surfacing) in a very cold environment. The number of messages sent by each tag varied from 524 to 8164 ($\bar{x}$ = 3180) at the time of their last status message.

Most of the locations (80%) were location class zero (with unknown accuracy). We eliminated 216 locations (30%) which resulted in: (1) such long distances whales would have traveled at unreasonably high speeds (> 25 km/h) or, (2) locations on land. The remaining locations described 111 days of tracking and 9633 km of trackline with mean speeds of individual animals ranging from an average of 1.0 to 6.2 km/h).

Whale 10824 provided the most detailed record with 203 locations during 34 days. It moved 4053 km through Canadian, U.S., and Russian waters. The whale spent considerable time near Herschel Island and Demarcation Bay. Had fewer locations been received, the migration route would still be apparent and the tag would have had a longer operational life, perhaps revealing more of the animal's wintering habitat. However, some of the detailed movements would have been lost and swim speeds would have been underestimated.

Sensor data from 11 whales were received during 1 - 34 days. The number of summary periods of information available for the three data types (duration, depth, time at depth) varied between whales. The latter two categories have never before been collected for bowhead whales. We received 566 periods of dive duration information, 477 periods of dive depth information, and

482 periods of time-at-depth data. For individual animals, the number of summary periods of data varied from 1-223.

Of the 42,332 dive durations recorded for nine animals, most (77.3%) were ≤1 min whereas only 1.4% were >19 min. The longest recorded dive was 62-64 min. Five other tags recorded dives of ≥61 min in one or more summary periods. The longest dive for the other three tagged whales returning duration data, were 33-35 min, 44-46 min, and 55-57 min. The longest dive was <33 min in 506 (89.4%) of the 566 summary periods recorded. The mean surfacing rate for individuals ranged from 18.2 to 47.0 surfacings/h. Mean blow rates, calculated from dives/h, ranged from 0.3 to 0.8 blows/min and were significantly different among animals.

Most of the animals' time (61%) was spent in the upper 16 m of the water column and <2% was spent deeper than 97 m. Water depths corresponding to satellite-acquired locations ranged from <50 m (63.7%) to >500 m (6.4%), with 85% of the depths <100 m. The maximum depth of each of 32,629 dives was measured for seven whales in 466 summary periods. Of these dives, 80.6% were <16 m. Dives deeper than 48 m often occurred in bouts. The deepest dive per summary period was reported for 468 summary periods by nine whales. The deepest recorded dive was between 440 and 455 m, the second deepest was between 344 and 359 m. Several animals spent more than half of some summary periods at depths greater than 49 m. One animal averaged 70.6% of its time at depths >97 m during five consecutive summary periods (17 h). Another animal spent 62% of one 3-h period deeper than 201 m.

The mean percentage of time spent under water by the nine animals ranged from 91.6% to 96.0% as surfacings were usually <1 min. The longest surfacing was between 13.5 and 14.4 min (n = 562 summary periods); however, 99.1% of the surfacings were <3.5 min. Based on our sensor data, the percentage of time animals were "potentially" visible from the air was comparable to previous observational studies of bowhead surfacing and dive behavior, but individual ranges exceeded literature values. The sensor information revealed characteristics of diving depths and durations that can affect aerial or shipboard surveys, thus influencing population estimates due to regionally different behaviors.

Changes in the dive behavior of whale 10824 were observed when, on 20 September, between Harrison Bay and Pt. Barrow, it moved to areas where ice covered 90+% of the surface. Thereafter, the tag reported significantly fewer but longer dives, the mean percentage of time exposed to the air was significantly greater, the longest surfacings during periods were significantly longer, and much more time was spent deeper than 48 m. These differences likely reflect behavioral responses to heavy ice conditions. This whale may have made deeper, longer dives under the ice and longer surfacings in small open pools, or polynyas, between the ice. It may also reflect some bias in heavy ice situations where the tag may not always clear the water surface to acknowledge a surfacing. For example, this tag recorded 25 summary periods where the longest dive exceeded 61 min, 23 (92%) of which occurred in 90+% ice cover. Although such long "dives" may actually occur in heavy ice, it is possible the animal broke ice to breathe and the tag did not come out of the water to register a surfacing.

None of the dive behavior variables we examined from each of the tags showed consistent diel patterns. It is likely the dive information reflected more about the animal's prey preferences and available water depths than a limitation of the animal's diving capability. We have no information that would indicate that 500 m is a limitation of the animal's diving ability.

SUMMARY

This study provided the first data on route and rate of movement for the fall bowhead migration from Canada to Russia. These data indicate areas of importance to bowhead whales in the Beaufort Sea and suggest that the heavy ice front may be the principle migratory cue for navigating across the Chukchi Sea. The changes in dive durations, depths and surface times seen in various ice conditions or regions would affect the sighting of whales during surveys and thus influence population estimates. Although 12 whales of similar size were tagged within one week in a 40 km^2 area, considerable variability in their subsequent movement, behavior, and distribution indicate that the population does not migrate "en masse."

Future studies will benefit from improved attachments, smaller transmitters, and shorter repetition rates. While a reduced duty cycle could result in longer duration tracks, it would not provide detailed movements around specific sites for the analysis of potential cause and effect relationships.

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QUESTIONS AND DISCUSSION

Steve Treacy: You described a lot of information. Could you give us a few main points?

Bruce Mate: Sure. First, we tagged 12 animals of similar size in one location in one week. They did not all move in the same direction, in similar water depths, or at the same speed. This suggests the animals do not move "en masse" in response to a single "environmental cue." Seeing individuals back-track after significant westerly movement was contrary to conventional wisdom. The importance of Herschel Island and Demarcation Bay was emphasized by the amount of time several animals spent there often on multiple occasions. It looks like bowhead whales, on average, should be visible from the air about 13% of the time. This takes into account some visibility down through the surface and surfacing sequences but there is variation between individuals and geographic areas. The latter may be due to changes in environmental conditions or in animal behavior. The animals are only at the surface about 5% of the time. Some animals utilize deep water when it is available, down to at least 400 meters, but 200 meters is more common for most of the animals we monitored in deep water.

The surfacing rates and other individual dive characteristics of the animals have a two-fold range from the lowest to the highest values in most categories.

Individual whales can move at a relatively consistent speed, although there is variability between animals.

Even if you look at every third, fifth, or tenth point, this technique provides the trend of migratory movements which is encouraging, given that there are some known ambiguities about individual locations.

Lon Hachmeister: What water depths were available when the whales were diving deeper?

Bruce Mate: That is in our final report. Available water depth is an important part of what the animal does. Although you wouldn't expect whales to dive deep in shallow water, apparently we had two faulty sensors that occasionally indicated depths greater than those shown on our charts.

In general, the animals appear to explore in some areas to bottom depths of 200 m. However, we cannot link specific dives from summary data with the exact time of a calculated location, so it's sometimes difficult to interpret. The summary data may be from one to five hours different from the location, so we can't be sure exactly where the animal was when the deepest or longest dive occurred.

Lon Hachmeister: Do you know where the whale's prey is in the water column?

Bruce Mate: It would be wonderful to do this type of bowhead research in conjunction with a prey study where a net or towed array provided prey depths and densities. We did that this year in August and September with the National Marine Fisheries Service for blue whales in southern California. You can see where the prey densities are and what they're doing.

Sverre Pedersen: This question relates to bowhead whales going to the bottom. We have indications from the air that the bowhead whales are feeding on the bottom. They're coming up with mud. The mud plume is coming off their back and I just didn't know if you had data that was accurate (precise enough) to indicate that?

Bruce Mate: Our depth data were measured to the nearest 4 m and reported to the nearest 16 meters. It could be adjusted to be more accurate but it would take more bit space in a message only 256 bits long. The specific timing of deep dives could be reported to coincide with locations but it would be at the sacrifice of the sensor data. It is a possible thing to do. We've seen the same thing with right whales in the North Atlantic, just before this bowhead study. Animals came up with mud on them in 200 m deep water and we knew they had to be going to the bottom.

It would be nice to have people going to areas of interesting satellite data to confirm what is going on when certain dive patterns occur. It does appear that bowheads utilize the bottom often, but I can't be quantitative about it.

Larry Bright: Did you mention the battery life was about 30 days?

Bruce Mate: We heard from one animal up to 49 days. We had planned an intermittent transmission schedule which would have given a less frequent location spread over 25-30 months. With continuous transmission, the whale transmitter that went 34 days did better than we expected in such cold water. Now I think we could get even longer duration tracks but it would be at the sacrifice of many locations/day.

Larry Bright: Do you know how long your tags stayed on?

Bruce Mate: One stayed on at least 49 days. Five probably used up their batteries so we don't know how long they stayed attached. A couple of tags stopped before the battery was used up so they were probably attachment failures. We've seen attachment failures on other species we've tagged also but we are working on new attachments which we hope will extend the tags useful life on the whale.

The big problem is hydrodynamic drag. The tags are reasonably large. You might think that whales are so large, size shouldn't be a problem, but stick your hand out of a window while going 60 miles per hour and feel the drag! What you feel is trivial compared to a whale moving at five miles per hour through a dense medium like water. Water is constantly tugging and the small attachments are limited to shallow penetration of the blubber. There isn't a whole lot to hold the tag on.

Thomas Napageak: I have a question about tagging procedures. Where are you planting these radio tags?

Bruce Mate: We're trying to get it up very close to the midline of the back without being right on the center, because of the vertebral elements, and we're back from the blowhole. When you see the animal surface, you see the blowhole and then there's a depression frequently filled by water and then the broad portion of the back. About in the middle of that broad portion of the back so that, hopefully, when the animal surfaces to breathe, we'll get a message.

Thomas Napageak: I can just feel that bowhead whale trying to come up, trying to break the ice, with a tag on it, like a sliver. That's harassing.

Bruce Mate: Your point is well taken. And it's one that we had a concern over as well. There aren't any of us in our group who tag animals who wish to really harass them or acquire information from an animal that is compromised, or to do any serious damage to an animal. We talked with a number of people and it was the feeling that the animal uses principally its blowhole to come up through the ice, and that this area of the back had the least amount of scarring. We actually checked with folks at Barrow about the scarring, and there's been some data actually produced on scarring. So we picked an area of the animal that did not have a lot of scarring and which we thought would not come into contact with ice, because, of course, we also wanted the tag preserved.

When we've seen tags come off, by the way, to set your mind a little at rest. We've seen a female with a calf that went 42 days and 2,500 miles in the North Atlantic that lost its tag and 16 days later just a small white mark about the size of a pencil was where the attachments were. It didn't look too bad.

ACOUSTIC EFFECTS ON BOWHEAD WHALES: OVERVIEW

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Reactions of bowheads to underwater noise from the offshore oil industry have been studied by ourselves and others over the past 15 years, with funding from the Minerals Management Service and oil industry. Reactions of bowheads to aircraft overflights, ships, ice-breaking, seismic exploration, dredging, and various types of drilling have been examined. This presentation summarized some of the available data for (a) ships and boats, (b) drilling, dredging and other sources of continuous low-frequency sounds, and (c) seismic exploration. Richardson and Malme (1993) provide a detailed review of the responses of bowheads to noise. For a broader and updated review, considering disturbance responses of all species of marine mammals, see Richardson et al. (1995).

Man-made noises are known or suspected to have at least three types of effects on bowheads and other marine mammals under some circumstances. (1) **Disturbance effects**, including subtle changes in behavior, interruption of previous activities, and short- or long-term displacement. (2) **Masking** of important sounds, including calls from conspecifics, reverberations of the animal's own calls, predator sounds, and other significant environmental sounds, e.g., ice noise or surf noise. (3) **Hearing impairment**, temporary or permanent, if the received level of the sound is high enough.

In following sections, we consider only the disturbance effects of man-made sounds on bowheads, although masking undoubtedly occurs to some unknown degree. Hearing impairment (and other injuries) can occur when marine mammals are exposed to nearby explosions. However, it is not known whether the strongest non-explosive man-made sounds, e.g., seismic pulses, can impair the hearing of nearby whales. If so, these effects are expected to be restricted to very short ranges—less than those at which avoidance normally occurs (Richardson et al. 1995:372-6).

Bowheads exhibit a wide range of reactions to man-made noises, in part depending on the type and level of the noise. These reactions range from:

- tolerance (no overt behavioral response) to
- subtle behavioral changes (e.g., minor changes in surfacing-respiration-dive cycles),
- more conspicuous changes in general activities,
- short-term avoidance (swim away, or change course to divert farther to the side), and possibly
- longer-term displacement (suspected but not proven in bowheads).

SHIPS AND BOATS

In general, bowheads react strongly and rather consistently to approaching vessels of a wide variety of types and sizes. Bowheads interrupt their normal behavior and swim rapidly away. This reaction often begins when the approaching vessel is still as much as 4 km away, when the received level of vessel noise may be rather low—only a few decibels above the natural ambient noise level. Surfacing, respiration, and diving cycles are affected; fleeing bowheads have short surfacings with few breaths per surfacing, and often have short dives. Bowheads in the path of an oncoming vessel often attempt to "outrun" it, rather than swimming away from the path of the vessel. Because bowheads are relatively slow swimmers, even a rather slow vessel can overtake a fleeing bowhead, whereupon the whale usually dives or turns away to the side as the vessel comes within a few hundred meters. The "flight" response can cause bowheads to travel several kilometers from their original location. Fleeing subsides by the time the vessel has moved a few kilometers beyond the whale. After single disturbance incidents involving feeding bowheads, some individuals return to their original locations.

Vessels moving slowly and in directions not toward the whales usually do not elicit such strong reactions. This can be so even when the level of vessel noise received by the whales is higher than that eliciting flight reactions during rapid vessel approaches. The rate of change of vessel noise seems more critical than the absolute level in determining the severity of flight reactions. Bowheads actively engaged in mating or other social interactions seem relatively unresponsive to boats.

Reactions of bowheads to icebreakers breaking ice—a very noisy activity—are discussed later in these Proceedings. Playback tests suggest that reaction radii around an actual icebreaker would be highly variable, but often up to 10-50 km.

DRILLING, DREDGING AND OTHER SOURCES OF CONTINUOUS LOW-FREQUENCY SOUNDS

Reactions of bowheads to several types of dredging and drilling operations, and to underwater playbacks of recorded dredging and drilling sounds, have been studied. These types of sounds are all concentrated at rather low frequencies, and most of these sources are stationary or slow-moving. In general, when the received level is low, e.g., 10 dB or less above ambient, bowheads often tolerate the sound and continue with seemingly-normal activities. In contrast, when the received level is 20 dB or more above the natural ambient noise level at corresponding frequencies, feeding bowheads often move away; traveling bowheads approaching the noise source often adjust their courses so as to pass farther to the side than would have occurred without a course change. Both feeding and traveling bowheads exposed to these types of rather steady, low-frequency noises tend to have short surfacings with few breaths. Traveling bowheads sometimes slow down when approaching one of these noise sources, and speed up when moving away.

Noise from conventional drillships and their associated support vessels tends to be stronger than that from semi-submersibles, and both are noisier than various platform- and island-based drilling operations. Given the rather high levels of noise emitted by conventional drillships and their support vessels (especially icebreakers), there is evidence that some traveling bowheads 10 to 20+ km from the drillsite may divert farther to the side.

Long-term consequences of these short-term reactions are poorly known. After several years of intensive offshore oil exploration in the Canadian Beaufort Sea, utilization of that area by summering bowheads seemed to decrease. It is not known whether this was a cumulative, long-term effect of industrial activities, or was caused by naturally variable food distribution or other factors.

SEISMIC EXPLORATION

Pulses of noise from airgun arrays and other similar sources have high peak levels, often exceeding 160 dB re 1 μPa at distances up to 5-10 km from the seismic vessel. Seismic pulses are often detectable underwater 50-100 km away, even in shallow continental shelf waters. Most bowheads show strong avoidance when an operating seismic vessel is within 6-8 km, and there probably are some avoidance effects at greater distances. Surfacing-dive cycles tend to be unusually quick in the presence of seismic noise, with fewer breaths per surfacing and longer intervals between breaths. In summer, this pattern was evident among bowheads 6 to 73+ km from seismic vessels as well as during controlled tests at closer ranges. However, available scientific evidence suggests that active avoidance is uncommon unless the seismic ship is within 6-8 km and unless the received level of seismic pulses exceeds about 160 dB re 1 μPa.

The "avoidance threshold" to seismic pulses is much higher (~ 160 dB) than the reaction thresholds for boat, dredging, or drilling sounds. The difference is probably related to the fact that seismic sounds are brief pulses whereas boat, dredging, and drilling sounds are continuous.

On a broad-scale basis, the Bering-Chukchi-Beaufort population of bowheads continues to occupy summering areas where bowheads have been exposed to seismic pulses during previous days, weeks and years. Whether some individuals are less likely to use areas where they have been exposed to seismic noise in the past is not known. Bowheads also continue to migrate through areas where the population has been exposed to seismic noise during previous years. However, Inupiat whalers report that bowheads are more difficult to locate during autumn migration when seismic vessels are active. This has not yet been confirmed by scientific studies, but existing analyses have limited statistical power for analysis of this question (Moore and Clarke 1992).

CONCLUSIONS

Noise from oil industry operations can elicit short-term behavioral reactions, often including sudden dives and other changes in surfacing-respiration-dive sequences. When strongly disturbed, pre-existing activities of bowheads are often interrupted and they may swim away. In general, bowheads—like other baleen whales—commonly tolerate exposure to man-made noises that are weak, e.g., no more than 10 or 20 decibels above the natural background sound, especially if the noise is steady. Bowheads tend to be more sensitive to the increasing noise of an approaching boat. They tolerate higher levels of pulsed seismic sounds than of steady drilling or dredging sounds, but often show strong avoidance when a seismic vessel approaches within 6-8 km. Sensitivity seems to vary greatly among whales, and responses are often graded: Weak sounds may elicit subtle behavioral reactions, stronger sounds of that type elicit more obvious behavioral changes, and still stronger sounds elicit active avoidance. Short-term behavioral reactions typically persist for periods of a few minutes to a few hours. Little is known about the long-term consequences of these short-term behavioral reactions.

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INDUSTRIAL SOURCES OF UNDERWATER NOISE

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SUMMARY

INTRODUCTION

The material for this presentation was taken primarily from *Marine Mammals and Noise*, by W. John Richardson, Charles R. Greene, Jr., Charles A. Malme and Denis H. Thomson, published by Academic Press, 1995, 592 p. Particularly applicable are Chapter 2, "Acoustic Concepts and Terminology," and Chapter 6, "Man-Made Noise."

Sound is generally measured as a **pressure** variation p, although sound is also manifested as particle motion. The rate of variation is related to the sound **frequency**, in hertz (cycles per second). The **sound pressure level** (SPL) in decibels is defined as 20 log (p/p_0), where p_0 is a reference pressure. In underwater acoustics, the reference pressure is one micropascal (1 μPa). It is important to state the reference pressure in presenting sound pressure levels, e.g., 99 dB re 1 μPa. The logarithmic nature of decibels leads to many misunderstandings, most of which can be avoided by stating the reference units.

Most naturally-occurring sounds are not tonal (very narrowband). Rather, sound power is distributed across wide bands of frequencies. When such sounds are analyzed to determine their distribution with frequency, usually by a fast Fourier transform (FFT), the results are described by **sound pressure spectral density levels**, in dB re $(1\mu Pa)^2/Hz$.

Sound sources are described by their **source level**, the SPL that would be measured from an equivalent point source of sound at a distance of 1 m. For example, a sound projector source level might be said to be 172 dB re 1 μPa-m. A large sound source like a ship must be measured sufficiently far away that it appears to be a point source; its source level then applies only to far-field observations. Sound sources are often directional, and their source levels then vary with direction.

INDUSTRIAL SOUNDS

Industrial sounds can be distinguished by their time characteristics: they are generally either transients (short-lived, like explosions, hammerblows, airgun bursts and sonar pings) or continuous (long-lasting, like machinery sounds, propulsion sounds from ships and boats underway, dredges, and offshore drilling sounds).

Continuous Sound Sources

As a general rule, the character of sounds from vessels underway is related to vessel size. Large vessels tend to have big, powerful engines, and propellers turning slowly, producing high levels of sound predominantly at low frequencies. Thus, large tankers and container ships may have source levels > 185 dB re 1 μPa-m (frequencies 45-7070 Hz) and dominant sound power at frequencies below 100 Hz. An outboard-powered Zodiac, on the other hand, is reported to have a 45-7070 Hz broadband source level on the order of 156 dB re 1 µPa-m and dominant sound power in the 6300 Hz 1/3 octave band. Other vessels generally fall in between.

Drillships have been reported to have 45-7070 Hz wideband source levels of 174-185 dB re 1 µPa-m and dominant sound power in the 63-400 Hz 1/3 octave bands. Their sound comes primarily from power sources like diesel-electric generators. Their hulls, which both contain the generators and are in good contact with the water, radiate sound better than do the legs of semisubmersibles or drilling platforms supporting the operating machinery.

Dredges have been reported to have source levels of 172-185 dB re 1 µPa-m in the 45-890 Hz band. Their dominant sound power is in the 100-160 Hz 1/3 octave band.

Icebreakers actively breaking ice follow a pattern of full power forward to ram the ice, then being stopped by the ice, then backing down to gain space, then powering forward again. Strong cavitation sounds occur when the ship is stopped by the ice after ramming and when the ship reverses direction from astern to forward. Broadband source levels during icebreaking have been reported from 177-193 dB re 1 µPa-m.

Aircraft create sound continuously but it couples into the water generally only within a cone 26° wide (Snell's Law) beneath the aircraft. Thus, the sound from a passing aircraft has both transient and continuous qualities. Rough water will increase the cone size, and in shallow water sound is reflected outward between the bottom and the surface, extending the zone of sound beyond the extent of the cone. Depending on aircraft speed, its sound underwater may be audible for up to a minute. A Bell 212 helicopter has been reported to have a source level at 22 Hz (second harmonic of the main rotor blade rate) near 150 dB re 1 µPa-m, similar to the reported source level of a de Havilland Twin Otter at 82 Hz (propeller blade rate). A 4-engine turboprop P-3 Orion has been reported to have a source level of 162 dB re 1 µPa-m in the 56-80 Hz band.

Transient Sound Sources

The strongest transient sound source is an explosion. An 0.5 kg TNT charge has an effective broadband peak source level of 267 dB re 1 µPa-m. Peak pressure is proportional to only the cube root of the charge weight, however. Received level computations of peak pressures from explosions require considerations of shock wave propagation for distances over which the wave is not acoustic. Black powder, which "burns" (deflagration) at much slower rates (0.03-0.3 m/s) than does dynamite or TNT (4.6-9.1 km/s), has a much lower effective peak source level; 0.5 kg yields a broadband source level of 246 dB re 1 µPa-m.

Geophysical surveys ("seismic surveys") in all but the shallowest water use arrays of airguns for impulsive sound sources. An array may have from 3 to more than 40 airguns of different volumes. An airgun is charged with high pressure air (often 2,000 psi), which is released suddenly into the water to create a rapidly-expanding air bubble, which creates a shock wave whose amplitude depends on the air pressure and on the airgun volume. The risetime of the wave is slow compared to that from high explosives, and marine life is not damaged to the extent it can be, depending on distance, by high explosives. Controlled timing of the air release of the airguns in a horizontal array results in a wave focused toward the crustal layers beneath the array. The airgun array depth, often 6 m, results in the surface-reflected waves providing a strong negative pressure pulse just following the direct, positive pulse. The sound levels for horizontal propagation are reduced compared to the levels of the downward wave and are aspect dependent because of the phasing of the waves from the individual guns. Generally, levels to broadside are somewhat higher than levels toward either end of the array. A 4.9 L airgun may have a peak source level of 225 dB re 1 μPa-m; a 66 L array may have a source level of 255 dB re 1 μPa-m. The pulse energy is predominately at frequencies less than 120 Hz.

Other sources used for geophysical surveys include boomers, sparkers, water guns, sleeve exploders, gas guns, and Vibroseis. Vibroseis is used on land or sea ice. It consists of a truck-mounted vibrator whose frequency is swept from about 10-70 Hz within a few seconds. Source levels of 210 dB re 1 μPa-m are reported.

Active sonars, used for depth sounding, fish finding, submarine hunting, bottom mapping, and navigation can have operating frequencies from 2-500 kHz and source levels of 180-230+ dB re 1 μPa-m.

Oceanography studies often use sound sources to measure ocean features and processes. A sound transmission experiment related to average ocean temperature change measurement was conducted off Heard Island in the Indian Ocean in 1989. The sound source level was about 220 dB re 1 μPa-m at varying frequencies near 57 Hz. The source depth was 175 m and the sounds were received at listening stations 18 Mm distant. A subsequent experiment, called Acoustic Thermometry of Ocean Climate (ATOC) is planned for the eastern Pacific. Its sources will be at depths of 850-980 m, frequencies 75 ± 15 Hz, and source level 195 dB re 1 μPa-m. The duration of transmission was originally planned to be 20 minutes every 4 hours, with 5-minute ramp-up periods so that the full power will not be achieved instantly.

Comparison of Industrial Sound Sources Underwater

The potential reactions of marine mammals to man-made sounds will depend in part on whether the sounds are continuous or transient. Comparisons of the two general categories of sounds may be made on the basis of long-term average powers or intensities, but the peak levels of short sound bursts may also be important. Until more is known about animal responses to continuous and transient sounds, it seems best to describe them separately.

Explosions produce by far the highest peak pressures among the transient sound sources, 267 dB re 1 μPa-m for even a small 0.5 kg charge of TNT. Powerful search sonars and high-energy nonexplosive sources used in seismic surveys also generate high peak pressures. However, their short duration and long intervals between bursts reduce average sound levels. The strongest of the continuous sound sources, such as supertankers, container ships and icebreakers, generate high levels of sound near the surface (on the order of 195 dB re 1 μPa-m) for long periods. The ATOC source produces the same source level, although it does not operate continuously and it is about 900 m deep.

ACOUSTIC EFFECTS ON BOWHEADS DURING SPRING MIGRATION

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Previous studies of noise disturbance to bowheads have been in summer or autumn, mainly in open water. The study summarized here was the first to examine reactions of spring-migrating bowheads and belukhas to noise from oil industry activities in the Beaufort Sea. This work was done during four spring seasons, 1989 through 1991 plus 1994, and the final report is available (Richardson et al. 1995).

This study was conducted, in part, because of concern that oil development and production activities in or near spring lead systems might cause blockage of migration. The National Marine Fisheries Service concluded, during consultations under Section 7 of the Endangered Species Act, that

> "development and production activities in the spring lead systems used by bowhead whales for their migration would be likely to jeopardize the population... NOAA Fisheries will reconsider this conclusion when new information become[s] available."

This study was funded by the Minerals Management Service to obtain some of the needed information.

The objectives were to:

1. determine ambient noise levels and sound propagation loss rates in spring lead conditions as needed to predict noise exposure vs. distance from the noise source;

2. determine the effects of underwater noise from oil production platforms and icebreakers on distribution and movement patterns and behavior of bowhead and belukha whales migrating through leads in spring;

3. avoid interfering with other studies and with the spring bowhead hunt.

Objective 1 was addressed by subcontractor Greeneridge Sciences. Reactions of bowheads to steady low-frequency drilling noise were summarized at previous Information Transfer Meetings and in Richardson et al. (1991). This presentation briefly mentions the work with drilling noise, but concentrates on more recent work concerning reactions to icebreaker sound. In comparison with the drilling sound, icebreaker sound has broader bandwidth and is more variable over time.

METHODS

Most of the work was done in the area 25-75 km northeast and east of Barrow. During consultations with the Barrow Whaling Captains' Association, Alaska Eskimo Whaling Commission and the North Slope Borough Dept. of Wildlife Management, it was agreed that this area was far enough east of the whaling activities near Barrow to avoid any potential interference.

Recordings of drilling or icebreaker sound were projected into the water using one or more underwater loudspeakers suspended from the edge of the pack ice or, occasionally, the land-fast ice. Movements and behavior of whales approaching and passing the projector site were observed by biologists and acousticians on the ice, and by another crew in a Twin Otter aircraft circling at altitude 460 m.

DRILLING NOISE PLAYBACKS

In 1989 and 1990, the sounds projected into the water were steady, low-frequency drilling sounds recorded under the ice near the *Karluk* drillsite. During playbacks with a small sound projector, we could not reproduce the lowest frequency components of the *Karluk* drilling sounds, below about 80 Hz. However, at distances beyond a few hundred meters from the source, the overall broadband levels during playbacks were at least as strong, and generally stronger, than the levels from the actual *Karluk* drillsite. The playback levels diminished with increasing distance from the source, but were above the typical ambient noise levels out to a distance of 5 km or so.

Bowheads approaching the playback site commonly came well inside that 5 km radius, often approaching within a few hundred meters. When they came within 1 km, there were statistically significant changes in several measures of behavior. These included changes in surfacing and respiration sequences, changes in swimming speeds, increased turning, and diversion away from the playback source.

At times, subtle behavioral effects extended out to 2 km from the playback site, and possibly to 4 km, even though some individual whales approached well inside those distances. During the date when this was most evident, the received level of the drilling sound was about 12 dB above the background ambient noise at 4 km range, where we suspected that the first subtle effects were occurring. However, in the absence of an alternative migration corridor, at least some bowheads came as close as 200 m, where the received sound level was about 40 dB above ambient. Details are given in Richardson et al. (1991).

ICEBREAKER NOISE PLAYBACKS

In 1991 and 1994, we tested the reactions of bowheads to noise from an icebreaking supply ship, the *Robert Lemeur*, recorded while it was managing ice. The icebreaker noise extended up to higher frequencies, well above 1 kHz, than did the drilling noise used in the earlier playbacks. Icebreaker noise also was much more variable over time.

The projectors could not emit sounds with a source level as high as those of the actual icebreaker. Therefore, a given received level of icebreaker sound would be found farther away from the actual icebreaker than from our projectors. The projectors used in 1991 and 1994 did not adequately reproduce the components below about 40 Hz.

Bowheads often came within a few hundred meters of the projectors during playbacks. However, the proportion of bowheads that came within 400 or 500 m during playbacks was reduced relative to control conditions.

Most bowheads that approached within 3 km came close enough to the playback site for received sound levels to exceed natural background levels at corresponding frequencies. Therefore, the icebreaker sounds were probably audible to most of these whales. Among bowheads that came within 3 km of the projector site, we noticed diversion by 18 of 80 whales or groups during icebreaker playbacks, but only 1 of 116 cases under control conditions—a highly significant difference. Some bowheads showed apparent diversion at low icebreaker-to-ambient ratios, <10 dB, whereas others showed no obvious diversion at much higher icebreaker-to-ambient ratios, >30 dB. This observation is consistent with other evidence that there is no single level of man-made sound above which all bowheads react and below which none do. Instead, the proportion reacting tends to increase with increasing sound level and increasing signal-to-ambient ratio.

We looked at several measures of behavior vs. distance, received sound level, and icebreaker-to-ambient ratio. Several measures were significantly different when the received level of icebreaker sound was 20 dB or more above the natural ambient level, and in two cases there was evidence of an effect at icebreaker : ambient ratios as low as 10-20 dB. Statistical power analysis confirmed that behavioral effects could have extended to icebreaker : ambient ratios <20 dB, and thus to greater distances from the projectors, without being statistically detectable. This difficulty in identifying the minimum sound level causing reactions, and thus in determining the maximum radius of influence, is a consequence of low sample sizes, high natural variability, and the graded nature of the behavioral responses.

Overall, playbacks indicate that reactions are common when icebreaker noise is 20 dB or more above ambient, and some effects may occur at levels down to 10 dB above ambient. The source level of an actual icebreaker is much higher than that of the projectors used in this study. If bowheads react to an actual icebreaker like *Robert Lemeur* at sound levels similar to those found during our playbacks, they might commonly react at distances up to 10-50 km (5.4-27 n.mi.) from the actual icebreaker. These predictions make many assumptions, and there are many uncertainties. Some arguments suggest that reaction distances may be overestimated by these procedures; other arguments suggest that reaction distances may be underestimated (see Richardson et al. 1995:305-316).

In any case, detection and reaction distances would vary widely from day to day and place to place, depending on sound propagation conditions, ambient noise level, and the reaction threshold of a particular whale. Some bowheads might not react to the *Robert Lemeur* engaged in icebreaking unless it were within 2 km—considering the case of a whale with a 30 dB reaction criterion, shallow water, poor propagation, and high ambient noise. Other bowheads might react at distances as great as 95 km, considering a whale with a 10 dB reaction criterion, deep water, good propagation, and low ambient noise. If one considered a different icebreaker, a somewhat different set of predictions would result, as the underwater sounds from different icebreakers are not identical.

Thus, one of the important results of this study is that there is no single reaction threshold and no single reaction radius. Instead, the probability of reaction and the strength of reaction tend to increase gradually with decreasing distance, increasing received sound level, and increasing signal-to-ambient ratio.

CONCLUSIONS

Based on the playbacks, we concluded that spring migrating bowheads show both behavioral reactions and course diversions in response to icebreaker noise. Because of the high source levels of icebreaker noise, these effects could extend to distances considerably greater than those observed directly during the playbacks. If effects are common out to radii of 10-50 km, as playbacks suggest, a single icebreaker could affect a large area. We found that bowhead mothers with accompanying newborn calves are less likely than other bowheads to travel through heavy ice. Of all bowheads, it is probably the mothers and newborns whose migrations are most likely to be interrupted if there is icebreaking in or near the migration corridor.

This study dealt with spring migration, but effects of oil development near the autumn migration corridor are of more immediate concern in this meeting. Effects of icebreaking in autumn have received little study. We expect that bowheads would react to icebreaking in autumn as well as in spring, with the possibility of quite large diversion radii at some times. However, the potential for migration blockage is probably lower in autumn because heavy ice cover is less common then than in spring. Also, bowhead calves are older in autumn, and have better swimming and diving capabilities than in spring.

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LETTER OF AUTHORIZATION FOR INCIDENTAL TAKE

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Draft Letter of Authorization (LOA) regulations allowing the incidental but not intentional take of marine mammals north of the Arctic Circle are presently being evaluated. National Marine Fisheries Service (NMFS) anticipates the regulations will be in place by January 1996. Currently there are no existing Letter of Authorization regulations in place for oil and gas operations in Northern Alaska since the original Five Year Authorizations expired on August 28, 1995.

No major changes are anticipated in the new Five Year Authorization except for a provision requiring peer review of proposed monitoring plans. All Letters of Authorization will be processed in Washington, D.C. with input from the field. The term "take" means to harass, hunt, capture, or kill or attempt to harass, hunt, capture, or kill any marine mammal. The term "harassment" is defined in the amended 1994 Marine Mammal Act, "take" as any pursuit, torment, or annoyance which could (1) injure a marine mammal, or (2) disrupt the behavioral patterns (e.g., migration, breathing, nursing, breeding, feeding, or sheltering) of marine mammals.

The genesis for authorization "to take" by the oil and gas industry started after the Marine Mammal Protection Act (MMPA) was passed in 1972. During the late 1970s, the Alaska Department of Fish and Game became concerned about ringed seal pupping being affected by seismic on ice activities in the nearshore Beaufort Sea. Seismic operations would generally begin shortly before female ringed seals would start to den in ice ridges. Seal biologists believed that the tracked vehicles and associated human activity would cause the seals to abandon their pups. Because there were no provisions to incidentally "take," the seismic operators agreed to stop seismic on ice activities on March 30th. This date coincided with the start of the denning season. This date greatly reduced the window of availability for seismic operators to gather data safely. In 1980 the MMPA was amended to allow a small take exemption for various activities including on ice seismic activities. The NMFS regulations required the operators under a federal or state seismic permit to submit a report to NMFS on sighting of any ringed seals. As long as NMFS ascertained that the level of take was not adversely affecting the Beaufort Sea ringed seal population the take permits could be issued for a five year period.

The take provision was eventually expanded to endangered species (the LOA) thereby allowing the incidental take of bowhead whales in 1990 for a period of five years. The authorization for this take required a far greater monitoring and reporting effort than the original ringed seal regulations. Additionally, the authorized operator had to prepare a plan of cooperation with each village that hunted bowheads that were affected by the oil and gas exploration activity.

Extensive monitoring and subsequent data collection was obtained for several offshore drilling projects. Under the original Letter of Authorization, NMFS ascertained that bowhead whales were avoiding the drilling rigs. No in-water seismic activities were attempted under a Letter of Authorization and therefore no monitoring data was collected for this type of activity.

QUESTIONS AND DISCUSSION

John Richardson: Could you clarify if the five-year provision still exists? Is it just that the new regulations for the one-year process have not yet been finalized?

Ron Morris: That's correct, John. There will be another five-year permitting period with a one-year at-a-time permit to be issued to the industry that applies for it. We're starting all over with a new five-year period. Over that five years, we'll make a determination whether animals will be affected. If they're not, then we'll allow one-year permits through that five-year period.

John Richardson: I guess what I was getting at is whether the original process for getting five-year regulations and Letters of Authorization under that process still exists but, in addition, there is a new process...

Ron Morris: No, no. That one is gone. We're starting brand new right now.

John Richardson: And is it not correct that a one-year LOA has been issued already under the new provisions to a seismic company off California?

Ron Morris: Yes, but above the Arctic, none will be issued. Now, I've mixed metaphors here to a degree in providing some background there. Seismic operations on the ice are allowed because that's a different LOA.

We call them Letters of Authorization because we actually send you a letter saying you are authorized. Conversely, we don't have an application. For example, I'll get a call from a fellow in Houston and he'll say, "Send me an application for a Letter of Authorization." And I say, "Well, we don't have an application." I'll tell him that you have to send us a letter. Keep in mind, there are no applications. It's not like getting a hunting license. You actually write us a letter and then we write you a letter back.

Bruce Mate: For those of us who didn't see the new regulations that were proposed and recognizing that after the comment period, it may change, can you give us the benefit of what the thrust of the changes were? You indicated that there was some, perhaps, disappointment on the industry side of not ever showing takes or that you sort of alluded to the fact there may have been some programs that didn't really produce information in that direction as well.

Can you give us an idea of what the new ones were proposed?

Ron Morris: Well, I think it will come out about the same way as in the past. I think the industry will be in a better position based on the analysis and the better reports that are being produced to insist when industry doesn't say there is a take--

I'm not going to get into companies. But my point is that the last report we received showed an avoidance by bowheads to an oil rig drilling. And the industry did the study. They paid for it. A nice big report. But the bottom line was there was no take. Their analysis of the data showed no take.

We analyzed the data and did a full-blown scientific analysis that said there was a take.

I don't know how we're ever resolve that, Bruce. I mean, it's just the basis of the industry. I've done work with them for a long time. Their lawyers choke when you say "take." I mean, they just gag, their throats stick. They get tight and they just won't say "take."

Bruce Mate: If I could just follow up on this for a moment. The Act does allow them to make a take?

Ron Morris: That's my point.

Bruce Mate: The Letter of Authorization is for that, so there's no reason to avoid mentioning...

Ron Morris: They mention take. They can take.

Bruce Mate: They're authorized to take. It's just that it has to be low numbers and negligible impact, right?

Ron Morris: And they can admit they have taken, because that's what they have a permit to do. But in their eyes, there's never been a take.

Years ago, when I started with Fish and Wildlife, we were the experts and what we said went. Now, all these companies hire experts and everybody fights about what the truth is. It used to be the government agencies were the experts. And now, everybody's got an expert that has an opinion.

Frank Long: Are you saying that the incidental take provision will be in-place in all of the applications for the industry?

Ron Morris: We hope to have the regulations in place sometime in January that will apply to all the Arctic areas in which the AEWC hunts. It's my understanding that the companies which want to do work in your area are anxious to come up and meet with you and want me to come with them to talk to you. But yes, by the next open water season, there should be regulations in place. A company could apply and they would have to come to you and tell you what they want to do. I would be with them. We'd try to work out a monitoring plan, etc. If there are regulations.

And Nuiqsut would be totally involved, as Thomas Napageak and I have worked in the past. We'll do that again this next time.

Richard Newman: Who needs to educate whom as to the meaning of the word "take?" I think all anybody is squabbling about is what does it really mean. I think maybe the industry might perhaps be objecting to saying that they're taking anything because the word "take" as legally defined here means something totally different from the ordinary common English language use of the word.

Ron Morris: Well, Congress, in their infinite wisdom, has come up with a new, revised definition of harassment, which is a take. I think the gentleman's point is well taken. For some of us when you talk about take, you're talking about Wildlife Biology 101. A take is once you reduce an animal, you kill it and it's on the ground. It's yours. You've taken it.

Well, in the marine mammal vernacular, if you cause an animal to do something it normally isn't doing, you've "taken" that animal. Now, that's not the same. But that's what a take is according to the Marine Mammal Regulations, Rules and the Law.

And I'll read the definition that we're talking about:

"Harassment would be defined in the existing term take to include any pursuit, torment or annoyance which could: 1) injury a marine mammal, or 2) disrupt the behavioral patterns, e.g., the migration, breathing, nursing, breeding, feeding, or sheltering of marine mammals."

So all the above constitute a take. And that's generally what the industry does occasionally. They don't kill an animal. They haven't killed one yet. And they can do this incidentally as in accident. They can't by design chase an animal and harass it. That's what we're talking about. There's an oil rig out there and it's making noise and a hundred bowheads swim by the rig. And when the rig's not there, they're a little closer to it. When the rig is there, they're off 15, 20 kilometers. We think that's a take. You're changing the behavioral pattern.

It may be semantics to some people, but that's what a take is under the Marine Mammal Law. I'd be first to tell you that a lot of times laws don't make sense. The Endangered Species Act, to a lot of people, doesn't make sense and some of the provisions of the Marine Mammal Act. But we feel, and the Congress feels, that harassment is defined and we're out there to protect these animals and as importantly in Alaska, to protect the rights of the subsistence takers. And that's why these definitions are in here.

If you pick up the provisions of the law, it's replete with "thou shalt not affect the subsistence take by the Alaskan natives." That includes oil companies up here. It also includes people in Resurrection Bay. There are provisions where Section 119 of the Marine Mammal Act, says Natives can co-manage marine mammal resources with us. The new regulations on take will cover that angle. If there is a co-management agreement, subsistence rights have to be protected and provisions have to be made to protect the subsistence uses.

And that's where all the shouting, of course, comes from, because the Natives are vocal. You've heard their story and their arguments for why they need these animals. That's where most of the conflict arises in this business of take and the animals being farther away from the hunters than they normally would be.

Grant Walther: I have a couple of questions. First is what penalties are there for violations regarding this act? And second, if there are substantial penalties, are companies denied being able to do geophysical exploration or oil exploration or drilling in the Arctic? And if so, do they have to wait out a year or two? Is that one of the penalties? It seems like that would be a penalty that would work.

Ron Morris: If they don't have a permit, they'd better not take, period, because that's a big time offense.

Grant Walther: Has any company ever been denied a permit?

Ron Morris: No.

Grant Walther: So it's just a matter of writing for the permit?

Ron Morris: Not necessarily. The purpose of the monitoring plan and to do what we're doing is to gather enough information so that we could make a more learned decision in future outcomes.

For instance, on Year One, before we issue a permit in Year Two, we had to have the reports in hand, the monitoring reports analyzed to determine what the level of take was and whether there was a take, and whether we would issue a permit the second year.

So the point is that they can all apply and possibly get a permit, but the evidence might come in that we would say no because based on what happened the year before, or during the monitoring study, we would see something that was more than we had counted on and we have the power to suspend the permit while it's being used.

The provisions of the Act can be very onerous. We don't have any examples that I can give you with the oil companies, but let me give you one that happened many, many years ago. And I don't suggest or even want to connect oil companies with this. A humpback was swimming along in southeast Alaska and a guy decided he didn't have anything better to do, so he started shooting at it with a 22 rifle. And just his luck, there was somebody on a beach who saw him. With just as much luck, the guy had a telephone who was able to call the troopers. The troopers flew a plane over and found the boat and came into town. We cited the boat. To make a long story short, the captain, who was asleep at the time the guy was shooting at the humpback whale, got a $25,000 fine and they took his boat away, a $100,000 seiner.

So there are plenty of provisions in the Act and this is what we want the oil companies to avoid.

Steve Langdon: Is the permit dependent upon a plan of cooperation?

Ron Morris: Yes, and this is my personal comment, unfortunately, it's not mandatory. In other words, they can agree to disagree and that's the end of it.

BP'S BOWHEAD WHALE MONITORING NEAR THE NORTHSTAR DEVELOPMENT UNIT, AUGUST 1995

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BP Exploration (Alaska), Inc. conducted aerial surveys for bowhead whales in the vicinity of the Northstar Unit from August 23 to 31, 1995. The objective of the surveys was to establish baseline data on the early season migration of bowhead whales through the Northstar area. Aerial surveys were flown in MMS Survey Block No. 1, from approximately 150-147°W, from the barrier islands to approximately 71°N. An extensive aerial grid of 12 flight lines spaced 8 km apart was flown once, and an intensive grid of 8 lines spaced 8 km apart was flown three times. Twenty-eight sonobuoys were dropped and 21.5 hours of ambient noise data recorded. A total of eight bowhead whales and six belukha whales were observed. This data, in combination with the Minerals Management Service spring and fall migration survey data (1979-1995) will be used to support development permits for the Northstar Unit, and to ensure that activities do not interfere with subsistence use of the nearshore and offshore area.

QUESTIONS AND DISCUSSION

Warren Horowitz: Because of potential weather problems during your aerial surveys, do you plan any supplemental monitoring with tagged whales?

Chris Herlugson: Right now, we are not doing that. We are very early in our planning for the Northstar Development. As some of you may have heard, we are in the very initial stages of working on an EIS for this project. A lot of what will happen in the future will depend upon the outcome of the EIS, i.e., what is required in terms of future monitoring; what we believe is required in terms of monitoring our activities ourselves. So, I can't say right now what we would be doing. Personally, I would be hesitant about getting into tagging studies for a project of this scope. It is always possible, but I think right now that might be out of the scope of something like this.

OVERVIEW OF NORTH SLOPE BOROUGH BOWHEAD WHALE RESEARCH WITH A FEW COMMENTS ABOUT INDUSTRIAL ACTIVITY IN THE BEAUFORT SEA AREA

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Since 1981 the major focus of the North Slope Borough (NSB) bowhead research program has been to estimate population size and trend based upon visual sightings and passive acoustic locating of spring migrating whales passing Point Barrow. The estimate of population size currently accepted by the International Whaling Commission (IWC) is 8,000 (95% confidence interval 6,900-9,200). The IWC accepted rate of increase is 3.1% (95% confidence interval 1.4% to 4.7%). Studies have documented what senior hunters had told us in 1981-82 as traditional knowledge: 1) that the bowhead population was much higher than the 600-2,000 that scientists estimated it to be in 1978, 2) that bowheads are not "afraid of" ice and will swim "into" ice covered waters, 3) that bowheads pass Point Barrow on a "wide front" and don't just confine themselves to the open water of a lead, 4) that bowheads can break ice to breathe, 5) that bowheads are sensitive to man-made noise, and 6) that some bowheads in the spring leave the area of St. Lawrence Island and go up the Chukotka coast and therefore do not come near the census station at Point Barrow.

GENERAL COMMENTS

First of all, the few things that I wanted to mention about our research are mentioned in the abstract, so if I skip some of them, please refer to the abstract.

Rather than talk about our research, I would like to expand on a few things that should be done after listening to this session and after having been involved in bowhead whale-related matters for many years.

The first point is, and this goes back to something that some people were talking about earlier, to give some consideration to the traditional knowledge of the people who live in the area. For future work that is done in the Beaufort Sea area, give more consideration to the traditional knowledge of the people who live there.

The fellows sitting in the back here, Mr. Burton Rexford, Mr. Joe Kaleak, etc., have lived their whole lives in the Beaufort Sea area. They know a lot about what's going on. In general, and I've watched this for a long time, their views are pretty much just ignored. MMS deserves credit for having these people on the agenda to present their views themselves. I think that was really good.

Let me give you an example. We heard from Mr. Frank Long and others the other day, about the problem with marine seismic exploration noise and what it does to the distribution of bowhead whales. Here's a case where traditional knowledge is saying one thing and limited scientific studies are seeming to say something else.

Another example about traditional knowledge is just today, in a presentation by Dr. Bruce Mate, he showed a slide by one of my colleagues, Craig George, of a bowhead whale breaking through the ice. Dr. Mate showed a slide from Ms. Lori Quakenbush. But anyway, let's not forget where this idea came from. There's a person who is now dead who said, "Look, you dummies, bowhead whales break through the ice to breathe all the time and I'm getting tired of you not giving that due thought. So here's what I want you to do. Go out on the ice here and look for this thing (certain cracks in the ice). And when you find it, you'll know that I'm not lying."

That was Harry Brower, Sr., who's now passed away. He is the Eskimo hunter who told us about the whales. Lots of hunters told me about whales breaking the ice, but Harry very carefully sat us down and explained here's where you go to look for the evidence. When you get there, this is what you're going to see. This is how you need to interpret it because he's seen it for many, many years.

So we need to give folks like that their due credit.

The second thing in this regard is the whole NSB's research program, or the major part of the NSB's research program over the years. When we inherited the bowhead whale research program from the National Marine Fisheries Service in early 1980s, we had a problem of conflicting views. The conventional scientific wisdom was that there were 600 to 2,000 bowheads and that they stick pretty much to this open area (lead) in the ice as they sort of come by Point Barrow.

On the other hand, we had a group of people who I listened to every day who were saying, "I don't know how many bowheads there are, but there's a whole lot more than 600 or 2,000, because I've been watching them my whole life, 60 years or whatever. And I also know that they're not afraid of ice. You people are afraid of ice and gray whales are afraid of ice, but they're not afraid of ice."

So here we have these conflicting views. So what do we do? The normal thing to do, of course, is to go to the library and get out reference books and find out what's really going on. But we did not have a library at that time with all this information. Two reasons: 1) we didn't have a library in Barrow, and 2) the information wasn't written down. The closest thing we ever had to a really good arctic "library" in Barrow, was Dr. Max Brewer. When he retired from NARL and left, we were deprived of that. But I did the best I could and turned to the local "library system," which was people like Mr. Harry Brower, Sr., Mr. Burton Rexford and some of these other folks. They told me very consistent things about these whales.

> "1) There's a lot more than you people are counting. 2) They're not afraid of ice like you and like gray whales are. 3) They don't all stay in the lead. They go by Barrow on a broad front. I don't know how broad it is but it's a whole lot broader than that little patch of open water (lead). 4) These animals are afraid of noise. They respond to noise. 5) We don't think all of them come past Point Barrow, which is where you scientists are counting them, because we know from Eskimo people on Saint Lawrence Island that some of the whales go over to Chukotka. They don't ever come to Barrow.
>
> So if you guys are going to do a study to count whales, you'd better do it properly."

So we spent millions upon millions of dollars and many years essentially working out step by step what these people told us. And, in particular, this one person who very patiently sat down with us to explain: Harry Brower.

So I would ask MMS or anybody else who is going to work up there to do more, to go and seek out the help of people who live there. Not that they know everything, but they certainly know a lot more than they generally get credit for. It's useful to consult the local experts.

The second general point I want to mention is I don't think we need many more acute experiments with seismic boats where you take a seismic boat and have it approach whales and see what the whales do. There have been some of these done, and in my view, as I've expressed to the people doing these studies over the years, I think many of them have been confounded by the presence of other seismic noise in the background from another seismic boat 60 miles away that's booming away, or a seismic boat that was booming in the same general area an hour before.

The third point I want to mention is something that we really do need, and you heard this from the people themselves yesterday. We have to somehow get at what is really going on up there with the fall distribution of bowhead whales in relation to noise from seismic exploration and drill rigs, in particular, seismic exploration.

On the one hand, we have the people who are "on the ground," more precisely, on the water, "putting around" out there, looking for these whales and they can't find them when the seismic boats are working. But on the other hand, we have some limited scientific data that say things like behavioral responses begin at seven to ten kilometers and so on.

So, we have two observations and a gap between them. So I hope that MMS or someone gets at the truth and designs a study that will determine what is the noise like in the water around an active seismic exploration event. What is the noise really like 50 miles away and 20 miles away and so on? And what's the whale distribution around this? Are these animals pushed further offshore like the hunters say they are?

My guess is that when you do that study properly, you'll find out that the Eskimo hunters are just as right about that as what they told us in 1981 about whales being not afraid of ice.

The fourth point I want to briefly mention is the need for scientific review boards for some of these studies, particularly the ones that everyone knows are going to be controversial. To MMS's credit, but not after a lot of prodding I might add, they instituted a scientific review board for the so-called "noise in the lead study" that Drs. Greene and Richardson conducted. I think probably everyone will admit that the associated review process helped that study to become better than it might have been and certainly helped to keep the evaluation of the data hopefully on track. And the final report from that study, we'll see today.

If you have a scientific review board, they need to take into account the major stakeholders. We've heard the word "stakeholder" used a couple of times lately. The major stakeholders for such studies in the Beaufort Sea without any doubt are the AEWC, the North Slope Borough, the oil industry, and probably others.

The fifth general point, I'd like to mention is that you need a proper power analysis of the data that come from these impact assessment studies. I'm not a statistician but I've read so many reports over these many years which present four or five hundred pages of text and then basically come down in the Executive Summary to say "no adverse effects noted." But yet, the number of observations in the study is often times minuscule. The number of pages in the report is usually substantial. The number of observations is often minuscule.

So there needs to be some sort of a power analysis done to tell the ordinary person, like me or other readers who are not statisticians, how big an effect would you really have to have in order to detect it with the 13 or so observations that you've got.

That's a really important thing. Making a judgement of no "adverse effect noted," based upon a few observations is not fair.

The sixth point is, as industry moves toward development in the Beaufort Sea area, Canada and/or Alaska, you have to remember that there are at least three major stakeholders up there: 1) the bowhead whales, 2) the Eskimo hunters, and 3) the oil industry. The bowheads have been there "forever." Who knows how many tens of thousands of years those animals have been there. The Eskimo hunters have been there for 8,000 to 10,000 years. Only in the last 20 or 30 years has the other stakeholder appeared in the area.

I think the bowheads have the most "right" to the place, and the Eskimos the second right to the place. The oil industry has a right to be there too, but it has to take care not to interfere too much.

The final point, is I hope that MMS, the National Marine Fisheries Service, and others will work together to see that the industrial activity up there does not unduly interfere with two things: 1) it doesn't unduly interfere with use by bowheads of the area for feeding and for migration and 2) it shouldn't unduly interfere with the Eskimo's subsistence hunt of the bowheads.

There are lots of other animals also in the Beaufort Sea (polar bears, seals, etc.) But let's face it, it's the bowhead that drives the system. And finally, let's remember to use common sense in determining what is meant by "unduly" and "significant."

General Biology Session

OVERVIEW OF SPECIES THAT MAY BE AFFECTED BY DEVELOPMENT WITHIN THE ARCTIC ALASKA OCS REGION

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INTRODUCTION

Welcome to the General Biology Session of the Arctic Synthesis Meeting. My name is Lori Quakenbush and I am the Session Chair. I am a Fish and Wildlife Biologist with the U.S. Fish and Wildlife Service. I have worked in the Alaskan Arctic for the past 12 years studying marine birds and mammals. For the past 5 years I have worked on oil and gas exploration and development permits on the North Slope and OCS. Today I would like to present a brief overview of some of the species of concern that may be affected by development. Some of these species have dedicated presentations in this conference, or as in the case of bowheads, dedicated sessions, but others do not. This is not an exhaustive list of species of concern nor of potential impacts of oil activities.

The Environment

The dominant feature of the Arctic Alaska OCS is sea ice. Portions of the Chukchi Sea are ice-covered for nine months of the year (LaBelle et al. 1983) and the Beaufort Sea is never ice free. Before I talk about the species I want to define some terms and describe the dynamic sea ice environment.

Pack ice consists of annual ice and heavier multi-year ice that is in motion. Shore-fast, or land-fast ice, is ice that freezes to shore and is fixed in place. Drifting ice consists of floes of annual and multi-year ice that can be loosely or tightly packed depending upon the action of the pack ice. Drifting ice creates linear openings, called leads, and nonlinear openings called polynyas. These openings occur throughout the winter, but their locations are not predictable. Islands and prominent points of land create generally predictable areas of open water called recurring leads and polynyas. These areas are important marine bird and mammal habitats.

Bowhead Whales

The entire western Arctic stock of bowhead whales enters the Chukchi Sea via the nearshore lead system in April, and most pass Point Barrow by early June. Mating activity has been reported during the spring migration through Chukchi waters. Presently, bowheads are not known to summer in the Bering or Chukchi seas (Miller et al. 1983), although historic records of commercial whaling show that whales were harvested there in summer. Bowheads feed on zooplankton at the surface, in the water column, and on or near the bottom. Bowheads travel through the Alaskan Beaufort Sea into the Canadian Beaufort for the summer and return through the Chukchi to the Bering Sea for the winter beginning in late September.

Bowhead whales are an important subsistence resource for indigenous coastal people of the Bering, Chukchi, and Beaufort seas. Due to ice conditions and migration routes some of the villages hunt whales only in spring, others only in fall, and some are strategically located to hunt both spring and fall.

Bowhead whales and subsistence whaling are potentially vulnerable to noise and activity within the lead system during migration as well as to oil spills. It is thought that oil could foul the baleen filtering mechanism making feeding inefficient.

Belukha Whales

At least two groups of belukha whales enter the Chukchi Sea via the Chukchi Polynya and nearshore lead system in April and May. The first group passes through the Chukchi to summer in the eastern Beaufort. The second group arrives in Kasegaluk Lagoon in June or July and spends the summer there. The distribution of belukha in Kasegaluk Lagoon does not appear to be directly related to the availability of prey, which suggests the area may be important for other reasons. Kasegaluk may be a safe or otherwise preferred calving area, the warmer water may assist the thermoregulation of young calves, or benefit adults by accelerating the molting process and decreasing the energy expenditure (Hazard 1988; Davis and Thomson 1984).

Gray Whales

Gray whales were recently removed from the endangered species list due to population increases. Gray whales inhabit the Chukchi Sea from July to October. Systematic aerial surveys conducted in July showed the majority of gray whales feeding within 40 km of shore between Point Hope and Point Barrow. Gray whales feed on benthic amphipods that may be scarce in offshore waters (Stoker 1978). As a benthic feeder, gray whales may be vulnerable to oil and gas activities that affect the benthos.

Ringed Seals

Ringed seals are the most abundant of the seals in the Chukchi and Beaufort seas and they are present all months of the year, even in areas of continuous ice. They maintain breathing holes in the ice and excavate ice caves for resting and pupping. Ringed seals are known to maintain more than one lair (Kelly et al. 1990). Ringed seals give birth in lairs in late March to early April.

Ringed seals would be vulnerable to oil spilled under or in broken ice. Ringed seals disturbed during the pupping season by on-ice seismic programs and ice road construction for exploration and development, could respond by abandoning dependent pups. In May and June, ringed seals haul out on top of the ice to molt. Molting appears to be physiologically demanding and may be a stressful time for seals. Seals may be more vulnerable to disturbances or exposure to hydrocarbons at this time.

Spotted Seals

Spotted seals do not maintain breathing holes and prefer more open areas with less ice. They are present in the Chukchi Sea from May to October and are found in the lagoons. They are especially concentrated in Kasegaluk Lagoon at Akoliakatat and Utikok passes often with more than 1,000 seals per location (Frost et al. 1983). Some spotted seals (probably < 1,000) are found in the Beaufort Sea in summer. Haul out areas in the Beaufort Sea include Oarlock Island in Dease Inlet, the Colville River delta and Smith Bay.

Bearded Seals

Bearded seals are present in the Beaufort and Chukchi seas in all months of the year. Although they are capable of maintaining breathing holes, bearded seals are most often found in areas of broken ice. In the Beaufort Sea this behavior restricts them to the moving ice zone offshore in winter. Some unknown portion of the population migrates south in the fall to winter in the Bering Sea. Bearded seals are benthic feeders and oil spills and drilling mud and cuttings disposal could affect their food source.

Ribbon Seals

Ribbon seals are little known seals of the pack ice. Until recently they were thought to inhabit the North Pacific and Bering Sea, but recent sightings and review of the literature suggest that many ribbon seals spend the summer months in the Chukchi Sea (Kelly et al. in prep.).

Walrus

Walruses are present in the Chukchi Sea from May to November (Fay 1982). Walrus distribution and movements are related to the distribution and movements of the pack ice. They feed predominantly on benthic organisms in waters less than 80 m deep. Feeding areas are determined by a combination of ice conditions and water depth, therefore, walrus concentrations are not predictable. In summer, females with dependent young are found in the Chukchi Sea, few walruses of any sex or age class are found in the Beaufort Sea, and adult males form large herds that haul out in the coastal areas of the Bering Sea.

Walruses are vulnerable to oil and gas activities in at least two ways: 1) concentrations of walruses hauled out on ice or land are sensitive to noise generated by boat and air traffic and respond by stampeding into the water. This can result in calf mortality by trampling or separation; and 2) walrus are benthic feeders, therefore oil spills or drilling mud disposal could affect their food source.

Polar Bears

Pack ice of the Beaufort, Chukchi, and Bering seas is the essential habitat for polar bears in Alaska. The Beaufort Sea is never completely ice free and provides summer habitat for polar bears. When the ice advances in the fall bears begin to move south, some move into the Chukchi and Bering seas, while others remain in the Beaufort. There is evidence that polar bears west of Point Barrow may constitute a somewhat discrete population separate from bears of the Beaufort Sea.

The primary food of polar bears is ringed seals, however many other edible and non-edible items are eaten as well. Polar bears mostly hunt ringed seals in leads. Concentrations of bears may occur in certain areas due to ice conditions, which affect the availability of ringed seals. The presence of carrion may also result in concentrations of bears, but these concentrations are not regular or predictable in their occurrence.

All polar bears make "day beds" or temporary dens in winter, however, only pregnant females den for extended periods of time. Pregnant females enter dens in late October or early November. Cubs are born in December but do not emerge from dens until late March or early April. Maternity dens are excavated in drifted snow but can be on pack ice, fast ice, islands, or on the mainland. Approximately 53% of the 90 dens found in the Beaufort Sea between 1981 and

1991 were on the pack ice (Amstrup and Gardner 1994). Wrangel Island, in Russian waters of the Chukchi Sea, has the highest known density of maternity dens (Amstrup and DeMaster 1988).

Polar bears lick their fur to clean themselves, making them vulnerable to ingesting spilled oil if they come in contact with it. Bears are also known to eat rubber and petroleum based products voluntarily, indicating that it is unlikely they would avoid oil. Females with cubs in dens are also vulnerable to disturbance by oil and gas activities such as on-ice seismic programs and ice road construction. If a female with cubs is forced to leave a den between December and March, the cubs would probably not survive.

Common Eiders

Common eiders winter in the Bering Sea and migrate north in spring to nest on barrier islands in the Beaufort and Chukchi seas as well as in the Canadian Arctic. Common eiders are potentially vulnerable to oil and gas activity that occurs on the barrier islands during the breeding season. Common eiders undergo a flightless molt and may aggregate into large flocks at sea making a large component of the population vulnerable to an oil spill.

King Eiders

King eiders winter in the Bering and Chukchi seas and migrate north in spring with the common eiders. Kings nest in the tundra along the entire Beaufort Sea coast and in the Canadian Arctic. An estimate from a spring migration count near Barrow in 1976 placed king eiders at 800,000 and common eiders at 150,000 (Woodby and Divoky 1976). A 1994 estimate, also near Barrow was considerably lower with king eiders at 373,000 and common eiders at 71,000 (Suydam et al. 1995).

Spectacled Eiders

In Alaska, spectacled eiders nest in the Yukon-Kuskokwim (Y-K) delta and across the North Slope, primarily from Cape Simpson to the Sagavanirktok River. The breeding population on the Y-K delta declined from an estimated 47,700 pairs circa 1972 (Dau and Kistchinski 1977) to less than 3,000 pairs in 1992 (Stehn et al. 1992) and was listed under the Endangered Species Act as threatened in 1993.

The U.S. Fish and Wildlife Service (Service) and the National Biological Service (NBS) using aerial surveys and satellite telemetry has begun to identify molting, fall staging, and wintering areas. In November, 1994 an estimated 32,000 spectacled eiders were observed in the vicinity of St. Lawrence Island in the polynya to the south of the island and along the ice edge. Following up on a telemetry signal in March 1995, the Service found an estimated 140,000 spectacled eiders in extremely tight flocks in small openings of continuous ice. This location was about half-way between St. Lawrence and St. Matthew islands. A return visit one month later found an estimated 155,000 spectacled eiders in the same location but less tightly packed due to larger openings in the ice (Larned et al. 1995a). This number matches the current estimate of the world population spectacled eiders. Prior to this discovery, the major spectacled eider winter area was unknown.

Spectacled eider hens, fitted with satellite transmitters in the Prudhoe Bay area, in August were found to be in the Chukchi between Point Lay and Cape Lisburne in September. Along with many females were an estimated 30,000 males (Larned et al. 1995b). An additional 41,000 birds were observed in Mechigmenen Bay on the Chukosk Peninsula.

Follow-up flights are planned to better define the molting and wintering areas. Troy Ecological Associates for BP Exploration (Alaska) has been conducting surveys to monitor the status of spectacled eiders within the Prudhoe Bay oilfields, and has been using VHF telemetry to study nest success and brood movements within the oilfield.

Steller's Eider

The Steller's eider is another eider species, currently nesting in northern Alaska and northern Russian and wintering mainly along the Alaska Peninsula and Aleutian Islands. The only confirmed nesting area used currently in North America occurs in the vicinity of Barrow. There has been an apparent decline in the number of Steller's eiders nesting in Alaska, and a reduction in the breeding range of the species within the state (Quakenbush and Cochrane 1993). The Alaska breeding population of Steller's eiders were proposed to be listed as threatened but the listing process has been halted until the current moratorium on listing is lifted. Little is known about their migration route, they do not migrate with kings and commons but arrive in the tundra near Barrow in mid-June (Quakenbush et al. In prep.)

Oldsquaw

Oldsquaw nest in low density along the entire Alaskan coast of the Chukchi and Beaufort seas. Many oldsquaw winter in the Bering Sea along the ice edge and in leads and polynyas. They also winter in Southeast Alaska, the Aleutians, and as far south as California. Oldsquaw form large molting flocks in protected waters of the lagoons through July and August. Large flocks of flightless oldsquaw makes them vulnerable to oil spills and other disturbances.

Shorebirds

In fall, shorebirds, especially phalaropes concentrate in lagoons and on shore to stage for fall migration. Oil spills in nearshore areas during this time of year could affect a significant portion of the population.

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QUESTIONS AND DISCUSSION

Tom Newbury: What are the species of seals near the Northstar prospect in the Beaufort Sea?

Lori Quakenbush: Ringed seals are the most abundant seals in the Beaufort Sea. You can also find bearded seals there and some spotted seals in the summertime, in some areas. Ribbon seals are probably mostly out in the Chukchi Sea. The same for spotted seals. Harbor seals don't go that far north. Those are our Alaskan species.

Larry Bright: Male polars bears do very little denning, is that correct?

Lori Quakenbush: They make day beds or temporary dens just to hole up in storms or whatever. But, yes, there is no long-term denning as there is with females. And it is not just females, it is pregnant females that den.

SUMMARY OF THE POLAR BEAR HABITAT CONSERVATION STRATEGY AND IMPLICATIONS FOR FUTURE OIL AND GAS DEVELOPMENT

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The U.S. Fish and Wildlife Service (Service) issued regulations on December 16, 1993, under the Marine Mammal Protection Act of 1972 (MMPA), which authorize and govern the incidental, but not intentional take of small number of polar bears and walruses in the Beaufort Sea region. The "take" regulations required the Service to develop and begin implementing a strategy for the identification and conservation of important polar bear habitats in order to extend the "take" regulations beyond the authorized 18 month period to the full five year term. Following a 60 day extension to more fully consider public comments the Strategy was finalized on August 15, 1995, and the incidental take regulations were subsequently extended for an additional 40 months ending on December 15, 1998.

The scope of the Beaufort Sea incidental take regulations extended from a north-south line at Barrow to the Canadian border, offshore throughout the State and Outer Continental Shelf (OCS) waters, and 25 miles inland, excluding the Arctic National Wildlife Refuge (ANWR). The scope of Polar Bear Habitat Conservation Strategy (Strategy) is statewide.

The Strategy includes the following sections on: 1) the biology of polar bears; 2) their environment; 3) summaries of scientific information and local knowledge; 4) identification of habitat threats or concerns; 5) identification of important habitats; and 6) a description of implementation techniques. The objectives of the Strategy were to identify and protect important habitat, provide for subsistence uses, and to further the goals of the 1973 international Agreement on the Conservation of Polar Bears between Canada, Norway, Denmark, the former Soviet Union, and the United States. Particular reference is provided to Article II which instructs "Each Contracting Party shall take appropriate action to protect the ecosystem of which polar bears are a part, with special attention to habitat components such as denning and feeding sites and migration patterns, and shall manage polar bear populations in accordance with sound conservation practices based on the best available scientific data."

In order to assess information on polar bear and habitat use the Service focused on two sources of information: published and unpublished scientific information or data; and traditional knowledge which is oral spoken information provided by Native polar bear hunters based upon years of observation. Each source of information has its own particular strengths and also limitations. The evaluation of scientific information was through conventional literature review. The evaluation of traditional knowledge involved an extensive effort to interview and collate information from Native hunters and naturalists. In total 61 individuals residing in 12 villages were interviewed. The product of these interviews was a series of maps which depict traditional knowledge of seasonal polar bear habitat use, such as denning and feeding areas, observed within the area used by the residents for hunting or traveling. The information on composite maps was verified for each village during follow-up visits.

Threats to polar bear habitat were identified as industrial activity, shipping, contaminants, mining, global warming, and human population growth and corresponding demands or effects upon either habitat or polar bears themselves. The Strategy identifies general Important Habitat Areas for protection. These include feeding areas associated with recurrent leads and polynyas, areas where marine mammal carcasses accumulate, and in areas deemed to be of importance for denning bears, including the Arctic NWR.

The Strategy proposed conservation measures for these areas through the regulations governing incidental take, particularly through Letters of Authorization, which may specify provisions for monitoring the take, plans of cooperation with affected villages, and seasonal or temporal considerations for industrial activities, among other considerations. The Strategy also proposes measures to further the goals of the 1973 international Agreement on the Conservation of Polar Bears which include development and implementation of a Polar Bear Advisory Council, development of a Village Communication Plan, and through recognition of the importance of the status of the Arctic National Wildlife Refuge for maternity denning, and to cooperate and coordinate through international conservation initiatives. Lastly, the Strategy identifies a number of important research needs regarding polar bear and habitat relationships including the role and effect of contaminants in the environment.

So where are we today? It is important to recognize that the Strategy's identification of measures to conserve and protect polar habitat did not in itself accomplish these actions and that in many instances the funding necessary to accomplish these objectives is currently unavailable. However, there are a number of the elements that can be achieved under existing conditions and the Service has begun implementation of some of these measures of the Strategy while others are in a preparatory state.

1. The Service will continue to emphasize the incidental take program as a means to monitor and evaluate the effect of industrial activities on polar bears, their habitat, and their availability to subsistence users as required by the Marine Mammal Protection Act.

2. The Service will continue to work with Minerals Management Service (MMS) in the early planning stages of lease sales to identify resource issues of concern while the Strategy should provide a focus of the areas of important values to polar bears.

3. The Service will continue efforts to be instrumental in other programs which either indirectly or directly affect the ecosystem of the region. Examples include the Bering Sea Ecosystem initiative, the Coastal Zone Management Plan process, and the U.S.-Russia conservation initiatives.

4. The Service has begun surveys to delineate marine mammal carcass locations and in the future anticipates further studies to evaluate the energetic value, importance and use of carcasses by polar bears. This information and maps will be provided to industry in order to minimize potential disturbance of areas used for feeding. Initial surveys reveal that the number of carcasses available is much less in the Beaufort Sea region than in the Chukchi and Bering seas regions in western Alaska.

5. A Village Communication Plan will be developed and funds sought for its implementation.

6. Authorization to form an Advisory Committee and operational funding will be sought.

7. The Service will continue discussions towards developing a U.S.-Russia polar bear conservation agreement for bears of the Alaska-Chukotka (Chukchi/Bering Sea) population.

8. The Service is reviewing the effectiveness of U.S. implementation of the 1973 international Agreement on the Conservation of Polar Bears and preparing a report to Congress.

9. The Service will consult with the Parties on the overall effectiveness of the Agreement within the next year.

10. The Service will continue international efforts through the Arctic Environmental Protection Strategy and the Committee on Arctic Flora and Fauna for polar bear conservation.

In conclusion, while many of the initiatives identified in the Strategy have not received funding, we are fortunate to be experiencing healthy polar bear populations in Alaska. We are optimistic also since the marine ecosystem adjacent to Alaska is relatively healthy and intact and has been only minimally affected by human presence or activities. The Service will strive to continue the past successes in conservation of polar bear while working with industry, the State, other government agencies, and the public. The Service will continue its work on the North Slope and particularly in the Beaufort Sea region in proportion to the level, frequency, and duration of future development activities.

QUESTIONS AND DISCUSSION

Cleve Cowles: This morning there was an interesting discussion of how the scientific aspects of monitoring leads to the interpretation of "take." Was there a Letter of Authorization (LOA) issued for Shell Western in the Chukchi Sea for polar bear take?

Scott Schliebe: There was a couple of years ago. In the Chukchi Sea, I think there were three LOAs: two to Shell and one to Chevron. They spanned a period of two years and, I believe, four or five exploratory drill sites.

Cleve Cowles: I was just wondering how Fish and Wildlife Service handled this question of the interpretation of the observations of bears in relation to industry and the definitions of "take." Just as a comparison to this morning's discussion as far as bowhead whales and how monitoring may be involved with interpretation of observations relative to take and how you have handled that with the bears.

Scott Schliebe: Our definition of "take" is an alteration of behavioral processes. That can be attraction or avoidance. In the case of the Chukchi Sea, there were quite a number of encounters between polar bears and the survey crew. I don't think there were very many encounters between polar bears and ice breakers or vessels that were managing ice. There were many more encounters or interactions between walruses and those activities. Some of the monitoring in that case indicated that "takes" included preclusion by industrial activities of walruses' use of ice near the drilling rig. Back to your initial question, the incidental take permits do not authorize the lethal take, they only authorize the incidental take. There have been a number of incidental takes of polar bears concurrent to oil and gas activities, not only in the Chukchi Sea but also in the Beaufort Sea. That is the framework for the Letter of Authorization which provides protection to industry for those types of takes.

Cleve Cowles: Is it Fish and Wildlife Service's expectation that industry report quantified takes or has the Service done that independently?

Scott Schliebe: The Service has not done that independent from the monitoring. The requirement is that industry conduct the monitoring and that that monitoring program be approved by Fish and Wildlife Service. If the monitoring program is well structured and well designed, it should lead you to the conclusion regarding level of take.[1]

Bruce Mate: At the end of your presentation you stated that you are optimistic that you will be able to carry out several of the things you want to achieve but weren't funded for. Is that optimism a personal mindset of yours or do you have some reason to believe that funding will actually change and you will be getting some funds in the near future for that?

Scott Schliebe: It is more of a personal mindset than one that is borne out by budget forecasts. I still believe, however, that the emphasis that was placed on development of this strategy ultimately will result in funding to accomplish and achieve those components that were identified in it.

Grant Walther: Are there any known occurrences of oil spills and polar bears, in Russia, Canada, or the Alaskan Arctic? If so, what documentation is there regarding that?

Scott Schliebe: I am only aware of the instance of where three bears were intentionally oiled in Canada in an experimental sense. I am not aware of other instances in the wild where follow-up on the fate of an oiled animal was achieved. I believe there are a couple of anecdotal instances (of bears being oiled or ingesting oil) also in the Churchill Bay area where polar bears have been observed coated with oil or drinking, in one case, hydraulic fluid. But the fate of that animal wasn't determined.

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[1] 50 CFR 18.117 Requirements for monitoring and report state that "The Holder of a Letter of Authorization must submit a report to the Service's Alaska Regional Director within 90 days of the completion of any exploratory activities. The Holder and the Service shall meet and discuss the report each year. The report must include the following information... Results of the monitoring activities including an estimate of the actual level of take; ..."

NATIONAL BIOLOGICAL SERVICE OCS ENVIRONMENTAL STUDIES PROGRAM: RESEARCH AND MONITORING IN ARCTIC ALASKA

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INTRODUCTION

The National Biological Service (NBS) was created in 1993 by consolidating the biological research, inventory and monitoring, and information transfer programs of seven Department of Interior (DOI) bureaus. The NBS mission is to provide leadership in gathering, analyzing, and disseminating biological information to support management of the Nation's natural resources. Because the NBS has no regulatory authority, it serves as a source of unbiased information to DOI resource managers and other users. The scope and content of Outer Continental Shelf (OCS) research managed by the NBS is determined annually in consultation with the Minerals Management Service (MMS).

The NBS studies for Alaska and Pacific OCS Regions are administered by the Western Regional Office, Seattle, Washington. During Fiscal Year 1995 (FY 95), projects addressing seabirds, contaminants in marine mammals, and behavioral effects were conducted in Alaska. Brief project overviews of each are provided below. In addition, information on the distribution and abundance of young-of-the-year (YOY) arctic cod (*Boreogadus saida*) in Camden Bay, Alaska, is presented. Observations of YOY cod densities in September 1990 are related to this species' ecology and oceanographic patterns in the eastern Beaufort Sea.

I. NBS-MANAGED OCS STUDIES

Our environmental studies address priority research questions and information needs identified by the MMS through the Alaska Regional Stakeholders, other State and Federal agencies, and other interest groups. A program goal is to integrate these mission-oriented studies with other NBS research (e.g., Alaska Science Center). In this way, the NBS and its partners (e.g., National Oceanic and Atmospheric Administration [NOAA]) can address broader environmental issues or regional ecosystems that may be affected by oil-and-gas or other human activities. In every OCS study, MMS information needs are of priority concern and our milestones reflect current oil-and-gas leasing and Environmental Impact Statement schedules. Our monitoring studies involve systematic sampling of both control and impacted sites subsequent to baseline studies to develop time series data for detecting impact, trends, and changes in the baseline.

In FY 95 the NBS continued seabird colony and contaminants monitoring in Cook Inlet, Norton Sound, and Arctic lease areas. In addition, new research was initiated to develop the technologies needed to evaluate potential visual and acoustic disturbance effects on Pacific walrus. Previously, the NBS's Alaska Science Center (ASC) had identified the need for programs to (1) monitor the status and trends of Alaska and Pacific coast marine birds, and (2) integrate contaminants monitoring into ecosystem research, as high priority research areas.

Chukchi Mammals and Birds (ASC)

A two-year project was initiated to study behavioral effects of helicopter overflights on Pacific walrus (*Odobenus rosmarus divergens*) in the Chukchi Sea. To date the research has involved the development and testing of satellite-linked Geographic Positioning System, Temperature-Depth-Recorder, and Depth Recorder units on hauled out walrus at Cape Peirce, Bristol Bay. If successful, the technology will be applied in disturbance experiments at Point Wainwright during summer 1996. Investigators are compiling/synthesizing regional environmental information and data as part of their development of Geographic Information System capability. Initial emphases are being placed on walrus and spectacled eiders (*Somateria ficseri*). They are also evaluating an application of the Inter-site Population Sensitivity Index to walrus in the Chukchi Sea.

Cook Inlet Seabirds (ASC and U.S. Fish and Wildlife Service)

Colony monitoring at Chisik, Gull, and Barren islands is part of long-term research to elucidate oceanographic influences on seabird productivity. The populations selected for long-term study include representatives from surface-, pelagic-, and benthic-feeding species. The coordinated NBS/Fish and Wildlife (FWS) research includes traditional monitoring at the colonies in concert with oceanographic surveys of local, and larger-scale, physical properties (e.g., hydrographic) and biological attributes (e.g., prey, at-sea distributions of seabirds, etc.) thought to be major determinants of seabird productivity. Broad-scale and seasonal distributions of sea surface temperatures in lower Cook Inlet are being acquired from satellite thermal imagery. The research focus is the quantification of ecological relationships linking numeric and functional population responses.

Chukchi Seabirds (ASC and NBS)

In summer 1995, FWS biologists monitored cliff-nesting seabird species (kittiwakes [*Rissa spp.*] and murres) at colonies located at Capes Lisburne and Thompson. These surveys extended the time series from the mid-1970s and late-1960s, respectively. Monitoring objectives were supported by prey and telemetry studies to investigate summer (short-term) and winter (long-term, telemetry only) habitat use by common (*Uria aalge*) and thick-billed (*U. lomvia*) murres. The research is testing a hypothesis relating contrasting population trends in murres at the colonies to differential patterns of habitat use in the Bering Sea.

Alaska Marine Mammal Tissue Archival Project(AMMTAP.) (NBS, NMFS, National Institute of Standards and Technology)

The success of the AMMTAP reflects its many partners. Major research collaborators include the: NOAA, Department of Fisheries and Oceans (Canada), University of Ulm Germany, FWS, North Slope Borough, State of Alaska, Kawerak and TDX Corporations, Alaska Sea Grant Program, and the Cook Inlet Marine Mammal Advisory Committee. The purpose of AMMTAP is to collect tissues from Alaska marine mammals and to store these samples for future contaminants analyses. Marine mammals sampled are important subsistence resources and include: ringed seals (*Phoca hispida*), bearded seals (*Erignathus barbatus*), spotted seals (*P. largha*), harbor seals (*P. vitulina*), Pacific walrus, northern fur seals (*Callorhinus ursinus*), Steller sea lions (*Eumetopias jubatus*), belukha whales (*Delphinapterus leucas*), bowhead whales (*Balaena mysticetus*), and polar bears (*Ursus maritimus*). Liver, fat (blubber), and kidney tissues are collected from freshly-killed animals using standardized sampling procedures. Contaminant analyses include petroleum hydrocarbons, trace metals, PCBs, and persistent polychlorinated hydrocarbons. Future directions include expanding tissue collections to include greater food web representation and human risk assessments.

II. OFFSHORE FISHERY INVESTIGATION

Introduction

Large gaps exist in our knowledge of the ecology of arctic cod. In Alaska, they occur in marine waters extending from Norton Sound to Demarcation Point and are an often-acclaimed key component of Arctic food webs. They are the most abundant fish in the Alaska Beaufort Sea and are considered one of the "keystone" species or indicators of coastal ecosystem health. This small cod species is of minor value in subsistence fisheries at Barrow and Kaktovik. The fall timing (November) of these fisheries is important, however, because it demonstrates their coastal presence in early winter.

Biological descriptions of the species life pattern and major habitat associations in Alaska is not available. Craig and Haldorson (1980) encountered ripe arctic cod in Stefansson Sound in November 1978 and, by February 1979, all of the fish captured in this area were spent. Pre-spawning cod were captured again the following November and thus traditional use is indicated. This is the only documented spawning area reported to date from the Alaska Beaufort Sea.

A generalized early life history account is available from the scientific literature (e.g., Sekerak 1981). The eggs of arctic cod are buoyant, possessing a flimsy membrane, and are among the largest gadoid eggs. The egg stage lasts from 1.5 to 3 months; the larval stage (5.4-15 mm) for about 2 months; and the transition to juvenile occurs at a size of 30 to 50 mm. Young-of-the-year (YOY) arctic cod are planktonic and their occurrence and depth distribution appears synchronous with the spring bloom. Phytoplankton and early life stages of zooplankton are their major foods. Juveniles remain planktonic until the end of their first growing season. Older cod prey on zooplankton, substrate and ice-associated crustaceans, and young fish, including YOY cod. Information from northern Alaska indicates that most males mature at 2 and 3 years and females at 3 years. Spatial variation in the relative abundance of arctic cod is best known in nearshore areas, especially in late summer and autumn when onshore movements are common.

Objectives

The MMS sponsored NOAA research in the Alaska Beaufort Sea during 1988-1991 with objectives to (1) describe anadromous fish movements and migrations, and (2) investigate spatial-temporal relationships in fish habitat use. The study area included nearshore waters between Harrison Bay and Barter Island. In 1990, Camden Bay was the site of NOAA's fish telemetry studies (Jarvela and Thorsteinson, in press) and more than 50% of our fish sampling effort (Thorsteinson et al. 1991). The combination of multiple research objectives, limited field time, and inclement weather resulted in only one period of systematic sampling in Camden Bay.

In this paper I describe how the presence of relatively high, uniform densities of YOY arctic cod in nearshore waters of Camden Bay provides new insights into this species ecology in arctic Alaska.

Study Area and Methods

Camden Bay is a 90 km-wide bight abutting the Arctic National Wildlife Refuge (ANWR, Figure 1). The annual patterns of change in water properties and thermohaline structure in the bay are similar to other coastal locations (e.g., Hale 1991). Marine conditions are promoted by an absence of large local freshwater sources, lack of barrier islands, and comparatively deep water near shore. In most areas, marine water (-1 to 3°C, 27-32 ppt) predominates during the summer.

An active fish sampling protocol allowed direct comparison of catch and hydrographic data (Thorsteinson et al. 1991). On September 2 and 3, 1990, replicate samples were collected at each of 14 fishing stations situated along three N-S transects extending offshore at Arey Island (4 stations), Collinson Pt. (6), and Brownlow Pt. (4). The stations were generally located at distances of 2-, 3-, 6-, 9-, and 12-km from the coast over depths ranging between 2 and 25 m (Figure 1). A single station was located in the center of Simpson Cove at a depth of 2-m.

On this basis, the study area was post-stratified into four large subareas (Brownlow Pt. - 215 km^2, Camden Bay - 580 km^2, Arey Island - 215 km^2, and Simpson Cove - 85 km^2; see Thorsteinson et al. 1991 and Figure 1). The total area sampled was 1,076 km^2. The subareas correspond to western, central, and eastern portions of the bay, respectively. Each subarea was further subdivided into a surface grid of volumetric cells averaging 9 x 10^7 m^3 in eastern (5 cells) and western (5) subareas, and 19 X 10^7 m^3 in the central (7) part of the bay. The depth dimension corresponds to the depth sampled by the tow net. The length and width of individual cell boundaries correspond to the (1) geographic position of sampling stations on each transect, and (2) the placement of transects with respect to the physical boundaries of Camden Bay.

Arctic cod densities were estimated by computing the volume (m^3) of water fished per 10-minute set (distance towed [m] X area [m^2] of the tow net mouth) and standardizing the catch to numbers per 1000 m^3. The coefficient of variation (CV) was calculated (as in Zar 1984) to describe relative variability in station catches and spatial patchiness across the bay. The classification of CV values developed by Grossman et al. (1990) was further adapted to Camden Bay where: values ≤25% indicate an even distribution; 25% <CV <75% a relatively even distribution; 50% <CV <75% moderate patchiness; and CV >75% high patchiness. Area swept methods (Bakala and Smith 1978) were used to describe arctic cod abundance and biomass. Ninety-five percent (95%) confidence intervals were computed for population standing stocks and wet-weight biomass. Sample sizes were based on the computation of effective degrees of freedom (*v*) as described by Cochran (1963).

Hydrographic (CTD casts) data was processed as described in Thorsteinson et al. (1991). Additional meteorological and oceanographic data was obtained from stations located on the ANWR coast (Underwood et al. 1995).

Results

Marine conditions were encountered at 13 stations sampled; transitional waters were observed in Simpson Cove. The average temperature of the upper 2-m layer was 1°C at the most northern stations of the bay warming to 2.5°C within 2 km of the coast. Salinities >30 ppt were found in all exposed waters. Winds were from the northwest at approximately 3.5 m/sec during the 31-hr sampling period. Oceanographic conditions in Simpson Cove included surface temperatures of 4°C and salinities of 26 ppt. A strong salinity gradient was evident with 31 ppt, <4°C water, near the sea floor.

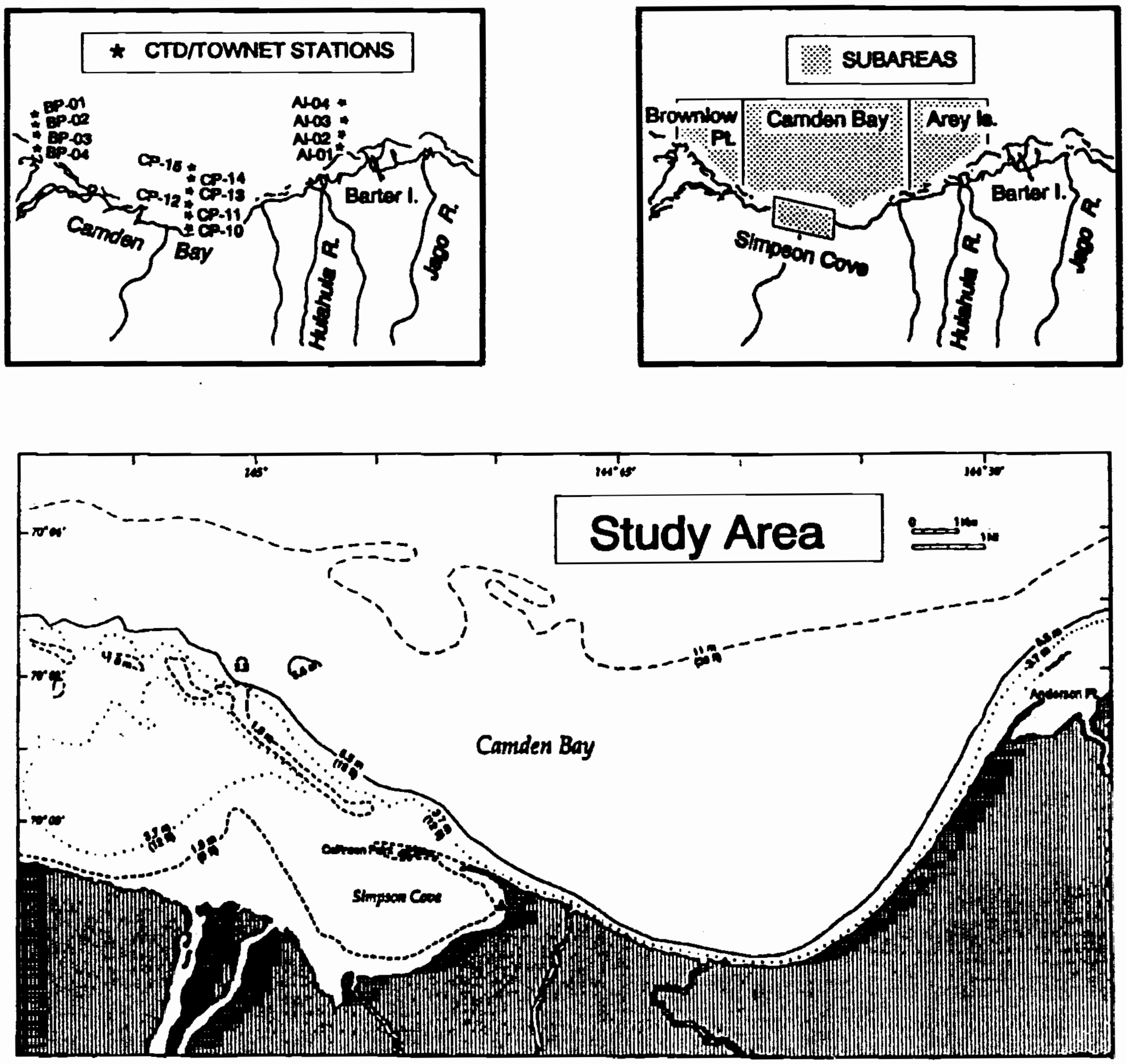

Figure 1. Camden Bay study area, station locations, and subareas.

A total of 5,744 arctic cod were captured in 28 tow net sets. The catch was almost exclusively comprised of YOY cod. The average fish was 45 mm long (fork length) and weighed 11.6 g. Catches were greatest in the central portion of the bay where densities averaged 97.5 fish/1000 m^3. Other indices of abundance are presented in Table 1 below:

Table 1. Population abundance and biomass of YOY arctic cod in Camden Bay, September 2-3, 1991.

Subarea	Total Catch	Mean Density YOY/1,000m^3	Estimated Population (YOY X 10^6)	Estimated Pop. Biomass (kg YOY)
Arey Island	175	16	6.6	79,044
Camden Bay	4,942	86	76.8	1,501,230
Simpson Cove	599	23	3.4	28,235
Brownlow Point	28	0.5	0.2	2,529
Totals	5,744	31.4	87	1,628,038

The total number of YOY cod present was estimated to be 87,000,000 fish. The 95% confidence interval (v = 15) for this estimate was 52.7 X 10^6 fish and 114.5 X 10^6 fish. Similarly, the 95% confidence limits (v = 15) for the estimated population biomass were 1,275,736 kg and 1,980,339 kg.

The spatial pattern of YOY cod distribution observed in the catch was one of diminished variability and greater abundance towards the head of the bay. Average CV values for each subarea were: 17% in Simpson Cove, 26% in Camden Bay, 62% in Arey Island, and 102% for Brownlow Pt. The highest relative abundance of YOY cod was observed within 6 km of the exposed coast. Greatest densities were reported at stations north of Collinson Pt. (Simpson Cove not included) (Table 2):

Table 2. Spatial distribution of YOY arctic cod (fish/1000 m^3) in Camden Bay, September 2-3, 1991.

Distance Offshore:	2-4 km	2-6 km	>6 km
Arey Island	55	25	2
Camden Bay	168	128	3
Brownlow Point	1	0.7	0.2

Discussion

Underwood et al. (1995) report large numbers of arctic cod in standard fyke net catches in Simpson Cove during July - September sampling periods in 1988-1991. Examination of the age composition of their arctic cod catches in 1988 and 1989 reveals an absence of YOY fish in July. Instead the inshore catches were dominated (90%) by 2-4 year old fish. Presumably, these cod were feeding on the rich mysid and amphipod food resources characteristic of arctic lagoons. Small numbers of YOY cod were captured in August and September 1990 at Simpson Cove and at Kaktovik and Beaufort lagoons. The onshore movement of YOY fish in autumn suggests a 50 mm size in fish transitioning from planktonic to benthic food habits. It may also reflect the size when cannibalism and predation are reduced. Older cod were rarely sampled in association with YOY fish in offshore habitats.

Prior to this research, and that of Underwood et al. (1995), little information was available about the fishes in the eastern sector of the Alaska Beaufort Sea. This is particularly true in offshore areas closest to OCS oil-and-gas exploration. Limited trawling by Frost et al. (1978) indicated arctic cod to be most abundant in the northeastern Chukchi Sea (10.3 fish/trawl), moderately abundant between Barrow and Prudhoe Bay (7.8 fish/trawl), and least abundant between Prudhoe Bay and Demarcation Pt. (1.9 fish/trawl). Their sampling extended our knowledge about the depth range of the species and their sampling occurred at much greater depths than reported here. Craig (1984) reported the highest concentrations of arctic cod 175 km north of Prudhoe Bay in winter.

The results of the standing stock evaluations presented in this paper suggest a mean overall YOY arctic cod density of 0.04 fish/m^2 in Camden Bay in early September 1990 (Thorsteinson et al. 1991). Craig and Haldorson (1980) estimated a school of 19 X 10^6 arctic cod in Simpson Lagoon during mid-August 1978. They estimated this school to correspond to a density of 0.14 fish/m^2. This is very similar to the 0.13 fish/m^2 we estimated in the central part of Camden Bay in this study (Thorsteinson et al. 1991). From an ecological perspective, 0.13 fish/m^2 corresponds to a wet-weight biomass of 1.5 g/m^2 or 0.15 g dry weight/m^2 (mean weight of average fish was 11.6 g). Assuming the daily rate of primary production is 1 g C/m^2 in Camden Bay, and a 10% efficiency between trophic levels occurs, implies sustainable biomass levels of 0.01 for secondary consumers. The catches suggest another center of abundance east of Prudhoe Bay and, perhaps, another stock offshore northeastern Alaska.

It is not possible to identify the parent stock of the YOY fish we captured in Camden Bay. The transport of young fish is passive and their development tied in ways unknown to coastal oceanography. It is possible that the young fish were transported into our study area from Stefansson Sound, or more likely, as suggested by the distributional data, another spawning area located somewhere in the east or farther offshore. Tow netting near Collinson Point in early August suggested few cod were present in coastal waters at that time (Thorsteinson et al. 1991). A northwesterly wind had been blowing for several days prior to September 2-3 and this might explain the paucity of fish near Brownlow Point. Considering the variable nature of winds in this region, their effect on coastal circulation, and the known occurrence of nearshore concentrations of older fish in nearby waters each fall (i.e., Kaktovik fishery), a spawning population and nursery ground could be located to the east. If this is true, early life history development, including the transport and development of eggs and growth of YOY fry, would be inextricably linked to the physical processes and productivity of Camden Bay. A coastal eddy is suggested by the coastal configuration, bathymetry, and known currents in the eastern bay. Verification of such a nursery awaits further testing.

ACKNOWLEDGMENTS

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PRELIMINARY RESEARCH ON PACIFIC WALRUS TO EVALUATE POTENTIAL EFFECTS OF DISTURBANCE BY OCS RELATED OIL AND GAS ACTIVITIES IN THE CHUKCHI SEA

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INTRODUCTION

Pacific walruses (*Odobenus rosmarus divergens*) range throughout most of the Bering and Chukchi seas (Fay 1982; see Figure 1). The Chukchi Sea is used in summer by adult females and young walruses. The proposed U.S./Russia simultaneous lease sale in the Chukchi Sea and the independent lease sale in U.S. portions of the Chukchi Sea would open the area to oil and gas exploration and eventual development. Oil and gas activities that occur during ice-minimum conditions in summer in the Chukchi Sea are likely to come into direct contact with adult females and subadult walruses.

Walrus in sea ice habitats are known to respond to disturbances resulting from various industrial activities (Brueggeman et al. 1990, 1991) and are sensitive to disturbances at land and sea-ice haulouts (Loughrey 1959, Ray and Fay 1963, Salter 1979, Fay et al. 1986). The response is usually a general movement away from the disturbance source (Brueggeman et al. 1990, 1991). If disturbances cause walruses to abandon preferred feeding areas or interfere with calf-rearing, resting, or other activities, then the walrus population could be negatively affected. Conversely, if such cause and effect cannot be demonstrated, then the overall effect of disturbance might be considered of little importance to the population.

We are conducting a study sponsored by Minerals Management Service to assess the manner and degree with which disturbance may affect walruses in sea ice and open sea habitats. The study will focus on the effects of over-flying helicopters on the use of haulouts by walruses along the ice edge.

METHODS

TELEMETRY

The disturbance study will involve pre-treatment, treatment, and post-treatment observations on haulout patterns and movements of animals fitted with transmitters to assess the overall impact of the disturbance on individual walruses. The treatment will consist of exposing hauled-out animals to helicopter overflights. The study will require suitable methods for (1) capturing and handling live animals, and (2) satellite telemetry for determining at-sea movements of walruses. Testing of methods was initiated in summer 1995 at a haulout at Cape Peirce, in the Bristol Bay area.

Animal capture and handling

Handling walruses to attach satellite transmitters and collect biological samples requires that they be immobilized for an adequate period of time. A variety of immobilizing drugs have been used in the past (Gales 1989), including ketamine (Hagenback et al. 1975), phencyclidine

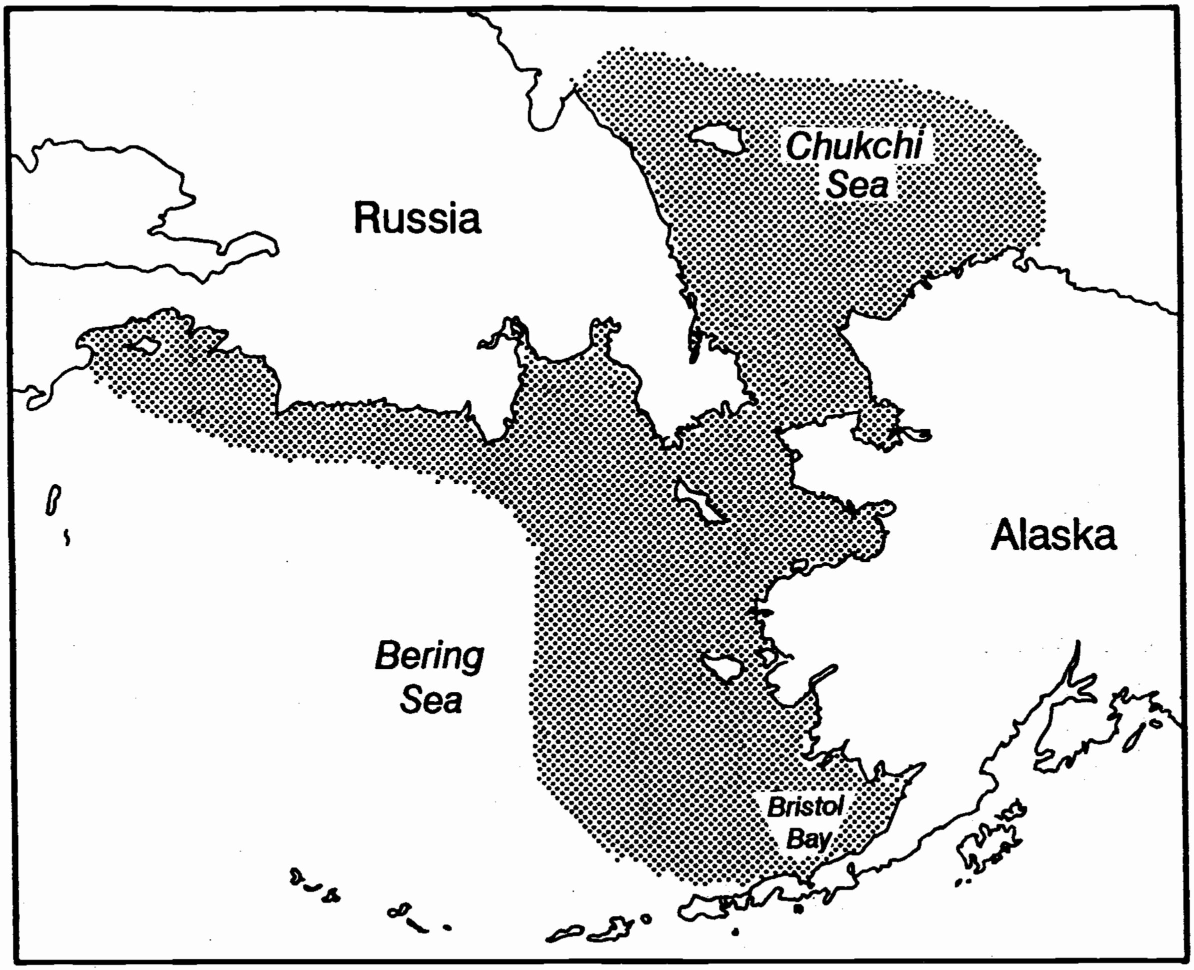

Figure 1. Range of Pacific walrus (from Fay 1982).

(Sernalyn®, DeMaster et al. 1981), etorphine (Hills 1992, Griffiths et al. 1993), Telazol® (Stirling and Sjare 1988, Griffiths et al. 1993), and carfentanil (Hills 1992). In our 1995 field efforts, we used carfentanil, because it has a relatively rapid induction time and requires a small volume for delivery. Furthermore, the recent availability of an improved antagonist, naltrexone, greatly reduces the chance of renarcotization, which was thought to be a problem associated with carfentanil in the past (Hills 1992). To extend the period of immobilization, we intubated and anesthetized the animal with isoflurane gas. A similar procedure has been used successfully on Steller sea lions (pers. comm. D. Calkins, Alaska Department of Fish & Game). This has the advantages of a more controlled level of anesthesia, longer duration, and resolution of tachycardia and hypertension due to the induction drugs, as seen with other large animals, such as elephants (Dunlop et al. 1994).

Transmitters

Both VHF radio transmitters and satellite-linked radio transmitters (Platform Transmitter Terminals, PTTs) have been used for monitoring walruses. Time-depth recorders (TDRs) have been used to obtain diving patterns of Atlantic walruses (Stewart et al. 1993, Wiig et al. 1993).

Various configurations of PTT housing, antenna design, and transmitter attachment have been tried. The preferred site of attachment has been on the tusk (Hills 1992, Stewart et al. 1993, Wiig et al. 1993); however, devices that are attached to the tusk are severely battered. Causes of PTT failures are unknown, because failed units have not been retrieved and are rarely seen in the field. It is speculated that failures are due to housing breakage or leakage, antenna deformation, or insufficient attachment to the tusk (Hills 1992, Stewart et al. 1993).

In 1995, we attached PTTs (three different designs) to the tusk of eight male walruses. Five of the transmitters were designed to collect dive information in addition to locations. In an effort to monitor the physical status of the PTTs, we attached a VHF radio transmitter to the opposite tusk of each walrus to aid in daily efforts to resight the animals at Cape Peirce haulouts.

Alternative transmitter attachments, such as subcutaneous implantation, may alleviate problems experienced with tusk-mounted transmitters. Subcutaneous transmitters or transmitters with subcutaneous anchors have been used in birds and small mammals (Korschgen et al. 1984). A dacron pile collar used in human patients for maintenance of long-term indwelling catheters (von Recum and Park 1981, Khanna 1990) has been adapted to fix percutaneous antennas to the skin and form a seal to prevent subsequent infection, and has resulted in successful use of such antennas in birds (Petersen et al. 1995). The use of subcutaneous transmitters on walruses is being investigated; the development of isoflurane anesthesia will enable the necessary surgery.

The development of PTTs using GPS for obtaining accurate and precise location information would enhance our ability to determine local movement patterns of walrus associated with sea ice and land-based haulouts. Uncertainty exists concerning the size of the transmitter package, attachments, and the ability to obtain locations using the GPS/PTT interface while the animal is at sea. Our research will evaluate the feasibility of the GPS satellite-linked technology for future use in studies of walrus in sea ice habitats.

OTHER PERTINENT RESEARCH ACTIVITIES

Measures of animal condition

Methods of determining animal condition from an evaluation of blood or other tissue components and various body measurements are being investigated in search of alternative means of assessing population status. Potentially, some of these methods may be incorporated at a later date into disturbance studies where measures of individual condition and physiological stress may be informative. Areas of investigation include hematology and serum chemistry, and extent and distribution of body fat.

GIS data base

U.S. and Russian scientists conducted periodic surveys of walruses in the Bering and Chukchi seas from 1958-1990, which include aerial counts of walruses on sea ice in the Russian and U.S. sectors, aerial and photographic counts of walruses at Russian land haulouts, and ground and aerial counts of walruses at U.S. land haulouts (Estes and Gilbert 1978, Estes and Gol'tsev 1984). Most of the information from U.S. surveys is accessible only through agency reports (e.g., Buckley 1958, Kenyon 1960, 1961, 1968, 1972). Data from early Soviet surveys were published in the Russian language (e.g., Fedoseev 1962, 1981, Gol'tsev 1968, 1972, 1976) and may be difficult for many researchers to obtain and use. These data, together with oceanographic data on the Bering and Chukchi seas such as bathymetry, sea ice distribution, surficial substrate, and the spatial distribution of selected benthic organisms, will be incorporated into a GIS data base so that they can be accessed by researchers addressing habitat and marine mammal relationships.

SUMMARY OF 1995 FIELD EFFORTS

During 1995 summer field efforts at Cape Peirce, capturing and handling techniques were tested on seventeen adult male walruses, and satellite transmitters were attached to eight animals. Biological samples and measurements were collected from each animal to investigate methods of evaluating animal condition. The immobilizing drug carfentanil and its antagonist naltrexone worked well on most animals. Procedures for holding the animal after initial immobilization were refined. We anticipate that the procedures will provide the necessary restraint for the implantation of subcutaneous transmitters in future work. The success of tusk-mounted transmitters will be evaluated upon completion of haulout monitoring in fall 1995.

Preliminary dive information from a single walrus indicates that the animal was spending an average of 50% of its time diving, which occurred in waters 30-45 m deep near the Cape Peirce haulout, and that dives lasted for 7-8 minutes. Dive information from this and other animals will be used to help identify feeding areas.

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QUESTIONS AND DISCUSSION

Anne Dalley: I was just wondering, with this thing strapped onto the tusk of the walrus, did it impede their ability to gather food?

Chadwick Jay: No one really knows. We do mount the transmitter over to the side of the tusk. When the walrus feeds, it feeds with its face right down and the tusks dragging along the substrate. The transmitter is attached to the side of the tusk.

Anne Dalley: Would the transmitter eventually come off if they are strapped on with metal bindings and epoxy?

Chadwick Jay: It is meant to be a permanent attachment. Now how long they last, again, we don't know because they are seldom resighted. That is the kind of information that we would like to know though for future development.

Bruce Mate: What has been the longest distances and durations of satellite tags that you had?

Chadwick Jay: In earlier work by NBS, well then USFWS, I believe the longest transmitter lasted for about 265 days, but that was an outlier. Most of them lasted in the order of two to three months. In previous work, a few animals have been tracked moving between the Chukchi and Bering seas.

USING IMPLANTED SATELLITE TRANSMITTERS TO TRACK THE MOVEMENTS OF MURRES AND PUFFINS

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To track the movements of breeding Common and Thick-billed murres and Tufted puffins, we surgically implanted 35-gram satellite transmitters at three field locations in Alaska (Barren Islands, Cape Lisburne, and Cape Thompson). Implantation disrupted most breeding attempts of murres at the Barren Islands. Birds stayed out at sea, primarily foraging south to Kodiak Island at distances of 40 to 100 km from the release site. Murres from capes Lisburne and Thompson foraged north and west into the Chukchi Sea. Individuals that retained breeding status in those colonies showed typical foraging ranges of 70 to 80 km. Locations of birds that ceased to commute averaged about 170 km from the colonies in the first month after release. First-month mortality was high for instrumented puffins (80%) and murres (60%) at the Barren Islands, moderate for murres at Cape Lisburne (50%), and low for murres at Cape Thompson (0%). The differences in mortality among study areas may reflect variable feeding conditions, although breeding success of murres was high (ca. 70 to 80%) at all three colonies in 1995.

QUESTIONS AND DISCUSSION

Bruce Mate: A lot of concerns have been expressed in the past about transcutaneous wounds on the animals. You have an antenna coming out of a bird from an internal transmitter. Have you recovered any animals so you can take a look at those sites and see how they deal with it? Or do you do something special with it?

Scott Hatch: With respect to the wounds we inflicted, that could be a factor. We lost three of our birds within two or three days post-release. Those we attribute to possible infection. It turns out, from what I understand from the veterinarians and various people I have talked to, a bird's immune system is better in this context than perhaps, pinnipeds and some other mammals that have been used, when you are doing implants. They have a lot of problems releasing pinnipeds after an operation like this, and they will get infections. It is a major factor. You have to have a much more sterile environment, perhaps, for doing this. Ours is clean, not sterile, surgery. The veterinarian we are working with feels this would be a low incidence thing at most. But we do have a few cases of mortality, soon enough after release, that that would be a likely scenario. But birds, as I said, seem to be little prone to that kind of a thing.

As far as recovering the birds, no we haven't done so. I don't believe there is any way we could home in on these transmitters. We do have some transmitters, even now, out there, apparently on beaches giving us the locations. It is useful, in one way, because we can look at the redundancy of those locations from fixed transmitters out in the field. We have a number of those. Unlike, maybe a VHF, where you go out with a directional antenna and have some prayer of actually locating the dead animals, we don't have that ability here. Maybe we could design something in the future to recover the dead birds. That would certainly be the way you would like to do it — have a look and do the autopsy.

Brenda Ballachey: You might mention the harlequin ducks...

Scott Hatch: If I knew much about it I would. I haven't had a chance to talk to Dan Esler about his work. May be you can help us there.

Brenda Ballachey: I am also working at the NBS and involved in a project where one of the other investigators put out 96 VHF implanted radios in Prince William Sound, a similar unit to what Scott uses but VHF rather than the satellite. Those have a mortality switch in them. They are also trying to recover carcasses wherever they can. The surgery seemed to be very successful on those because 89 of them are still on the air and they were put out in August. So, in that case, there seems to be very little surgically-related mortality. But I think your question breaks down into two parts, one is the surgery itself and second, the percutaneous antenna, subsequently as a source of infection. I think, generally, once it seems to be established, you are finding that it is pretty good. They did do some work on ducks in captivity, I believe, to test the methods. But on the walrus, where we are considering the percutaneous antenna, we are far more concerned because with the animal on a haul out where they are rolling, presumably, there is much more chance of infection getting in through that collar than on a bird where they are not rolling against each other in a mucky place.

POPULATION STUDIES OF MURRES AND KITTIWAKES AT CAPE LISBURNE AND CAPE THOMPSON

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Although Cape Lisburne and Cape Thompson are not in the central Beaufort area, I was asked to come and give a short presentation on these seabird colonies to update you on what we have been doing in the Chukchi Sea during the past 20 years. I first started working at these sites in 1976 with Dr. Alan M. Springer, Institute of Marine Sciences University of Alaska-Fairbanks (IMS-UAF), and thought I had made my last visits to them in 1991-1992. However, last year I was asked to return to both colonies to conduct additional studies during the 1995 nesting season.

Basically, I will be showing you some of the long-term data sets on murres *(Uria lomvia and U. aalge)* and black-legged kittiwakes *(Rissa tridactyla)* that we have accumulated from these Chukchi Sea colonies, but first some historical perspective. Field work was initiated at both locations in 1976 under the National Oceanic and Atmospheric Administration's Outer Continental Shelf Environmental Assessment Program (NOAA-OCSEAP, Research Unit 460). These studies, later directed by the Minerals Management Service (MMS), ended in about 1983. However, the Alaska Maritime National Wildlife Refuge (AMNWR) supported continuing small-scale efforts at Cape Lisburne during 1984-1986. In 1987 and 1988, the MMS sponsored additional monitoring work at capes Lisburne and Thompson, respectively. MMS-supported monitoring studies were also conducted at Cape Thompson in 1990-1991, and at Cape Lisburne in 1992. In 1993, the Cape Lisburne colony was visited again with AMNWR support, and in 1995, we conducted larger scale studies at both locations with joint MMS and National Biological Service support.

Also, I should mention here that AMNWR has designated Cape Lisburne as an annual monitoring site under their seabird monitoring program. However, the Refuge rarely receives enough money to visit it every year without outside support. The Refuge has also designated Cape Thompson as a second-level seabird monitoring site, and as such, we try to conduct work there every three or four years. But again, to meet this goal, we usually have to rely on outside help for funding.

Since 1976, we have acquired a total of 14 years of data on murres and kittiwakes at Cape Lisburne, and nine field seasons of information on these species at Cape Thompson. Also, because seabird research was conducted at Cape Thompson during the Atomic Energy Commission Project Chariot days, we have some valuable 1959-1961 data on the birds from that colony. We are lucky enough to have access to this historical information because Dr. L.G. Swartz, the principal investigator of the AEC-sponsored study, was both Dr. Springer's and my major professor at UAF during the early 1970s, and he turned his field notes over to us shortly before he retired.

Earlier today, you heard about a spring lead system that is important to a variety of birds and marine mammals in the Chukchi Sea. I would like to point out that there is another system that develops in the region during the summer months that is also important to seabirds and a variety of other wildlife. There is a strong current that flows northward through the Bering Strait and part of this flow passes by capes Thompson and Lisburne and eventually rounds Point Barrow. This northward flow of water persists most of the year, and during summer, it carries a rich drifting boreal pelagic food web past the colonies.

During spring and early summer, the Cape Thompson and Cape Lisburne regions are dominated by an Arctic benthic and demersal food web consisting primarily of Arctic cod *(Boreogadus saida)*, sculpins (primarily *Myoxocephalus* spp.), and flatfishes (primarily Pleuronectidae). However, by about mid-summer, a pelagic food web containing sand lance *(Ammodytes hexapterus)* and capelin *(Mallotus villosus)* begins to develop as the northward current flow begins to bring a variety of zooplankton endemic to the Bering Sea into the region, particularly large numbers of copepods (including *Eucalanus*, *Calanus*, and *Acartia* spp.). Usually, by about late July, we begin to see the effects of this rich, developing food web on seabird foraging patterns and diets at the Thompson and Lisburne colonies.

In addition to the northward current flow, another factor plays a key role in the late summer shift from an Arctic benthic/demersal food web to a pelagic food web in the Cape Thompson and Cape Lisburne regions of the eastern Chukchi Sea. During late spring and early summer a large relatively warm low salinity water mass begins developing in the eastern Bering Sea. This feature, named the Alaska Coastal Water mass, consists of a mixture of Bering Sea parent water, melting sea ice, and outflow from the Yukon-Kuskokwim Delta. During about mid- to late July, this water mass, which can easily be seen on satellite imagery, begins to reach the Thompson and Lisburne regions. By late summer in some years, it rounds Point Barrow, and in others it begins to dissipate in the Icy Cape region. This warm low salinity coastal water strongly influences both the diversity and richness of the developing pelagic food web that is carried past the seabird colonies by the prevailing northward current flow.

The effects of the Alaska Coastal Water mass can be dramatic. Often, nearshore temperatures in the Cape Thompson and Cape Lisburne regions rise by as much as 10° C and salinity declines by several parts per thousand in only 7-10 days time. These changes appear to strongly influence the availability of sand lance, one of the primary forage fish the seabirds rely on. In general, these fish usually begin to appear in nearshore surface waters near the colonies at about the time kittiwake chicks begin to hatch. However, if development of the Alaska Coastal Water mass is poor and nearshore waters remain cold, strong inshore runs of 0+ and 1+ age class sand lance either fail to materialize or are delayed, and surface-feeding kittiwakes fledge few nestlings. Conversely, in years when development of Alaska Coastal Water is good and nearshore temperatures warm sufficiently, large schools of sand lance appear in the surface waters and kittiwake productivity improves markedly (productivity in cold and warm water years can vary from almost zero to more than one chick per pair). I should also mention that we have some evidence suggesting that water temperatures can become too warm. In 1984, when temperatures were the highest we have recorded, few sand lance appeared and kittiwakes failed reproductively.

As a general rule, annual changes in summer water temperatures and the productivity of kittiwakes tend to be similar at the Thompson and Lisburne colonies. However, in 1995 we observed a marked difference in kittiwake productivity between these locations. At Cape Lisburne, where large schools of sand lance appeared before kittiwake eggs hatched and persisted throughout most of nestling period, productivity was relatively good, about 0.8 chicks per nest. In contrast at Cape Thompson, kittiwakes laid eggs, but reproductive success was essentially zero, because most pairs abandoned their nests shortly after hatching began. The near-complete failure of kittiwakes at Cape Thompson appeared to result from a severe mid-season shortage of prey in surface waters. Although sand lance were clearly present in the Thompson region, as indicated by murres bringing them to chicks and the high overall productivity of these diving birds (about 0.85 fledglings per egg, a level nearly identical to that recorded at Cape Lisburne), they were apparently not available to surface-feeding kittiwakes. We will be reviewing satellite imagery to see if differences in sea surface temperatures can help explain the differences in distribution and availability of this key forage fish species at the colonies.

Now I'd like to show you examples of some of the long-term data sets we have obtained at the Lisburne and Thompson colonies over the years. This graph shows counts of murres on a series of monitoring plots that we census from boats at Cape Lisburne (Figure 1). Because weather and sea conditions are often unfavorable, these are single counts (one per season) without any measure of variability. Although we were able to obtain two counts this year, it is the first time we've been able to accomplish that since the studies began in 1976. As you can see from the graph, these counts show a significant positive trend in numbers of birds. We believe this trend is real for several reasons. First, it is based on nine years of data collected over a 20-year interval. Also, it is supported by several other sets of data.

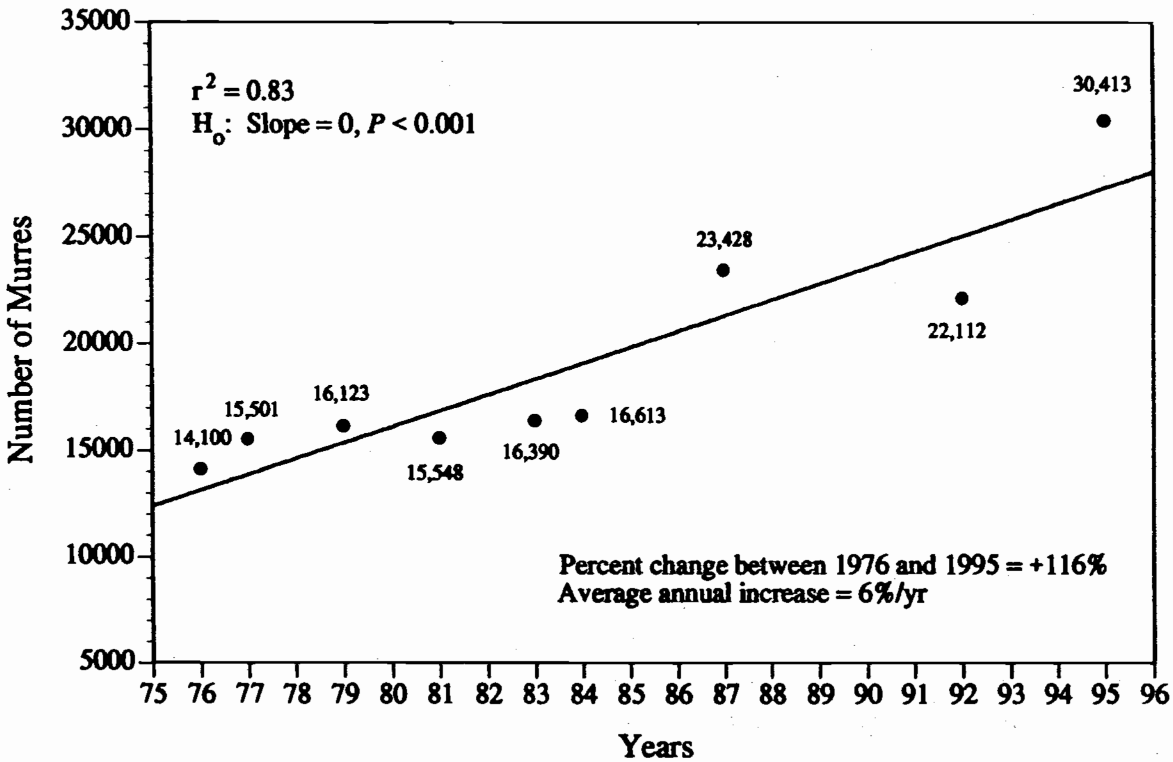

Figure 1. Trend in number of murres on boat plots 11, 12, 25, 26, 30, 32, 65, 66, 70, and 72 at Cape Lisburne, Alaska between 1976 and 1995 (counts are single counts without any measures of variability).

We now have several different sets of plots that we count at the Lisburne and Thompson colonies, and this is an approach that I am using at other colonies. For example, we are currently censusing several plot sets in the Barren Islands where I've been conducting a murre monitoring project for the *Exxon Valdez* Oil Spill Trustee Council since 1993. Basically, when you attempt to count a whole colony or a large section of it, you are rarely able to count it more than once or twice during the correct time of year and day because of logistics and weather. Since daily variation in attendance of murres tends to be fairly high (e.g., in the order of plus or minus 20%), you have to count the colony at least five times during the census period to get a reasonable measure of variability. However, when dealing with large colonies or sections of them such as these historical boat-based Lisburne plots, you are usually limited to only one or two counts that give no measurement of that variable. Because of this, we set up a series of smaller plots that we use to statistically track population trends. These plots, which we call multicount plots, are counted at least five and preferably ten times during the census period to provide measures of variability (the census period is defined as the interval between peak egg-laying and first sea-going of chicks).

Here is a graph showing replicate counts made on a set of seven land-based multicount plots that we set up at Cape Lisburne in 1987 (Figure 2). As you can see, there is a highly significant positive trend in murre numbers on these plots which supports the trend found on the larger set of boat-based plots that were only counted once each year. We also have a second set of multicount plots that we have been censusing since 1992. Although only three years of data

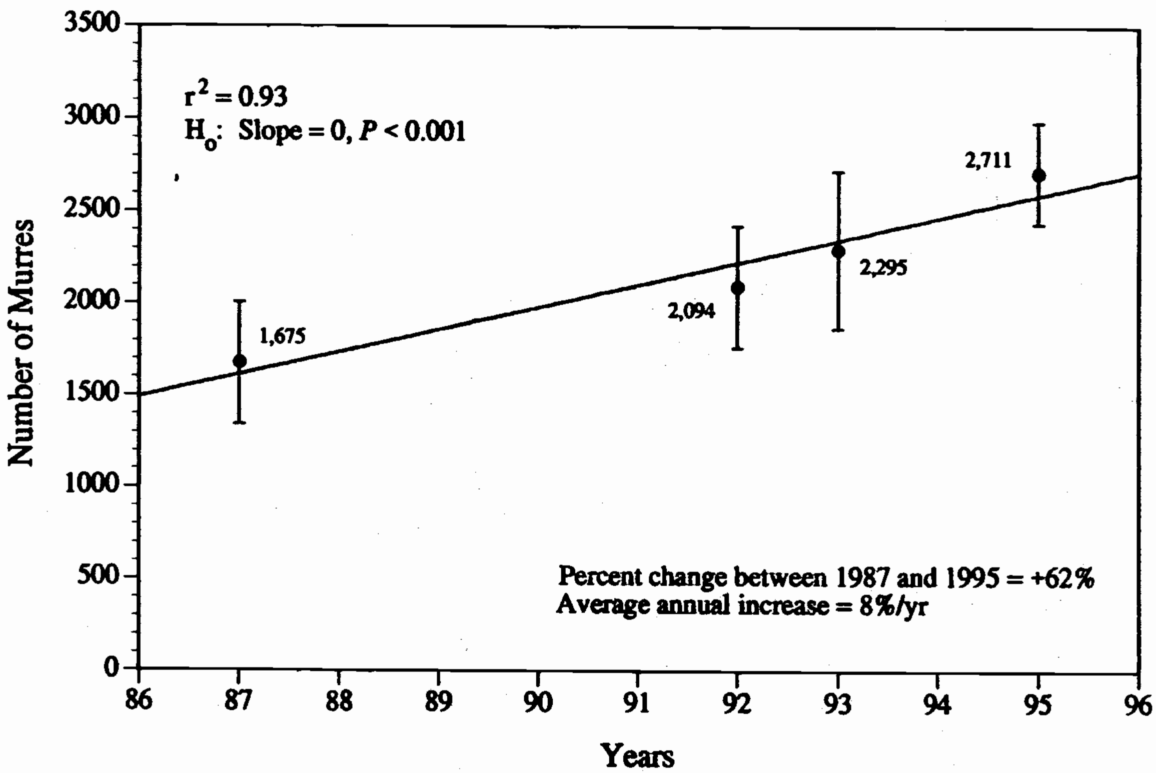

Figure 2. Trend in number of murres on land plots 1-7 at Cape Lisburne, Alaska between 1987 and 1995 (counts are multiple counts with measures of variability: 1987, n=8; 1992, n=9; 1993, n=5; 1995, n=10).

are available from it, it shows the same pattern. This year, we started another level of counts on two sets of smaller plots that we established to obtain data on productivity. As a result, in about four to five years we'll actually have five separate sets of data that can be used to track changes in murre population numbers at the colony. Using several different sets of census plots to track bird numbers at colonies is a valuable tool. When we see the same patterns emerge from the various data sets, it increases our confidence in the results. Because patterns are similar on the boat-based census and multicount plots at Cape Lisburne, we believe that there has indeed been a significant increase in murre numbers at the colony since the early 1980s. Also, using several plot sets provides an important measure of flexibility when conducting long-term monitoring programs at seabird colonies because weather and sea conditions, logistical problems, and changes in funding levels may prevent counting some sets of plots in some years (i.e., multiple sets of plots help ensure that at least some level of comparative information is obtained over the life of the project, despite these variables).

Here is another graph to quickly show you what the kittiwake population has been doing at the Cape Lisburne colony over the years (Figure 3). We actually make two kinds of kittiwake counts. This graph happens to show numbers of birds. However, we also count nests. Nests tend to be the more stable of the two, because birds tend to respond fairly rapidly to local changes in environmental conditions. As you can see, there is no overall trend in numbers. However, interestingly enough, we noticed that there was a positive trend between 1977 and 1986. Not a

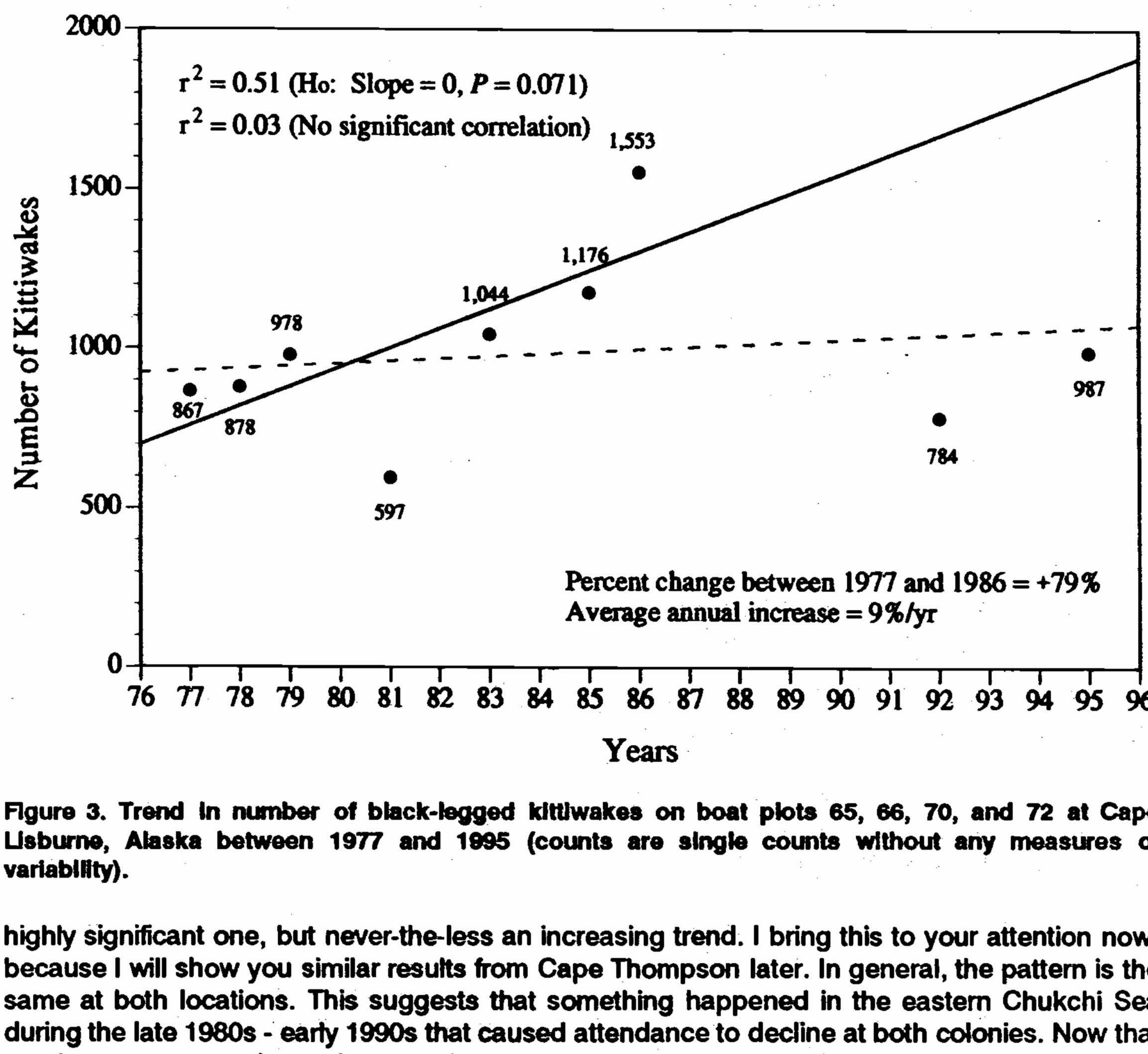

Figure 3. Trend in number of black-legged kittiwakes on boat plots 65, 66, 70, and 72 at Cape Lisburne, Alaska between 1977 and 1995 (counts are single counts without any measures of variability).

highly significant one, but never-the-less an increasing trend. I bring this to your attention now, because I will show you similar results from Cape Thompson later. In general, the pattern is the same at both locations. This suggests that something happened in the eastern Chukchi Sea during the late 1980s - early 1990s that caused attendance to decline at both colonies. Now that numbers appear to have decreased, we will follow the situation to see if it develops into a negative trend.

This graph shows our long-term data set on kittiwake productivity at the Cape Lisburne colony (Figure 4). It helps illustrate the high degree of variability typically found in kittiwake breeding success at Alaskan colonies. Note the low productivity in 1976—sea surface temperatures were quite cold and availability of food was poor during the nesting season that year. Also note 1984—the birds also essentially failed to reproduce that year. Again food was the limiting factor, but its low availability (lack of shoaling sand lance in surface waters) appeared to result from relatively high nearshore water temperatures. Nineteen eighty-four was by far the warmest of all the years shown on this graph. After 1984, sea surface temperatures dropped

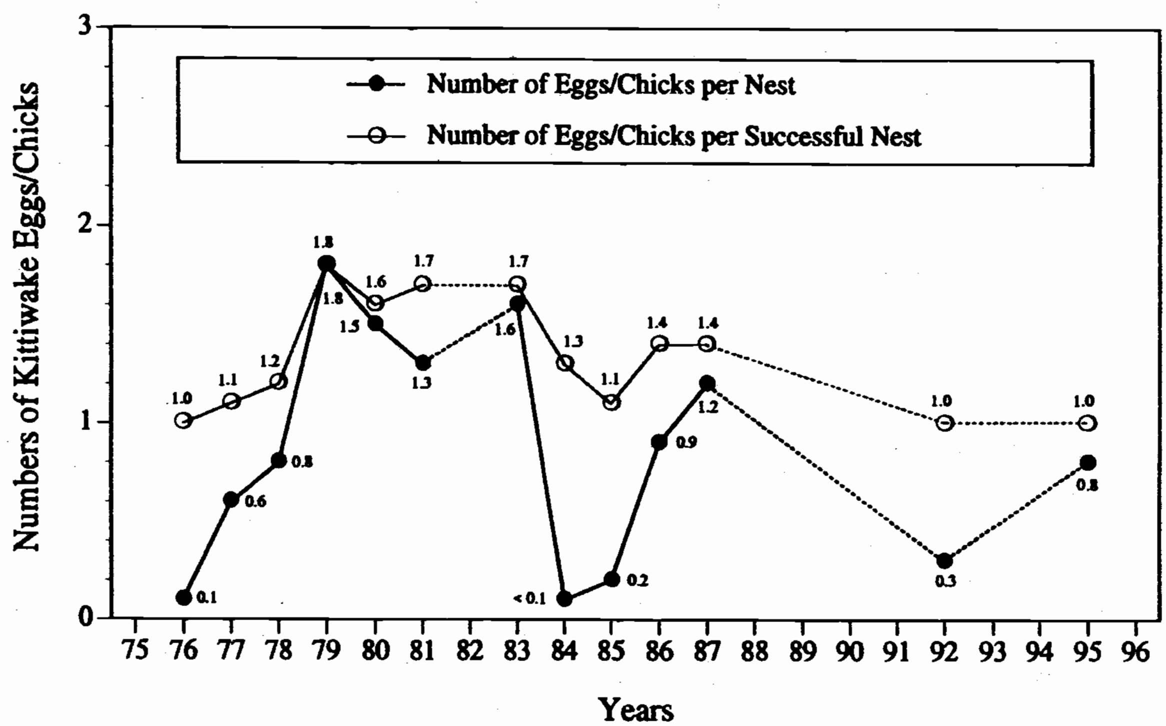

Figure 4. Productivity of black-legged kittiwakes at Cape Lisburne, Alaska between 1976 and 1995.

somewhat and productivity rose. I should mention that 1992 was somewhat of an anomalous year. Water temperatures were indeed cooler, compared to the mid-1980s, but productivity was also lowered by cold late summer air temperatures and snowfalls that killed chicks. In 1995, sea surface temperatures were slightly higher on average during late summer and air temperatures were unseasonably mild, compared with 1992, and reproductive success improved.

I should mention that we have other types of data from the Lisburne colony. Some of these data sets appear to be tightly coupled with some of the environmental information we've been collecting, and this is exciting because it is beginning to help us understand how the eastern Chukchi system works.

I initially started to explore relationships between seabirds and changing environmental conditions with Dr. Alan Springer, a partner of mine at the Institute of Marine Sciences UAF, and Dr. Edward Murphy, who is now a professor at the Institute of Arctic Biology UAF. All of us are continuing to work together on this subject to this day. In fact, Ed will be sending me some information from Bluff in Norton Sound next week because he has observed some of the same changes that we are starting to detect at Cape Thompson. So it's starting to become quite interesting, because these types of long-term data sets are now allowing us to make progress toward understanding the system.

Now, I'd like to show you some information from Cape Thompson, another large murre and kittiwake colony located only about 50 miles south of Cape Lisburne. In general, murre numbers appear to have undergone little change there since the mid-1970s. This graph, showing single counts at Colony 4, does not include Swartz's 1959-1961 information (Figure 5). If these

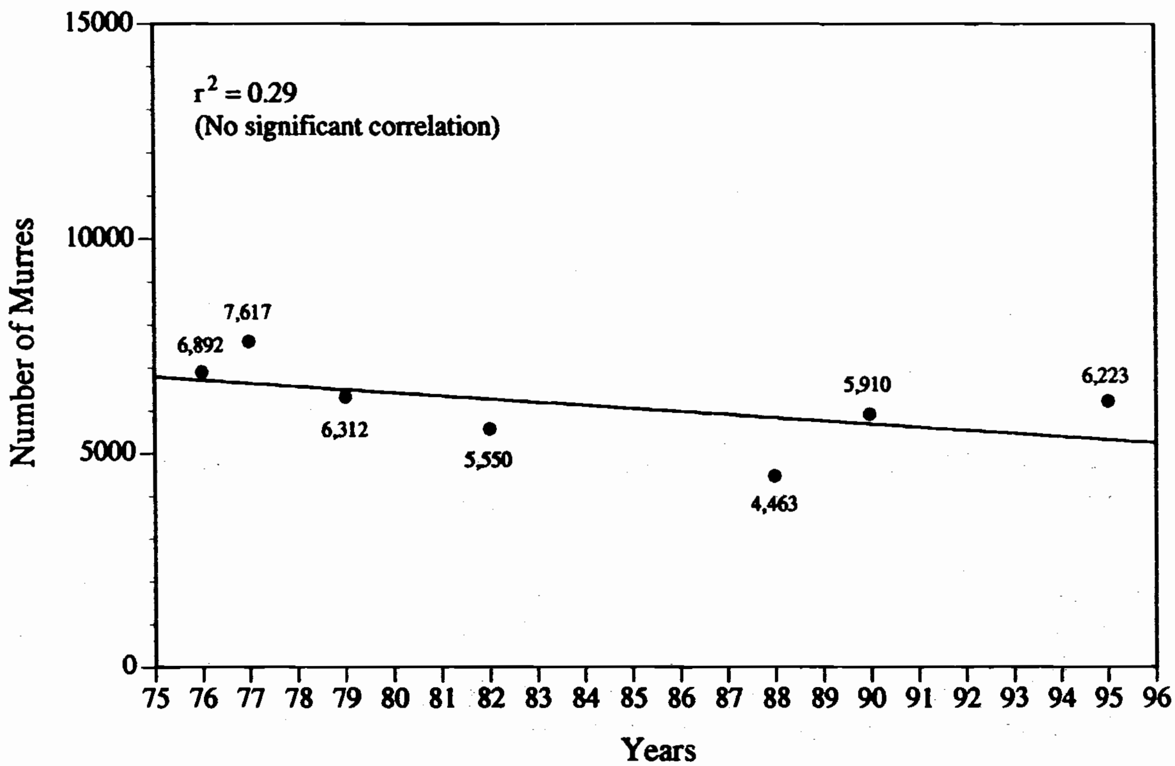

Figure 5. Trend in number of murres at Colony 4, Cape Thompson, Alaska between 1976 and 1995 (counts are single counts without any measures of variability).

data were included in some of the data sets, they would show that a population decline occurred between the early 1960s and the mid-1970s. Based on the 1976-1995 data, we believe that numbers may be starting to recover.

This graph shows data from set of murre plots established by Swartz in the late 1950s-early 1960s that we continue to track today (Figure 6). The counts shown here are multiple counts with measures of variability. Error bars are not present because these data are still being analyzed; however, I know what they basically are. I am only showing you the information from the late 1970s - mid-1990s. As you can see, there has been no significant trend in murre numbers during this interval on these plots—it's basically a flat line. However, this next graph shows data collected on another set of plots that were set up 1988 (Figure 7). These data do show a weak positive trend.

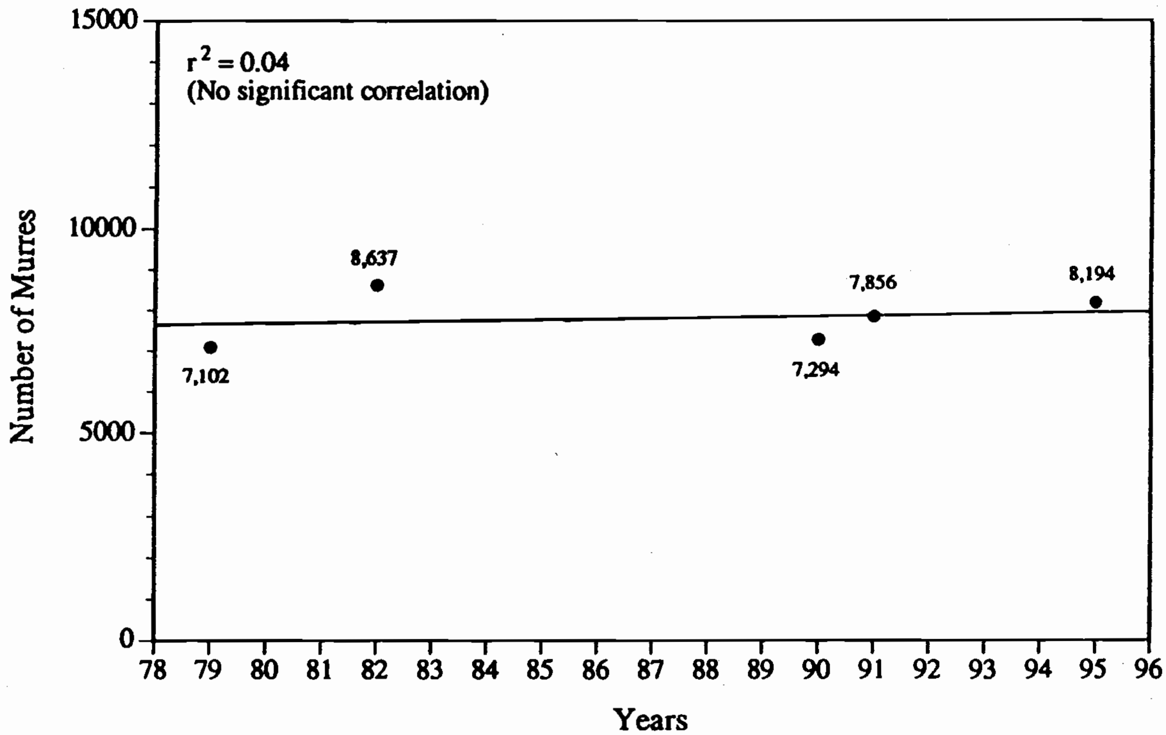

Figure 6. Trend in number of murres on seven LGS land plots at Cape Thompson, Alaska between 1979 and 1995 (counts are multiple counts with measures of variability).

These latter data are hardly compelling by themselves. However, we have some other information that suggests the Cape Thompson murre population may be beginning to change. We have noticed over the years that at colonies (e.g., the Barren Islands) with populations that have little depth to them (e.g., age structures skewed toward older adults), numbers of birds on the cliffs begin declining rapidly as soon as chicks begin leaving and going to sea. The adults go to sea with the chicks and the nesting cliffs become bare in only about 10-14 days time.

In contrast at Cape Lisburne, we obviously have a large floating population of subadults that will soon be entering the breeding population. At this colony, numbers begin to increase on the plots about a week before chicks start to leave. This year, after sea-going started, numbers on some plots increased dramatically—in some cases doubling over about two weeks time. The late-season increase persisted for about two weeks and then numbers finally began declining as the last chicks started to depart the cliffs. This increase in numbers clearly results from an influx of prospecting subadults. When we watch sections of plots carefully, we see new birds show up that begin to hang out on the edges of the occupied breeding territories and territorial disputes increase. We also see that when members of breeding pairs leave the nesting ledges with their chicks, some of these new birds quickly move into the vacant nesting sites—sometimes as many as three or four individuals. These birds spend most of their time checking the nesting habitat out. The presence of these large numbers of prospecting birds indicates that there is a large, healthy pool of non-breeders out there that are waiting to be recruited into the breeding population.

We've started to notice a similar late season increase in murre numbers at Cape Thompson, and Dr. Murphy also noted this for the first time at Bluff this year. Ed now has numbers increasing on plots at the end of the census period. As a result, we predict that within

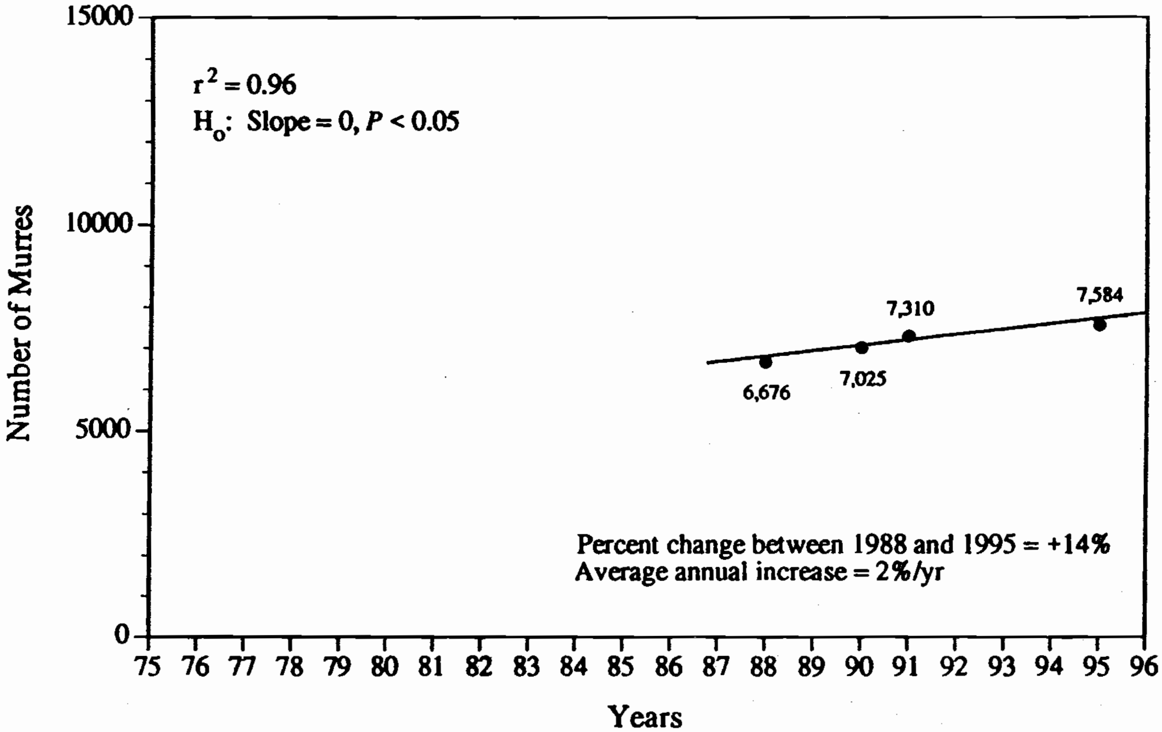

Figure 7. Trend in number of murres on 20 BSF land plots at Cape Thompson, Alaska between 1988 and 1995 (counts are multiple counts with measures of variability).

a few years' time we're going to find increasing trends at both colonies (populations of murres have remained low at both locations since at least the mid-1970s).

Here is the last graph I have that shows some of the data on kittiwake numbers at Cape Thompson (Figure 8). Just as we saw in the Cape Lisburne data set, no trend is apparent in population numbers over the 20-year long 1976-1995 period. However, a significant positive trend is present between 1976 and 1990. As I mentioned earlier, this pattern is similar to the pattern we found in the 1976-1987 portion of the Cape Lisburne data set. It appears, based on information from both locations, that kittiwakes were increasing at the colonies until about the late 1980s. Again, these complimentary data sets suggest that something may have occurred in the eastern Chukchi Sea in the early 1990s that caused kittiwake attendance to decline at the colonies. In both cases, we will make an effort to track kittiwake numbers over the next few years to see if this apparent change is real. We will also review available environmental data to see if we can pinpoint any specific conditions that may have contributed to this apparent change in attendance at the colonies.

In conclusion, I would like to leave you with the message that the types of long-term data sets I have shown you are now starting to pay off. We are in the process of developing a much better understanding of how these seabirds respond to changing environmental parameters. There is no doubt that these types of long-term information bases have great value, and we would like to thank NOAA and the MMS for the support they have given us over the years that has allowed us to continue collecting these kinds of data.

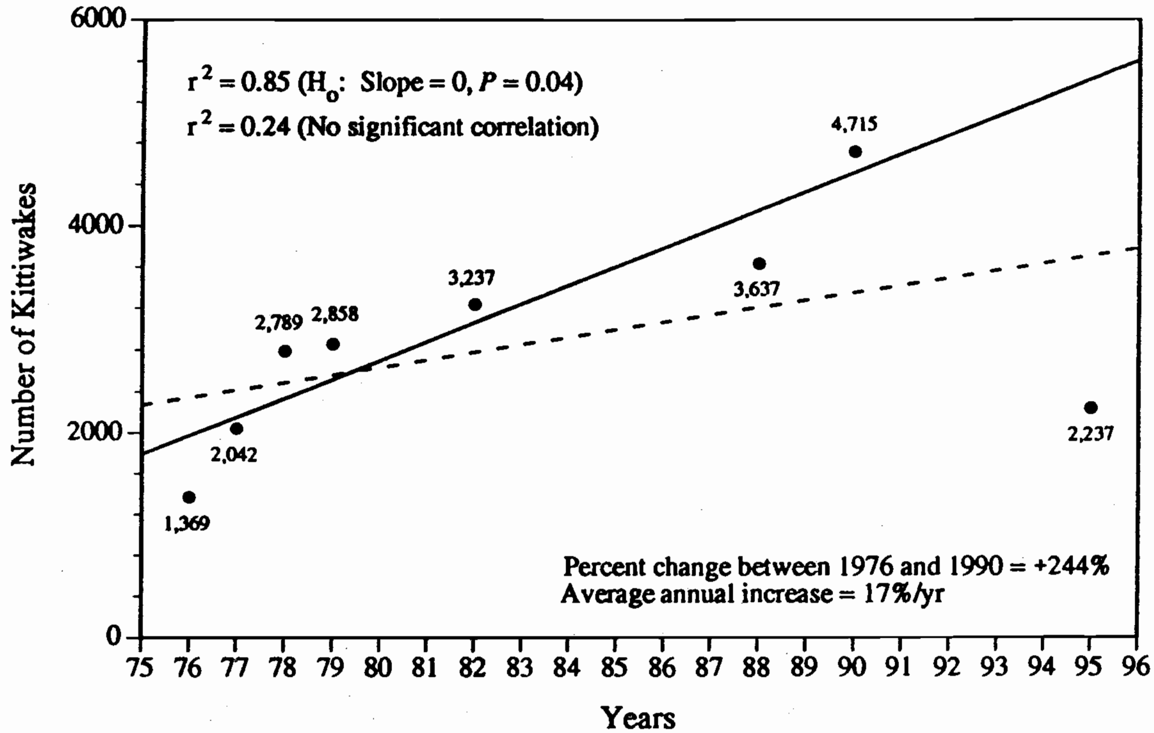

Figure 8. Trend in number of black-legged kittiwakes at Colony 4, Cape Thompson, Alaska between 1976 and 1995 (counts are single counts without any measures of variability).

QUESTIONS AND DISCUSSION

David Rugh: You spoke about some of the variabilities in the environmental conditions in the timing of birds leaving. Have you ever tested inter-observer counts? That is, you've been a common factor for about 20 years. Would someone else make an identical count to yours?

David Roseneau: Basically, yes. First of all, I can say that we've been lucky enough at Cape Lisburne to have one of the original investigators present almost every year. Either Alan Springer or myself in most cases. When the Fish and Wildlife Service became involved, Art Sowls and Vern Byrd also began counting the birds. They've been there a number of years with either Alan or myself, so they're now well-trained members of the census team. Basically we have somebody present every year who has a number of years of experience at the colony.

But to answer your question, yes, we've looked at differences in observers' counts. We did that back in the 1970s. We've looked at differences between observers, various types of individual observer error, the kinds of errors that can be introduced when making these types of counts, and basically, these kinds of errors do not appear to have large impacts on results. In general, given such factors as daily variation in bird numbers, these types of errors tend to only play minor parts.

However, I should mention that we have encountered people that apparently can't count birds. We have to be careful in this regard. Most people tend to estimate numbers a little low, usually about 15 percent, at least in my case. This does not create much of problem, compared to the potential problem of being inconsistent between counts. We've occasionally run across people that make both high and low estimates that vary by 50 percent or more, and we cannot use these individuals because of the large amount of error they would introduce into the data.

In general, natural variation in daily and hourly murre numbers is large enough to swamp the smaller kinds of errors that may be introduced by observers, including observers newly added to censusing teams. Also, new observers' abilities to estimate numbers of birds are tested in the sense that they are required to practice counting plots with experienced personnel. The amount of error that observers introduce into the counts is a relatively small portion of the whole and it's almost always overshadowed by natural variations in numbers. Observer error is something we have to be aware of, but controlling the introduction of significant errors is relatively easy to deal with.

UNIVERSITY OF ALASKA COASTAL MARINE INSTITUTE SPONSORED STUDIES IN THE ARCTIC OCS

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Fairbanks, AK 99701

OVERVIEW

A Cooperative Research Opportunity

The University of Alaska Fairbanks (UAF), the State of Alaska, and the Minerals Management Service (MMS) have joined forces to establish an Alaskan Coastal Marine Institute (CMI) at UAF as a means of providing MMS funding for research in Alaska that is of mutual interest to both the MMS and the State of Alaska. The research thrust of the Coastal Marine Institute is on potential coastal, marine, and human environmental issues pertaining to minerals exploration and extraction. Funding offered by MMS through the CMI is matched 1:1 by non-federal support. This arrangement provides a cooperative and cost effective means of funding research needed by the state and federal governments.

BACKGROUND

Minerals Management Service is the federal agency tasked to investigate the potential impacts of oil and gas (and other minerals) exploration and production in coastal and offshore U.S. waters (U.S. Economic Zone). In an attempt to stretch their resources, MMS has joined with the State of Alaska and the University of Alaska to focus research in those areas of shared interest. The vehicle for joining forces is the University of Alaska Coastal Marine Institute. Funds of up to one million dollars per year are made available to the Alaskan CMI through fiscal year 1997. There is no limit set on dollar amount for each project, but the intent of the CMI is to fund several smaller as opposed to fewer larger projects. A similar CMI is operating in Louisiana as a joint venture between MMS and Louisiana State University.

The Alaskan CMI is administered at UAF under the School of Fisheries and Ocean Sciences as a special project under the Dean's office. Direction for the CMI is provided by a Technical Steering Committee of six. It is composed of two members from MMS, two members from the UAF marine research community, and two members from the State of Alaska. MMS members are Dr. Cleve Cowles from Anchorage and Ken Turgeon from MMS headquarters in Herndon, VA. The two UAF members are Dr. Vera Alexander (as Director of the Institute) and Dr. John Goering. The two State members are Diane Mayer, Director, Division of Governmental Coordination and Gordon Kruse, Division of Commercial Fisheries Management and Development, Alaska Dept. of Fish and Game.

The CMI annually develops a request for Letter of Intent (LOI) based on the mutually shared research interests of MMS and the State as stated in a series of Framework Issues. Projects funded through CMI provide information which can be used by the MMS and the State for management decisions specifically relevant to the MMS mission. That is, projects are pertinent to either the OCS oil and gas program or the marine minerals mining program and provide useful information for one of the phases of program management, or for the scientific understanding of the potential environmental effects of these resource development activities in the arctic and subarctic environments. Additionally, projects are frequently designed to foster the training of researchers in relevant fields of study, especially through the award of graduate student assistantships or traineeships. Projects may be proposed by graduate students through the sponsorship of a faculty member. Projects can involve workshops to foster the continuing education and training of the academic and regulatory communities as well as MMS staff.

FRAMEWORK ISSUES GUIDING THE CMI

Projects funded by the CMI generally embrace one or more of the following Framework Issues which have been identified by the Technical Steering Committee to guide the selection process:

1. Studies for better understanding the affected marine, coastal, or human environment;
2. Modeling studies of environmental, social, and economic processes for better predictive capabilities and for defining information needs;
3. Experimental studies for better understanding of environmental processes, or the causes and effects of OCS activities;
4. Projects which design or establish mechanisms or protocols for the sharing of data or information regarding marine or coastal resource or human activities to support prudent management of oil and gas and marine minerals resources.
5. Synthesis studies of background information; and
6. Descriptive studies of offshore mining technologies.

THE CMI PROPOSAL CYCLE

Requests for Letter of Intent (LOI) are made in September and, based upon the Technical Steering Committee's evaluations of the LOI, full proposals are requested in early November for selected projects. Final review (internal and/or external) and potential acceptance of a project occurs the following February. Funding for selected projects is generally available in March-April.

RESEARCH PRODUCTS

The CMI-funded projects provide a variety of products, including a contribution to an annual CMI report detailing work in progress, and a detailed final report at the culmination of the work. In addition, investigators are strongly encouraged to publish their findings in peer reviewed journals and to present their work at symposia and to the lay public when appropriate. Data collected on CMI-funded projects are forwarded to the National Ocean Data Center, or to other appropriate repositories so they become available to other researchers and to the public.

The CMI has initiated three projects which are addressing biological information needs relative to the Arctic Coastal Ecosystem. These include:

North Slope Amphidromy Assessment - Natural stable isotope abundances measured in tissues of Alaska North Slope coregonine fishes are being shown to reflect differences in feeding habitat relative to size and age. This methodology is being developed so that it may be used as a tool for proxy analysis of fish behavior in future North Slope environmental monitoring studies. Development of the methodology consists of sampling Arctic and least ciscos, broad whitefish, Dolly Varden, and representative non-commercial fish and forage species through collaboration with existing sampling programs being conducted by the North Slope Borough's Department of Wildlife Management and BP Exploration through contracts to LGL, Ltd. Intensive sampling at a limited number of sites is enabling an analysis of population structure using natural stable isotope abundance.

Initial results of the first field season confirm that stable isotope data reflect amphidromous feeding modes.

Testing Conceptual Models of Marine Mammal Trophic Dynamics Using Carbon and Nitrogen Stable Isotope Ratios - Steller sea lions and harbor seals are declining in numbers in the northern Gulf of Alaska (GOA) and the Bering Sea and the northern fur seal has apparently stabilized after a decline from previously higher numbers. Although no lease sales are currently planned in the Bering Sea over the near future, if either species is declared endangered species, oil and gas exploration and production might be severely curtailed in Bering Sea or GOA continental shelf habitats. This project focuses on the food web dynamics supporting top trophic levels in the GOA, Bering, and Chukchi seas with an emphasis on attempting to find linkages to explain these population declines. We are using the natural abundance stable isotope ratios of carbon and nitrogen to trace trophic transfers of these elements with the goal of identifying possible changes in trophic status or habitat usage over seasonal, annual, and decadal time scales. Our preliminary data show large temporal changes in isotope ratios over the seasons which may deflect changes in diet and habitat usage. These initial data have also shown the presence of large isotopic gradients in zooplankton between the continental shelf biota of the Bering-Chukchi seas versus those from the pelagic regions near the Aleutian Islands. The isotopic variations in marine mammal tissues showing temporal signals, such as whiskers and claws, reveal that the fur seals change trophic positions in the food web on a seasonal basis. Little dietary information linked to isotope data is yet available to account for these changes. Over the next year our research will focus on expanding the prey isotope database and identifying possible causes for the observed isotopic variations.

The Alaska Frozen Tissue Collection and Associated Electronic Database: A Resource for Marine Biotechnology - The Alaska Frozen Tissue Collection (AFTC) is the primary regional archive for frozen zoological samples and a major contributor to biotechnology studies of Alaska and its waters. Advances in molecular biology are rapidly establishing the value of frozen specimens for detecting environmental change. Samples in the AFTC are essential for monitoring long-term trends in marine organisms. Though we are acquiring new material from several sources, important opportunities have been missed and, unfortunately, some investigators are still unaware of this resource. The objective of this project is to expand the Collection's zoological scope of marine organisms and thereby establish the AFTC as a state-funded regional resource for monitoring long-term trends in Alaska's marine environment. An electronic database will be developed that is accessible through the Internet, thus facilitating the transfer of information and sharing of genetic resources among investigators. The AFTC is also expanding collaborative efforts with the Alaska Marine Mammal Tissue Archival Project (AMMTAP) and other marine mammal projects throughout the state.

AN OVERVIEW OF THE U.S. FISH AND WILDLIFE SERVICE'S ECOSYSTEM APPROACH TO FISH AND WILDLIFE MANAGEMENT

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ECOSYSTEM MANAGEMENT

Within the U.S. the term "ecosystem management" has gained wide usage among resource professionals who are working together to reach common agreement on how to apply ecosystem concepts on the ground. While elements of the ecosystem approach are not new, the way these elements are combined represents an advance in coordinated resource management. An ecosystem approach requires changes in attitude to enable resource managers to look beyond their jurisdiction, and to establish true partnerships for resource planning and management with the goal of maintaining healthy, diverse and productive ecosystems.

Ecosystem management is a goal-driven approach to restoring and/or sustaining healthy ecosystems and their functions and values. It is based on a collaboratively developed vision of desired future ecosystem conditions that integrates ecological, economic, and social factors affecting a management unit defined by ecological and not political boundaries.

The U.S. Fish and Wildlife Service (Service) has adopted an ecosystem approach to fish and wildlife conservation as an underlying foundation for our operational activities and is making a serious effort to move from the conceptual to practical in terms of how we think, act and solve problems. As a result, the Service is attempting to apply the concept of managing and protecting ecosystems to everything it does from reviewing permits, evaluating fisheries, and managing our National Wildlife Refuges. Director Mollie Beattie said the Service's ecosystem approach "represents a new way of managing natural resources that takes into account the entire ecosystem and balances recreational use, economic development, and conservation of fish and wildlife so that *each* is sustainable."

In early 1994, the Service designated ecosystems across the country based largely on watersheds, and established ecosystem teams composed of managers and scientists within the agency. These teams have spent the last year contacting potential partners, establishing cooperative projects, and developing Action Plans that are intended to supply management direction and a "collective vision" of future ecosystem conditions.

As of October 1, 1995, the Service has reorganized its personnel structure around ecosystems. Field offices within a given geographic area will be supervised by a single assistant regional director. Supervision will be based on the location of field offices, not the services or programs they administer. This new organizational structure is designed to assure that issues are viewed more in a geographic or ecosystem context than in a programmatic, or specific resource context. Geographic supervision also provides greater opportunity to integrate our activities toward common priorities and to facilitate cooperation with our partners in land and resource management.

Jack Lentfer: They are not organized in the three regions as you are?

Larry Bright: No, they are not. That has been one problem. Each agency has been taking a little different approach, drawing lines a little bit differently on maps. That is starting to pan out, starting to come together. The lines on a map are not nearly as important as what people are doing, the process. So we have tried not to get bogged down by getting all the agencies in one room and saying, "Now we are not going to leave the room until we get these lines on the map drawn." We haven't approached it in that way at all.

Tom Newbury: During your talk, you mentioned regional mitigation strategies. I think that there are such strategies for onshore developments on the North Slope, and for nearshore developments with causeways. But for offshore developments in the Beaufort Sea the strategies are still being identified. Hopefully, some of the information that has been presented during this meeting will help with identification of mitigation strategies for offshore developments, such as Northstar.

Larry Bright: Yes, it reminds me of what was said earlier about time. It takes time. I think we need to slow down in terms of planning and get folks, especially the Native folks in the north, involved in the process, and give everyone enough time to visualize a strategy. But that kind of thing doesn't happen overnight.

Grant Walther: It is not quite clear to me. Is it the collection of data that is the fundamental problem? Do you need more data to work with? Or is it the interpretation of data that you already have?

Larry Bright: I am not sure what problem you are speaking to.

Grant Walther: Like field work. Do you need more field data?

Larry Bright: Well, in certain areas, we need data of a different type, for example, habitat on the North Slope. We work quite a bit with oil companies. There have been individual attempts to classify and map habitats on the North Slope. But we haven't pulled all of those together for a unified look at habitat across the coastal plain. So we really don't know what habitats are truly limited, what is abundant, what might be critical to certain species at certain times of the year. We need to pull that kind of information together on a landscape level. With this kind of information in hand, we can form strategies that protect or restore habitats across their normal range of variation, and foster the variety of wildlife that depend on them. It is difficult to make enlightened decisions on a project by project basis without that kind of overview of the system.

Grant Walther: The reason I asked the question the way I did is because I attended an archeological dig the last few summers, down near Delta Junction; the Broken Mammoth Site, for those of you who might be familiar with it. It is very interesting that not only do they have professionals who were "professional" Ph.D. archeologists, geochemists, etc. who were there to analyze what was going on in the dig and to pursue whatever they were after. But they also had a field school which ran simultaneously. They recruited students from all over the country. The first year was mostly Alaskan students, but the latter years they have had people from other schools. But then there was a group of volunteers who showed up who were like amateur archeologists. These were people who travel the circuit of digs all around the world. These people are quite knowledgeable. They are all trained as to how to do the professional field work. They are trained in the techniques before they actually go. They attend school for a week or so. Out in the field they have critique sessions every night. If the collection of data is a problem, if there is not enough funds to work with, I am just going to throw that idea out to you. May be you have considered it before, but it might be a way to tie in with the Native communities. So it is not just "us scientists" and "you village people." Students are a great resource with a great deal of energy. They want to do something practical besides the academic stuff they hear all year. They were even charging for these people to come and they were paying. I was kind of surprised. So I am just throwing that idea out and you may want to toss around.

Larry Bright: Thanks.

Physical and Geological Session

A COUPLED ICE-OCEAN MODEL OF THE BEAUFORT AND CHUKCHI SEAS

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A coupled ocean circulation/sea-ice model is used to simulate flow properties and sea-ice evolution in the Western Arctic during the year 1983. The coupled system, employing a semi-spectral primitive equation ocean circulation model (Haidvogel et al. 1991) and the Hibler dynamic-thermodynamic sea-ice model (Hibler 1979), is applied on a uniform (20 km) horizontal grid, and is forced by daily surface geostrophic winds and monthly thermodynamic fluxes. The model coupling is described in Hedstrom (1994) and the model results are presented in Hedstrom et al. (1995).

In addition to the grid and surface forcing, the model must be provided with the bottom depth. We have decided to use a bathymetry which ranges in depth from 50 to 500 meters with the water below 500 meters assumed to be at rest. The cross-Arctic boundary is treated as a wall with a specified outflow equal to the specified Bering Straight inflow of 0.8 Sverdrups. The initial conditions consist of temperature and salinity fields derived from a horizontal average of the Levitus climatology and zero initial flow. A nudging to the initial temperature and salinity fields was found to be necessary and was applied with a timescale of 100 days.

The coupled model was run for a total of five model years, repeating the 1983 forcing fields. Monitoring the average ice thickness shows that the model was largely spun up by the end of this period. The last year of this simulation became our central experiment and was used to compare the model with the available data. We also ran some parameter variations, including the addition of the Eby and Holloway (1994) eddy form stress to improve the representation of the Beaufort Undercurrent.

The model has Lagrangian drifters which trace the paths taken by particles released at given locations. Drifters moving with the ice velocity were used to compare the motions in the model with buoys released by Roger Colony during 1983. This comparison showed that there is substantial room for improvement in the simulation. However, the velocity fields from this simulation were sent to the Minerals Management Service which has produced its own buoy trajectories. These trajectories were made using the ice velocity when there is greater than 80% ice concentration and the water velocity plus 3.5% of the wind velocity for lower ice concentrations. It is these buoy trajectories which were used in their Oil-Spill Risk Analysis (OSRA) report.

The results of the central model simulation are consistent with the large-scale circulation features of the Western Arctic. In particular, the Beaufort Gyre and its seasonal variability in the sense and amplitude of its circulation are reproduced to the extent of our ability to quantify them in the target year of 1983. Local reversal of the climatological circulation along the continental shelf (the Beaufort Undercurrent) is not reproduced at the resolution of the current study. Incorporation of the Eby and Holloway eddy form stress parameterization improves the degree of skill in the Undercurrent region, though to an unknown degree. Clearly, simulations at enhanced resolution (perhaps 4 or more times finer than presently employed) are necessary to resolve the processes responsible for the generation of the Undercurrent.

The bulk properties of the ice distribution observed during 1983 — including ice concentration and thickness and its seasonal growth and retreat — are reproduced well by the coupled model to the degree that available observations allow model evaluation. Some systematic tendency for faster-than-observed melting in the spring and summer months is seen in the model along the Siberian continental shelf. The regional reasons for this disagreement are unclear.

The poorest model performance is seen in the comparison between the model-inferred ice floe ("float") trajectories and the observed trajectories of surface floats released in the Arctic in 1983. Mean motion of the simulated drifters is comparable to those observed; however, there is little agreement between individual sets of trajectories. The apparent inability of the present coupled system to reproduce the detailed motions of individual floats is likely a consequence (at least) of the heavily smoothed atmospheric wind stresses used in the present study (Kozo and Robe 1986). Though the bulk properties of the ocean/ice circulation are retained in the smoothed atmospheric products, local Lagrangian flow properties are clearly influenced by spatial and temporal filtering of the wind forces. It is suggested that further study be instituted of the influence of using higher resolution wind products.

Enhanced simulation skill, particularly as it relates to local properties such as the detailed dynamics of the Beaufort Undercurrent and the individual trajectories of ice floes and surface drifters, will require improvements to the coupled model and its inputs. Improvements in several areas are desirable, including ocean/ice dynamics, thermodynamics, and numerical methods.

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QUESTIONS AND DISCUSSION

Dick Prentki: Some of the emphasis in this meeting is development very close to shore, within 12 miles or 12 km, in some cases. Development would be over a much smaller area than the areas of concern in your Arctic model. What would be your recommendation on how to model the circulation or spill trajectories close to shore, once you know where you are going to develop?

Kate Hedstrom: I think you would still need to include the influence of the larger Arctic Ocean circulation, maybe with some kind of nested grid scheme. All of these things happen on a very small scale. It is just that we can't afford to model the entire Arctic at the 2 km resolution that we would like to do.

Dick Prentki: I understand that. But if you did have a small nested model, what resolution do you think is feasible with the current science or likely finances?

Kate Hedstrom: Certainly we could go finer that what we did here. For this study, each year of the simulation took 25 Cray hours on the Fairbanks Cray Y-MP. If you double the grid spacing in each direction, you need eight times as much computer power. That would be pushing it.

Tom Albert: Over the years, I have been impressed by the various models that I have seen for the ocean and other things up there, by the complexity, and for the parts that I could understand, the minute amount of actual real data. I have two questions. One is what do you think are the major data needs, real data needs on actual measuring of water, on measuring of ice, something not done in a computer, but actually going out and checking on things. Secondly, has anyone in this modeling process gone and talked to the people that live along the northern Alaskan coast and the northwest Alaskan coast, since the area of interest is the first 10 to 20 miles offshore and these people roam around in that area? Has anyone ever asked them?

Kate Hedstrom: I don't know of anybody having asked the people who live up there. It is certainly a good idea. As for the data needs, I am not the expert on that, but there is a guy at Rutgers, Andreas Münchow who would love to go up and make more measurements. I talked to him about what was actually known. He said that it is such a difficult area to work in that they haven't made many studies up there. There is a lot that is not known.

Igor Appel: The trajectory of ice motion shown are they received under the ...

Kate Hedstrom: The model trajectories that I produced are based on the ice velocities.

Igor Appel: From five points...

Kate Hedstrom: Oh, the five launch point releases were done by MMS and include a wind-driven component.

Igor Appel: Are they influenced only by the wind?

Kate Hedstrom: No. If there is 80% or greater ice cover, they move with the ice velocity. If there is less than that, then they move with the ocean velocity, plus 3.5% of the wind.

Igor Appel: It seems that the trajectory from the third and fourth point are significantly different at least in the winter. If this is true, what is the explanation that the envelopes are different? The points are very close to each other, but the envelope is significantly different.

Kate Hedstrom: I don't know the answer to that. They are dominated by the ice velocities from that model.

Tom Newbury: A question was asked about the amount of real data as opposed to model data. I was wondering if Dr. Lon Hachmeister would say something about the amount of field data available for the area around the causeways and Seal Island?

Lon Hachmeister: Certainly, over the years there has been a lot of the large-scale data taken. I know that Knut Aagaard was out there even in the 1970s putting out current meter moorings. So there is data on the shelf, but not a lot of information in deeper water except for Roger Colony's buoys.

In answer to one of the questions that somebody had, I don't think it is going to do us much good to use high resolution grid spacing in models unless we get higher resolution data. The driving force, in the near shore, is the same as farther offshore — the wind. Unless we get high resolution wind information, it probably will not do us a lot of good to increase the grid size.

Regarding data availability in the nearshore, around the causeways, there is a lot of data. However, we would need a lot more information on the wind field before we start modeling in 5 to 10 m of water.

Nick Vanderkooy: Is there any cooperation taking place with Canadian agencies that are doing a lot of oceanographic work in the Beaufort Sea and modeling work, as well? I am thinking primarily of Dept. of Fisheries and Ocean and the Canadian Atmospheric Environment Services through their Ice Central Office to verify some of the results that you do have.

Kate Hedstrom: I don't know of any. Andreas Münchow has gone out on Canadian vessels to do research in the Mackenzie Delta region. That is about all I know of that.

Dick Prentki: Right now I don't think that Minerals Management Service is doing any joint work with the Canadians in Beaufort Sea oceanography. We do have one project which is working with the Japanese in the Chukchi Sea. I have a comment on Dr. Albert's question on using Native knowledge. We haven't done too much oceanographically in the last five years or so; but between 1975 and 1985, we conducted at least a handful of studies where we did have researchers talk with Natives. Some of the things that came out of that were, if you look at the ice nomenclature, the ice types that the scientists track, we track about as many as the Natives do: 40, 50 or 100. I forget whatever the number is, but science has taken some of those Native categories and uses them. Interviewers have also gone back and obtained information on historic ice overrides and information on what Natives remember about historic bad ice years, etc. We do have that data incorporated into the database. But that was work that we did mostly between 1975 and 1985, I believe.

Cleve Cowles: Another thought in that respect: the physical oceanography study at the Coastal Marine Institute is cooperating with the North Slope Borough on a logistic basis. Because that study is incomplete, there probably hasn't been much communicated back to the local people on the North Slope; but part of the overall concept or design of the Coastal Marine Institute is to have the people at the Coastal Marine Institute try as much as possible to establish that communication. I would see that happening in the future.

TRENDS IN OCCURRENCE RATES FOR OFFSHORE OIL SPILLS AND THE BEAUFORT SEA

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INTRODUCTION

Occurrence rate estimates for offshore oil spills are periodically updated by the Minerals Management Service (MMS) to include the most recent years of record. Data summaries, statistical analyses, and results of the most recent update on occurrence rates for offshore oil spills have been published (Anderson and LaBelle 1994) in the peer-reviewed scientific literature to insure wider scientific review and dissemination; this presentation will in large part summarize this latter paper, but in the context of potential Beaufort Sea oil production.

THE SPILL RECORD

The MMS estimates oil spill occurrence rates for large spills (≥1,000 barrels [bbl]) from the historical record for U.S. Outer Continental Shelf (OCS) platform and pipeline spills (currently 1964 through 1992) and worldwide tanker spills (currently 1974 through 1992). There are several reasons for the emphasis on large spills. Large spills are consistently reported, smaller spills may not be. Large spills persist longer than small spills with consequently more than proportionately greater potential effect. Causes of large spills differ from smaller spills, many causes of small spills are incapable of spilling as much as 1,000 bbl. Very important is the dichotomy between relative number and volume of small and large oil spills (Figure 1). On the OCS, large spills account for less than 0.1% of the spills, but 77.1% of the volume spilled. Spills of less than one barrel constitute 91.9% of the spills, but only 4.3% of the volume spilled.

Size and causes of large platform and pipeline spills on the OCS are variable. There have been only eleven major platform spills on the OCS, with the largest being the Santa Barbara spill of 1969 of 80,000 bbl. Most large platform spills are still under 10,000 bbl. Causes of platform spills range from vessel collisions (3), blowouts (4), structure or equipment failure (3), and hurricane (1). There have been twelve large pipeline spills, again, mostly less than 10,000 bbl, but with largest, at 160,638 bbl, occurring in 1967. Anchor dragging caused seven of the spills, trawls, hurricanes, and corrosion each caused two.

OIL SPILL OCCURRENCE RATES

The MMS uses oil-spill risk analysis most extensively in lease sale Environmental Impact Statements (EISs) where the only direct measure of oil development is the resource estimate. All other aspects in the development scenario in the EIS — pipeline miles, number of platforms, years and rates of production — are derived from the resource estimate. Any OCS production in the Beaufort Sea is expected to be piped through the Trans-Alaska Pipeline (TAP) to Valdez and then tankered elsewhere. The MMS has also, therefore, compiled statistics on TAP tankering and spills.

The spill occurrence rates can be expressed and normalized in terms of number of spills per volume of crude oil produced, piped, or tankered. The rate statistics used by MMS incorporate a statistical trend analysis to evaluate whether the data indicate a change in the frequency of large oil spills. For example, improving safety technology could be reducing the

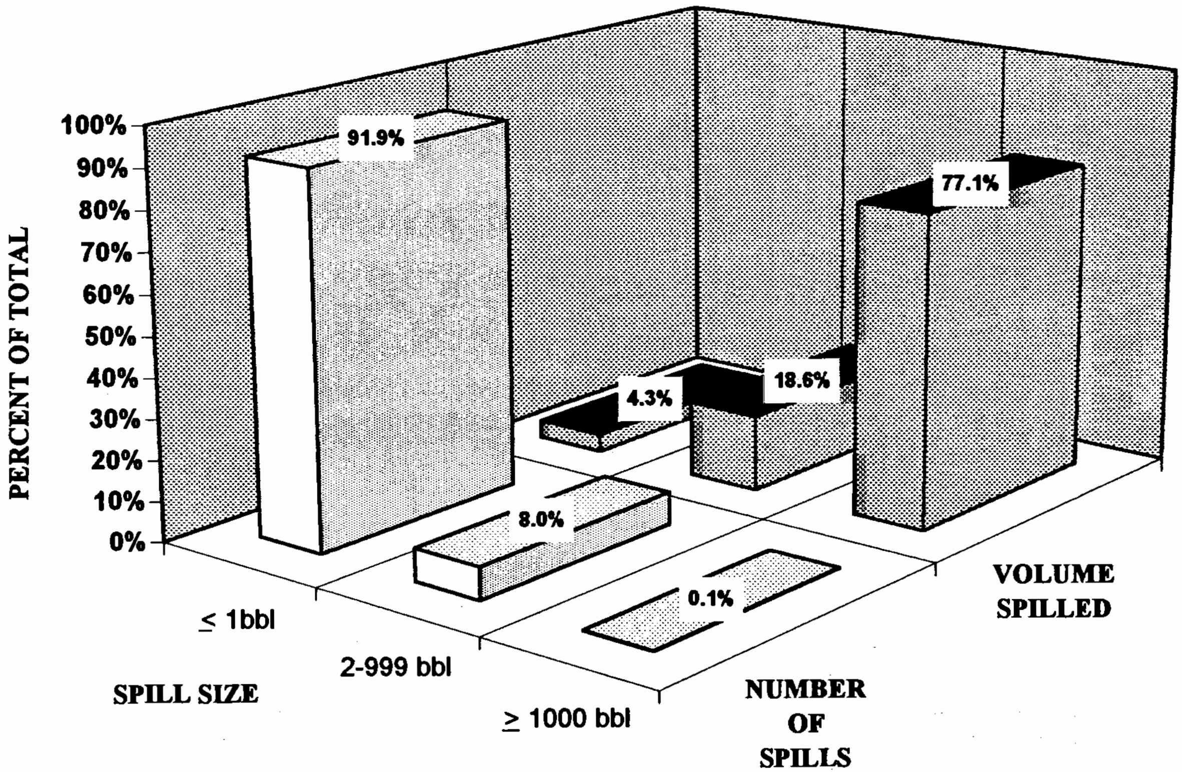

Figure 1. U.S. OCS spills: size versus total spill volume.

likelihood of large oil spills. Details of how the trend analysis is done can be found in Anderson and LaBelle (1994). Factoring in the most recent years of spill records (post-1987) has lowered the MMS estimate for the platform spill occurrence rate, has increased the estimates for the pipeline spill occurrence rate, but has not changed the estimate for the worldwide tanker spill occurrence rate (Figure 2). The changes are attributable to both a longer historical record (=more data) and periodic statistical re-evaluations of rates and trends. The increase in spill rate for pipelines between the 1990 and most recent, 1994 analyses is not due to so much to an increase in spillage, but rather to a disappearance of a statistical trend toward less frequent spillage. The 1990 analysis included pipeline data through 1964-1987, with no spills in the last six years of that record. Subsequently, pipeline spills occurred in 1988, 1990, and 1992; and the apparent trend in decreasing spillage disappeared. On the other hand, a decreasing trend in frequency of platform spills was substantiated in the 1994 analysis.

For the first time in the 1994 MMS estimates, spill occurrence rates were calculated for tanker and barge spills occurring in U.S. waters, and for spills of North Slope crude oil transported by tanker from Valdez, Alaska (Figure 3). Thus, estimates for tanker spills of Beaufort produced oil can now be directly projected from experience along the tanker route on which Beaufort oil would be shipped. The frequency of spills from TAP tankers has been slightly less than that for all tankers in U.S. waters or for all tankers. The frequency of large spills from barges is more than threefold higher than for any other transportation mode. The barge statistic may have some future relevance to the Beaufort Sea. It has been suggested that crude of Canadian Beaufort oil discoveries could be barged to the U.S. Beaufort Sea and sent through the TAP pipeline. However, also note that although large spills from barges are more frequent than from

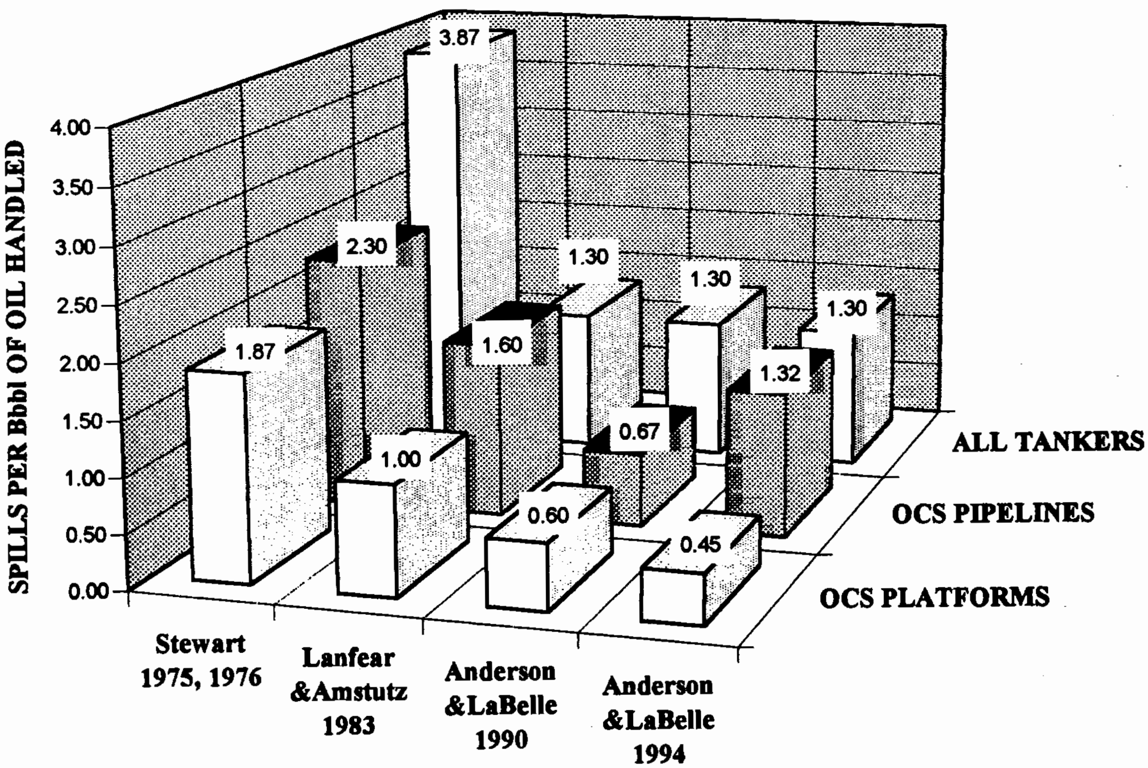

Figure 2. Comparison of historic spill rates for spills of at least 1,000 bbl.

either pipelines or tankers, the average and median sizes of large barge spills are much less those of pipelines and especially tankers.

APPLICATION

Statistically, the occurrence of oil spills can be treated as following the Poisson probability distribution, which governs the occurrence of rare and random events. Radioactive decay is another example of a process which follows a Poisson distribution. Figure 4 shows an example of how MMS applies the spill occurrence rates and Poisson distribution in the draft EIS for Beaufort Sea Planning Area Oil and Gas Lease Sale 144 (USDOI, MMS 1995), our next proposed Beaufort lease sale. Because of the emphasis on the theme of cumulative and "string-of-pearls" development during this meeting, the example is for the cumulative case, which includes Sale 144 plus other developed and undeveloped Federal and State offshore resources totaling 1.842 billion barrels (Bbbl). The figure is for spills within the Beaufort Sea, and thus incorporates spill rates for pipelines and platforms, but not for tankers. The combined spill occurrence rate for pipelines and platforms times the 1.842 Bbbl resource provides the statistically "expected" number of 3.26 spills. Application of the Poisson distribution provides estimates of probability of having no spills, the probability of having a specific number of spills, the probability of having one or more spills, and the most likely number of spills.

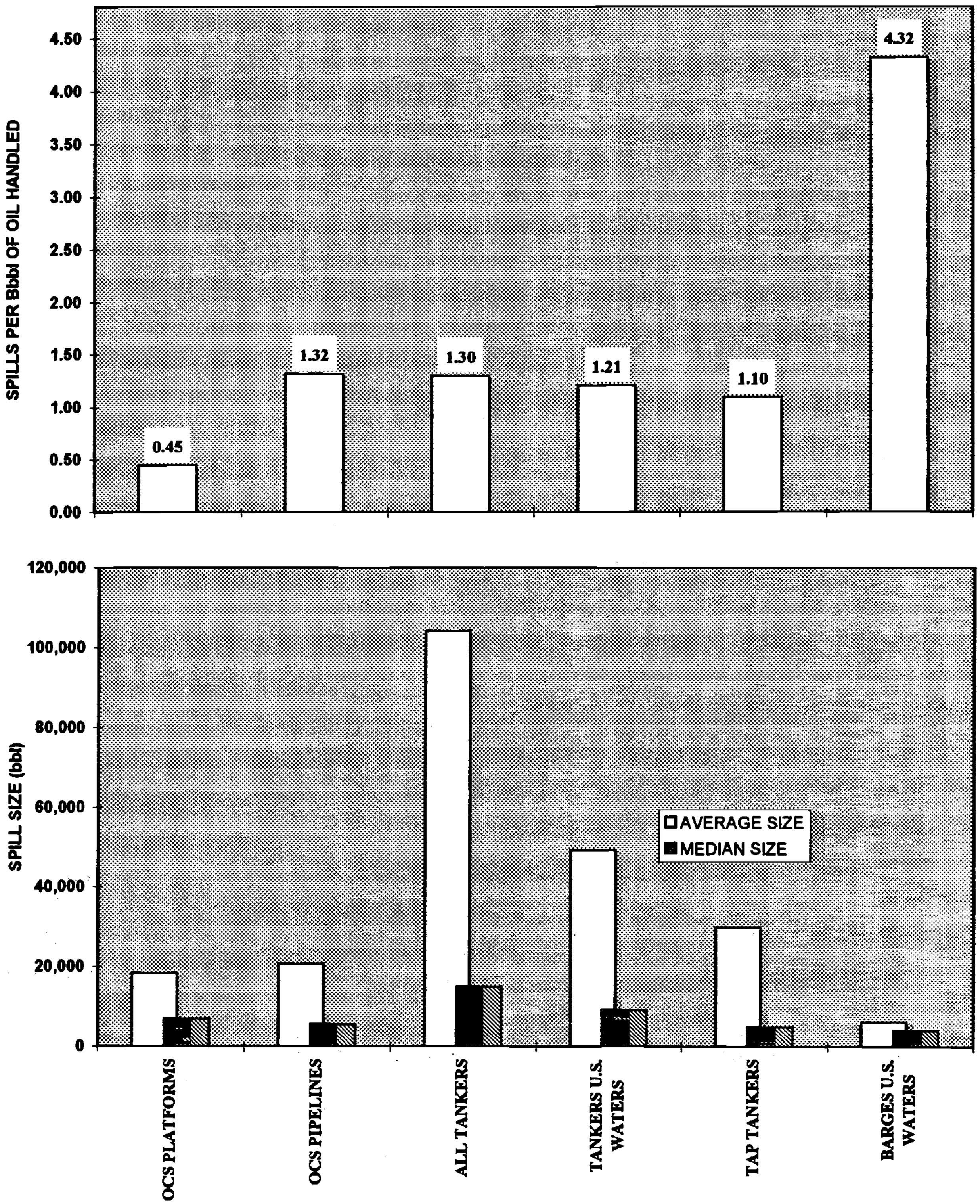

Figure 3. Comparison of spill rates and sizes by source.

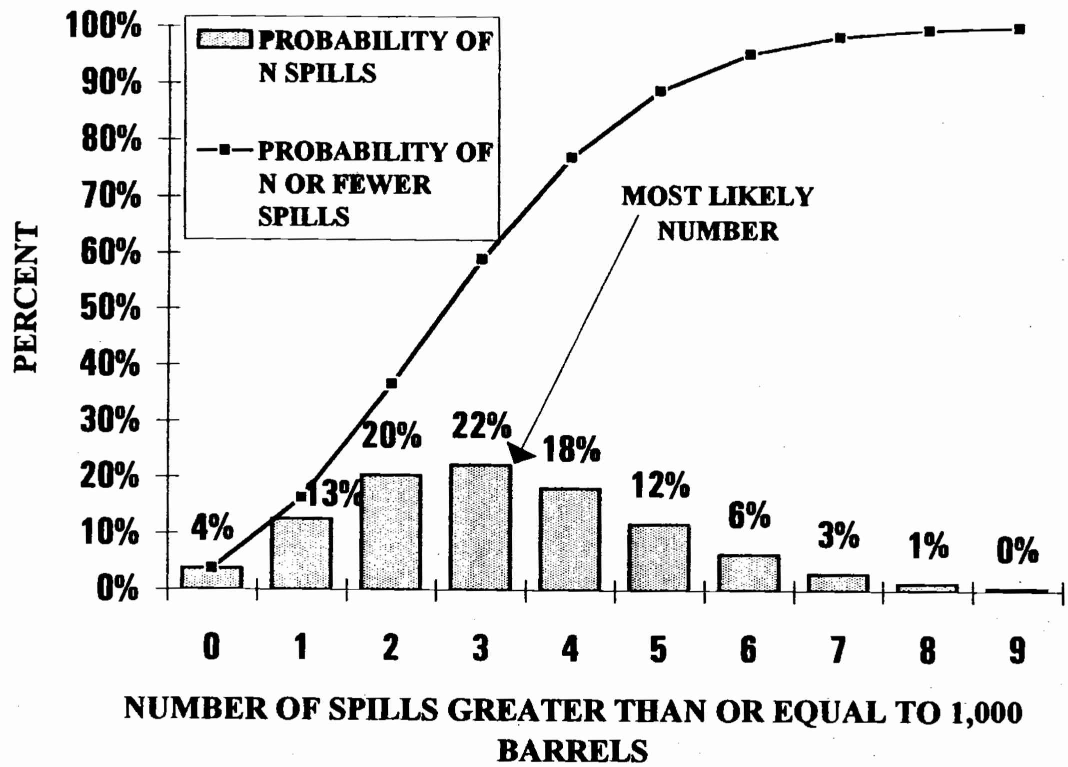

Figure 4. Beaufort Sea cumulative case (Sale 144 plus other offshore state and federal developed and undeveloped resources = 1.842 Bbbl): Poisson distribution for expected number of 3.26 spills.

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QUESTIONS AND DISCUSSIONS

Grant Walther: Did you or did you not factor in the *Exxon Valdez* spill in this predictive model, the Beaufort Model?

Dick Prentki: Yes, the *Exxon Valdez* spill is included in the spill rates that came out in 1994 which we are using now. That spill didn't make much difference in the spill rates. It was the major U.S. spill, catastrophic for Alaska in a lot of senses; but it didn't affect the overall spill rates.

Tom Newbury: What is it that changed the predicted number of spills between the reports by Anderson and LaBelle in 1990 and 1994? In the 1994 report, the estimated number of spills from pipelines is the same as it is for tankers.

Dick Prentki: When they did the last calculation, the last version of the statistics which were published in 1990, data only through 1987 was included. When MMS did that analysis, there had not been a pipeline spill since 1982. The MMS did the statistical analysis using a non-parametric technique which looks at production intervals and questions whether you have had a spill in this production interval or a spill in the next one. The statistics indicated that there was a decreasing trend in pipeline spills. What happened is that more data came in with spills and the trend disappeared. We have had some more pipeline spills. So the analysis now shows there is no decreasing trend and therefore when MMS calculates the spill rate, we take this entire time period, sum up the amount of oil produced and the number of spills, divide the number of spills by the amount of oil.... That is why the number went up.

Tom Newbury: If the estimate was converted from number of spills to volume of oil-spilled, would that change the trend?

Dick Prentki: It might. If you remember the first pipeline spill which occurred in our records in 1967 was 160,000 barrels. It was by far the largest spill we have had on the OCS, almost by a factor of two. There have been only 12 spills on record and the first one is much larger than the rest. So yes, it would drive down the average volume. Which is one argument for using median spill size when you do analyses rather than the average spill size. But if you use the average spill, you may be more environmentally conservative — if you want to call assuming larger catastrophes are "conservative," a little semantics problem there.

Lon Hachmeister: In your last figure you showed a high probability of spills occurring between two and four for pipelines. Have you coupled that with some of the other information you had on some of your earlier slides to estimate what volume of spills might be likely there within those two to four spills?

Dick Prentki: That two to four spills was for both pipelines and platforms not just pipelines. So it would be all of the spills in the Beaufort Sea that you could expect from development of all of that oil. Generally when we look at this in-house, we have looked both the average spill size and the median. If we are dealing with a large number of spills, we might in our analysis use a spill size distribution such that if you had six spills, six times, you are going to get six times the average volume. But your median spill size is usually much smaller than average size, and you want half of the six spills to be $\leq$ the median and half to be $\geq$ the median. So if you have six tanker spills, with an average size of 100,000 barrels, you might assume one of half a million barrels and five of 20,000 barrels. Usually if you deal with smaller numbers of spills, like three, there is no set way that is dealt with. I haven't seen a statistical treatment of projecting multiple spill sizes. either. What we have done is based on assumptions.

Lon Hachmeister: Two to four doesn't sound bad if they are all under 5,000. Two for four "*Exxon Valdez*" would be more significant.

Dick Prentki: I am not sure how this is analyzed in the current Beaufort Sea EIS. In the first Beaufort Sea EIS following the *Exxon Valdez* oil spill, we were concerned about the size estimate of tanker spills in Prince William Sound and possibly we went off the wall. We assumed one spill of a million barrels and then adjusted the rest of spills down to get the proper statistical total volume of spillage. That approach didn't get much comment at the time because readers of the EIS were more interested in what was happening in the Beaufort Sea rather than the Gulf of Alaska. It is a touchy subject and I haven't seen a statistical treatment of how that should be done nor a scientific recommendation. It has been more of a seat-of-the-pants type of thinking.

Jim Craig: I have no problems with your numbers there...

Dick Prentki: They are yours!

Jim Craig: Well, I don't know if they are mine or not, I won't "fess up" to them. I have a question about the location of this spill. You had a spill from three different main sources, generally not much from platforms expected, but from pipelines and tankers. You had a number of spills expected to result from North Slope cumulative production...

Dick Prentki: Expect is a statistical term. I am not predicting....

Jim Craig: I know. You are not hoping, that is the expected model...

Dick Prentki: We are projecting that number.

Jim Craig: Projected number would be a better way to say it. My question is related to the location of these expected spills and how they are addressed in the environmental impact statement. Since most of this oil is probably transported south through TAPS, and then on tankers, where would the spill locations actually be?

Dick Prentki: The way we currently handle tanker spills allows us to plot a tanker route and then spill randomly all along that route. So essentially, so if we are projecting two tanker spills we can distribute the probability of those two spills along the entire tanker route. Generally, MMS assumes that half of the tanker spills would occur in our model area or Alaska area and half somewhere farther south. For pipeline spills, we generally do the same thing. I am not quite sure how such spills were distributed what happened in the Beaufort EIS. Usually, pipeline spills are spread along the hypothetical pipeline routes. But those routes aren't known anywhere near as well as tanker routes out of Prince William Sound. For example, from the first day of the meeting I recall that there may be a 20 mile pipeline from Northstar to shore, crossing the Barrier Islands or not. They way we do things now, that 20 mile pipeline would have the same number of spills projected for it as one that went from Northstar through Bering Strait and then down to the lower 48 without ever touching land. We don't have any distance factor, length of pipeline factor, in that. If you get to development and try to use these numbers, you might need to factor that into your analysis.

Jim Craig: I guess that is what I am alluding to here. You have a certain number of spills predicted for the cumulative production from the area. It is a much different impression if you've got three spills greater than a 1,000 barrels occurring on the North Slope as a result of North Slope production versus occurring somewhere between the North Slope and the West Coast as a result of production. How is that addressed?

Dick Prentki: The 3.28 in that chart would just be spills, which would be strictly within the Beaufort, from production in the Beaufort. In the current case, we are projecting the number of spills to occur from export of that oil out of Prince William Sound. We don't actually run a trajectory analysis down there, we just have project and report the number of spills. For the Beaufort, how MMS handles the oil spill risk analysis for pipelines and platforms changes partly with how Resource Evaluation does the resource estimates. If the people in Herndon, Virginia who do the oil-spill modeling are given proprietary information about where the oil is likely to be within the model they can target those locations and assume that is where platform spills occur. If the Resource Evaluation procedure does not give the modelers that information, they assume equal distribution of oil and spill at all model platform locations.

ANALYSIS AND FORECASTING SEA ICE CONDITIONS OF THE ALASKAN NORTH SLOPE

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The National Ice Center (NIC) produces sea ice analysis and forecast products that are utilized by military, government, and commercial operations in the polar regions. Sea ice analyses, describing current conditions, are produced through the integration of a variety of remotely sensed and ground-truth data sources. Long-range (30-90 day) forecasts of regional sea ice extent and coverage are a valuable asset to the success of maritime commerce in Alaskan North Slope coastal waters. Reliable predictions can be used to prolong safe ship operations into the fall season and in strategic planning for the commencement of shipping activity each summer. The purpose of this paper is to describe the production and dissemination methods used for NIC operational sea ice analysis products as well as operational long-range ice forecasting techniques as they pertain to Alaskan waters.

Visual, infrared, passive microwave, and Synthetic Aperture RADAR (SAR) imagery are combined at the NIC with less frequently received ship/shore reports and aerial reconnaissance data to produce regional and tactical-scale sea ice guidance products. Sea ice parameters, critical to safe navigation, include: the location of the ice edge, concentration of the various stages of development of ice, and the presence/absence of navigable open water leads. It is well documented that environmental parameters (surface wind, ocean currents, and air temperature) play an integral role in predicting dynamic (ice drift) and thermodynamic (ice formation/ablation) changes in the sea ice cover. Due to the absence of forecasting skill for these forcing variables on longer time scales, the NIC employs a combination of sea ice forecasting techniques to produce the Alaskan seasonal ice prediction. These techniques include: a) a linear air temperature/ice thickness relationship with date of initial ice break-up, b) absence or presence of multi-year ice in shipping lanes, and c) an analog/statistically based procedure that relates regional ice anomalies with variations in large-scale atmospheric forcing of sea ice. Methodology for producing NIC seasonal sea ice forecasts are discussed with particular emphasis on historical skill in predicting the severity of summer ice conditions in the western Arctic.

QUESTIONS AND DISCUSSION

Dick Prentki: I assume that the bad ice years are attributable to the ice pushed against the Alaska shores — not that there is more ice in the polar ocean in those years. Is that your understanding?

Jeff Andrews: Well, there were a couple of other things. As far as our validation goes for the ice severity, we look basically at the distance to the ice edge on 15 September. The main point of measurement is Point Barrow, because that is the choke point for the ice movement. The measures include distance to the 5/10ths boundary on 15 September, the number of days that the sea route to Prudhoe Bay is ice free, the number of days that the route is 5/10ths covered, and the number of days between the initial and final days. We use all of this to calculate a cumulative severity index.

There is another source of information — the drifting buoys — that we have been using since 1988. The drifting buoys give the rate of movement of the ice per day; we have been trying to correlate that into the forecast conditions. Initially, it looked like the rate was less than 2 kn per day. But in 1992 we seemed to have much more movement per day. We are now looking at a lot of different things for improvement. I think problems come from using too much data. But we are always looking for things that will help key us build a better forecast.

Now I have a special theory about the autumn that I have been testing over the last two or three years. The main difference with the autumn is all young and new ice that forms almost instantaneously. It seems to be a weather-related phenomenon.

Don Hansen: I have a question about your ice maps. Do you have trouble identifying the formation of new ice?

Jeff Andrews: The only thing that visual images give us is a key, because even with the images you can't detect new ice — especially if it is thin. It is still going to appear black. You are not going to be able to pick up the finger rafting that occurs with ice as it starts to form. You can get a better indication with the microwave imager (SSMI); it will give you an early indication. That is generally what we use to detect new ice formation. The only problem is that most of the time the new ice forms near the coast and the SSMI is easily contaminated with coastal information. So you lose 25 km there. Also, the SSMI is weak in areas of light concentrations of ice, especially if the ice is only one to three tenths and is surrounded by 9/10ths ice. The SSMI won't recognize it as ice; it will recognize it as water because it doesn't actually fill enough of the pixel for it to register as ice.

Don Hansen: I think that might have been a particular problem this fall because, when we were up there, we had a lot of new ice formation, in spite of high sea states. We had ice forming not just from the shore outward, but even offshore. You could see grease ice forming pans of new ice and there would be waves underneath it. It was unusual. I have never seen that before. I have been flying up there since 1987. Each year is different. This year there weren't any chunks of pack ice to break up the new ice. Often, if you have wind and small pieces of floe ice or sails, the floes would act like ice breakers and break up the new ice. This year there wasn't any of that.

Jeff Andrews: The one slide that I showed that showed on the DMSP, that showed the area northwest of Barrow. We didn't see that for a week. The SSMI gave us an indication that ice was being advected. Well we were having a hard time buying that because the ice edge had been 30 miles to the north. When the clouds finally broke, we saw that the ice was there. And about that time the coal barge was coming up on a resupply mission and they couldn't get in because the ice was too thick. The delay lasted about a week and a half, waiting for the ice to advect a little bit further offshore so they could go into Barrow.

I have an advantage over most of the people who analyze the satellite images in that I flew for five years over the ice. I can identify easily what I am seeing on satellite images. If I am looking at shuga, brash, young, or new ice. Also, you have to consider sun angle, hours of daylight, and sea surface temperatures.

Tom Newbury: I really appreciate your index. I noticed that Steve Treacy referred to the index in his talk about the median depth analysis of the bowhead whale migration and its relationship with ice. It also correlates very well with observations during some of the operations. Your index shows cycles in severity, that every five years there tends to be severe ice conditions. In 1985 when the Corona Prospect was explored, the ice conditions were severe. Later, in 1991 and 1992, when Galahad and Kuvlum were drilled there was severe ice again. It is a very useful index for us.

MODELING AND PREDICTION OF ICE HAZARDS NEAR THE OCS DEVELOPMENT PROSPECTS IN THE BEAUFORT SEA

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INTRODUCTION

The study of local natural geographical features supports industry with necessary data on conditions for offshore construction. For the Arctic Alaska Outer Continental Shelf (OCS) Region, sea ice is important and, in many cases, a limiting factor. The presence of ice during most of the year and the significant variability of the ice state caused by wind, current, tide, and thermal processes is the main feature of the Beaufort Sea ice regime.

In the region under consideration, ice hazards are elemental phenomena that can cause great damage to structures and also direct harm to the environment. In critical cases, these hazards can endanger the safety of personnel working offshore. The most dangerous sea ice hazardous phenomena are as follows: the appearance of pack ice, rapid development and movement, heavy ice and icebergs, compacting in ice cover, superstructure icing, and scouring. The distribution of ice cover also indirectly governs another hazard — high seas.

Ice atlases of hazardous phenomena and long-term ice forecasts can determine the basis for strategic planning and decision making. Operational ice support with current information and short-term forecasts includes remote sensing of the ice state and numerical modeling for those parameters that cannot be observed.

Construction in Alaska OCS waters needs knowledge, not only of the general development of processes in ice cover, but also detailed knowledge on the influence of ice conditions in the area of structures. Therefore, for cases with an increased probability of hazardous conditions, additional systems of ice management should be considered as a mandatory measure.

Ice Cover in the Vicinity of Alaska OCS

Ice cover influences industrial activities differently in ice-infested waters. Sometimes ice cover is useful for supporting offshore activities in the Arctic. It can be used to unload and transport cargo, build moorings and artificial islands, and create air strips. At the same time, ice cover can be hazardous for other activities.

First of all, the presence of any ice should be considered a hazardous phenomenon in most cases. But the appearance of ice cover with high ice concentrations is dangerous for all kinds of activities in ice-infested waters. Heavy ice cover (with concentrations more than 50-60 percent) exists in the vicinity of much of Alaska's OCS, usually until the end of July. In unfavorable years, heavy ice exists all summer and through to freezing in autumn.

Feasible dates for the beginning and ending of navigation along the Beaufort Sea coast with icebreaker support can be considered a good example of interannual variability. Beginning navigation is possible in the first half of June. An average date for beginning navigation is early July but can start as late as the end of July. Ending dates of navigation vary from early October through late November. It is necessary to emphasize that the aforementioned dates are typical and do not reflect extreme conditions that could significantly alter these dates.

Ice Forecasting

Not only seasonal but also great interannual variability is typical for ice conditions in the Alaska OCS Region. Significant changes in the ice cover state explain the need for developing methods of ice forecasting for the area under study. Because even the appearance of ice cover should be treated as a hazardous phenomenon, all ice forecasts can be included in this consideration.

Allowing for future ice conditions is a necessary requirement to develop plans for working in ice-infested waters. The content of long-term ice forecasts is determined by the importance of ice parameters having the most significant variability. The main task of long-term forecasting is to predict conditions and duration of working offshore.

Thus, forecasts of flaw polynyas, diverging, and fractures in ice cover allow the early beginning of work in ice-infested waters in the spring. For the autumn period, the forecast of ice freezing is of great importance.

The Alaska OCS is characterized by significant, rapid changes in ice conditions and therefore short-term forecasting has a large significance. Short-term forecasts should meet more restricted requirements and state ice conditions more precisely.

Dynamic characteristics and redistribution of ice cover present the main interest for short-term forecasting. Ice drift, concentration, ice edge, and compacting are among the most important parameters.

Methodology of Calculations

Long-term statistical forecasts take into account previous transport in atmosphere, air temperature, and vorticity (velocity of rotation) of the ice drift in the Arctic Ocean. Allowing for changes in the location of points used to determine atmospheric forcing on sea ice, presents the main advantage of the developed approach.

Mathematical modeling of the evolution of sea ice cover is considered to be an effective means of developing ice forecasts. In our models we combine theoretical constructions, using the laws of physics, with empirical conclusions, developed as the result of field observations. Anisotropic descriptions of ice cover behavior and allowing for changes in ice edge configuration are other features of the model used.

Joining numerical and physical-statistical methods seems the most appropriate approach for long-term forecasting. For shorter periods, numerical methods have obvious advantages which permit the calculation of spatial and temporal changes of many ice cover state parameters.

Numerical calculations allow us to get the spatial distribution of different sea ice cover characteristics, such as: ice concentration, thickness distribution, edge configuration, drift velocity, zones of divergence and compacting, distribution of ice floe sizes, and their strength and motion.

Ice Redistribution

Numerical methods of computing ice cover evolution have found wide application for solving a number of scientific and applied tasks.

Verification shows good results of long-term forecasts for periods of 1-4 months and short-range forecasts for up to 5-7 days.

There are no systematic errors in calculating magnitude and direction of drift. Root-mean-square errors are less than published estimates for other models.

The model simulates slightly smoothed locations of the ice edge for long-term calculations. Calculations for short-range changes describe all of the main features of ice redistribution under the influence of dynamical and thermal processes. Some results of calculations for numerous ice cover state characteristics are available in Appel (1995).

The most interesting example of local long-term statistical forecasting was the prediction in 1993 of the initial date when ice concentrations at the Kuvlum site would be 50 percent or less. More than three months in advance it was noted that the ice conditions would be favorable to carry out exploration. Later, on June 1st, long-term forecasts showed an opportunity to begin working in Camden Bay on 10-17 July. The actual beginning of breakup, characterized by retreat of the compacted ice cover from the Alaska coast, occurred between July 7th and 17th.

Ice Compacting

Observation data from onboard ships in ice has helped to study compacting in the ice cover. This phenomenon is included in the numerical model. Compacting in ice cover is usually connected with the movement of cyclones over the region. The compacting corresponds to specific parts of atmospheric formations and its intensity — to velocity and trajectory of cyclones and anticyclones. The zones of significant negative air pressure in moving deep cyclones are characterized by the predominance of heavy winds, falling pressure, convergence, and heavy compacting of ice cover.

Theory explains this phenomenon by the convergence of isolabaric wind — the wind component, connected with movement of atmospheric synoptic formations. The greater the atmospheric pressure gradient and the velocity of cyclone movement, the greater the compacting in ice cover. This is typical for conditions outside the coastline influence. In the vicinity of islands and coastline, compacting is determined by wind speed and its direction relative to the coast. The strongest compacting is observed in a relatively narrow belt of ice cover along the coastline or fast ice, which includes the location of all exploratory drill sites on the Beaufort Sea Outer Continental Shelf.

The reliability of the calculation of intensity and orientation of compacting has been confirmed by observation data from ship and air reconnaissance.

The processes of compacting in ice cover are accompanied by the formation of pressure ridges. In its turn, ridged ice cover intensifies all hazardous influence. But, in addition, pressure ridges might cause another specific hazardous influence on underwater constructions.

Scouring

The study for offshore pipeline construction requires evaluation of possible scouring depth. Theoretical investigations and field observations on grounded hummock and ice piling up at artificial islands allowed one to obtain a general connection between scouring depth and influencing factors.

To evaluate the possible depth of scouring we need information on ridge morphology, drift velocity, ice strength, and others. Ridge morphology has been determined during numerous field experiments and is included in the mathematical description of the processes. Now necessary data on pressure ridge dimensions can be received as a result of model calculations simulating ice cover dynamics. Ice drift and strength also can be calculated.

Developed formulae can be applied to describe the results of interrelations between the sea bottom and pressure ridges of differing ice age. Using methods of probability theory allows us to deduce an equation giving the chance of occurrence for different scouring depths. Such an equation is used to make principal decisions on pipeline design. Conclusions derived show that for conditions of the Beaufort Sea the depth of scouring can exceed 5 m. The maximum probability of scouring in the Beaufort Sea is observed at depths of 20-30 m.

Superstructure Icing

The icing of ships or marine structures is the result of freezing water coming from the atmosphere (atmospheric icing), sea (sea icing), or atmosphere and sea simultaneously (mixed icing). Sea and mixed icing presents the greatest hazard. Negative air temperature and strong wind, accompanied by waves, lead to superstructure icing. Accumulation of ice on different parts of a vessel causes critical changes in its stability and can also influence other marine structures.

Analysis of existing observation data on icing helped to develop methods of icing calculation. The parameterization of those data allowed us to use a nomogram or prepare simple calculation schemes to estimate current and future intensity of icing.

In the autumn-winter period another similar hazardous process can be observed. It is the adhesion of snow-ice masses to the hull of a ship or other marine structure. The bond between hull and ice leads to formation of a snow-ice "pillow" that can even cause the vessel to stop.

Wind Waves

Ice cover in the Beaufort Sea not only causes direct influences, but distribution of ice cover also determines development of another hazardous phenomenon — sea waves. Significant retreat of ice cover from the Alaska coast creates favorable conditions for the development of high seas presenting hazards for ships and structures. Development of waves depends upon wind speed and direction, sea depth and bottom topography, and also wind fetch. The fetch in the vicinity of Alaska OCS, to a great degree, depends upon ice edge location. Waves can be especially high in September and October when long wind fetch and also deep cyclones are often present. When fetch is equal 800 km, wave heights can reach 7-9 m. Wind waves can be calculated and predicted with high accuracy.

CONCLUSION

The problem of using knowledge of hazardous phenomena for working on the Arctic shelf should attract greater attention. An optimal allowance for hazardous phenomena presents one way to increase the effectiveness and minimize environmental influence of working in extreme conditions of the Arctic zone. To take into account the influence of hazardous phenomena, it is necessary to know the ice regime of the area and the structure and dynamics of ice cover.

The present level of knowledge on ice regime for the Alaska OCS can be reflected by maps developed on the basis of existing observations and calculation methods. The most convenient presentation of this information is in a form of usual or electronic atlases. Such an atlas, in addition to ice maps, will include calculated probability density for different ice parameters and their combination and typical synoptic situations causing the appearance of hazardous conditions.

Those conditions would be taken into account for rational design of offshore structures and also strategic planning work on shelf. The strategic planning and decision making can be more effective if long-term forecasting is also taken into consideration.

The second aspect of allowing for hazardous phenomena is operational support with current information and short-term forecasts. The data from high resolution satellite images will be used to study meso- and small-scale features of ice behavior. Numerical modeling will give additional information on ice cover state including those parameters that cannot be observed, in particular, ice thickness and areas of compacting.

Some supplementary notes about strategy to develop a scientific operational ice support system for working in Alaska OCS and cooperation between exploring and supporting companies can be found in Appel (1994).

LITERATURE CITED

Appel, I.L. 1994. Scientific operational ice support for offshore exploration in Arctic seas: state and strategy of development, Offshore Technology Conference, Houston. 241-248.

Appel, I.L., and C.B. Samuels. 1995. Simulated sea ice data. Fourth Conference on Polar Meteorology and Oceanography, Dallas. 47-52.

QUESTIONS AND DISCUSSION

Tom Newbury: You showed a profile of the amount of open water in 1993. Do you have a similar projection for 1992? During Kuvlum operations in 1992, there was very bad ice, but during operations in 1993 there was very little ice.

Igor Appel: When we developed the method it was verified on many years. The years of 1991 and 1992 were not included into consideration to create the method. But later, the method was verified on these two years before the real forecast was developed. And it shows mild ice distribution in 1991 as far as I remember and very heavy ice conditions the next year.

Tom Newbury: Aside from the obvious operational hazard associated with extremely heavy ice, there is a hazard associated with extremely mild ice. When the ice is very mild and the ice edge is far off shore, there is a long fetch and large waves can develop. During one year when there was a long fetch, several of the offshore islands were damaged by heavy storm waves.

Igor Appel: As far as I know that phenomenon is well known to you also. Yes, it is a real hazard. It is not the direct influence of ice but ice distribution that explains the development of these waves. Sea wave height can be calculated very easily and can be forecasted up to at least three days in advance with high accuracy. It can be useful. Such information can be developed and can be available to estimate future development of sea state under mild ice conditions.

Grant Walther: I have a question concerning the ice scouring map that you showed us of Barter Island area. What was that based upon? Is that a one year study or it is several years?

Igor Appel: The map showing the distribution of ice scouring is a map combining observed data not calculation. So it is a real distribution of scouring depth in the water off the Alaska North Slope.

Grant Walther: Was that based on a one year study or over several years?

Igor Appel: The field observations included several years of studies.

Grant Walther: Does there tend to be a variability at all as far as the scouring depths are concerned? Or do they seem to be very consistent and constant?

Igor Appel: Scouring depths can undergo large variability from year to year also. Because it depends upon the morphology of the ice pressure structure. And this morphology depends upon all processes during the previous winter. It can be calculated and I don't think it is necessary to forecast the structure of ridges but we can calculate the keel depths, and we can estimate possible scouring variability from year to year.

Grant Walther: Then you mentioned that the subsoils were also impacted by the scouring. Does there seem to be a predictable range as to what the amount would be subsurface?

Igor Appel: Yes, there are a few works devoted to the study of this process. Modeling, as theory explaining the deformation under the scouring and also laboratory experiments showing the same results. So there are estimations that can be taken into account.

NEW ARCTIC NDPES GENERAL PERMIT

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INTRODUCTION

This presentation introduces a new NPDES general permit and discusses its relationship with oil and gas exploration activities in the Arctic. The U.S. Environmental Protection Agency has recently issued the Arctic National Pollutant Discharge Elimination System (NDPES) general permit which will authorize discharges from offshore oil and gas stratigraphic test and exploration wells in federal and state waters of the Beaufort and Chukchi Seas (60 Federal Register 27508, May 24, 1995).

On September 20, 1994, the draft Arctic general permit was opened to a 120 day public comment period. Comments were received from 17 parties. The final permit was issued May 24, 1995 and became effective 30 days later. The permit expires June 23, 2000. The permit is in force and has not been legally challenged.

Key points of this talk include: 1) what is an NPDES general permit?, 2) what's new in the Arctic general permit?, 3) summary of permit conditions, and 4) take home points.

WHAT IS AN NPDES PERMIT?

NPDES general permit covers multiple point source dischargers of similar waste streams in the same geographical area (in contrast to individual NDPES permits which are for single discharge points). The Arctic general NPDES permit covers offshore oil and gas stratigraphic test and exploratory operations but does NOT cover discharges from development or production wells. The area of coverage for the permit is the federal waters of the Beaufort and Chukchi Seas planning basins (as defined by the Minerals Management Service) and the Alaska state waters contiguous to landward boundary of the aforementioned planning basins (Figure 1).

WHAT'S NEW IN THE ARCTIC NPDES GENERAL PERMIT?

There are several unique features of this permit. This is the first permit issued under the recently issued offshore oil and gas effluent limitations guidelines. The area of coverage for this permit is defined by the Minerals Management Service planning basins rather than the specific federal or state lease sales. The permit also contains new conditions on the discharge of drilling muds and cuttings, including a toxicity limit on muds and a mud management plan requirement. The areal restrictions on drilling muds and cuttings discharges have been enlarged. In addition, the Arctic general permit is the first NPDES oil and gas permit which includes a Best Management Practices Plan requirement.

PERMIT CONDITION

The bases of the permit conditions include the Clean Water Act, the effluent limitations guidelines for offshore oil and gas, best professional judgment, Ocean Discharge Criteria (CWA Section 403c), and the Alaska Water Quality Standards. The exploratory waste streams authorized with limitations are: 1) drilling muds and cuttings, 2) deck drainage, 3) sanitary wastes, 4) domestic wastes, 5) test fluids, and 6) other miscellaneous discharges.

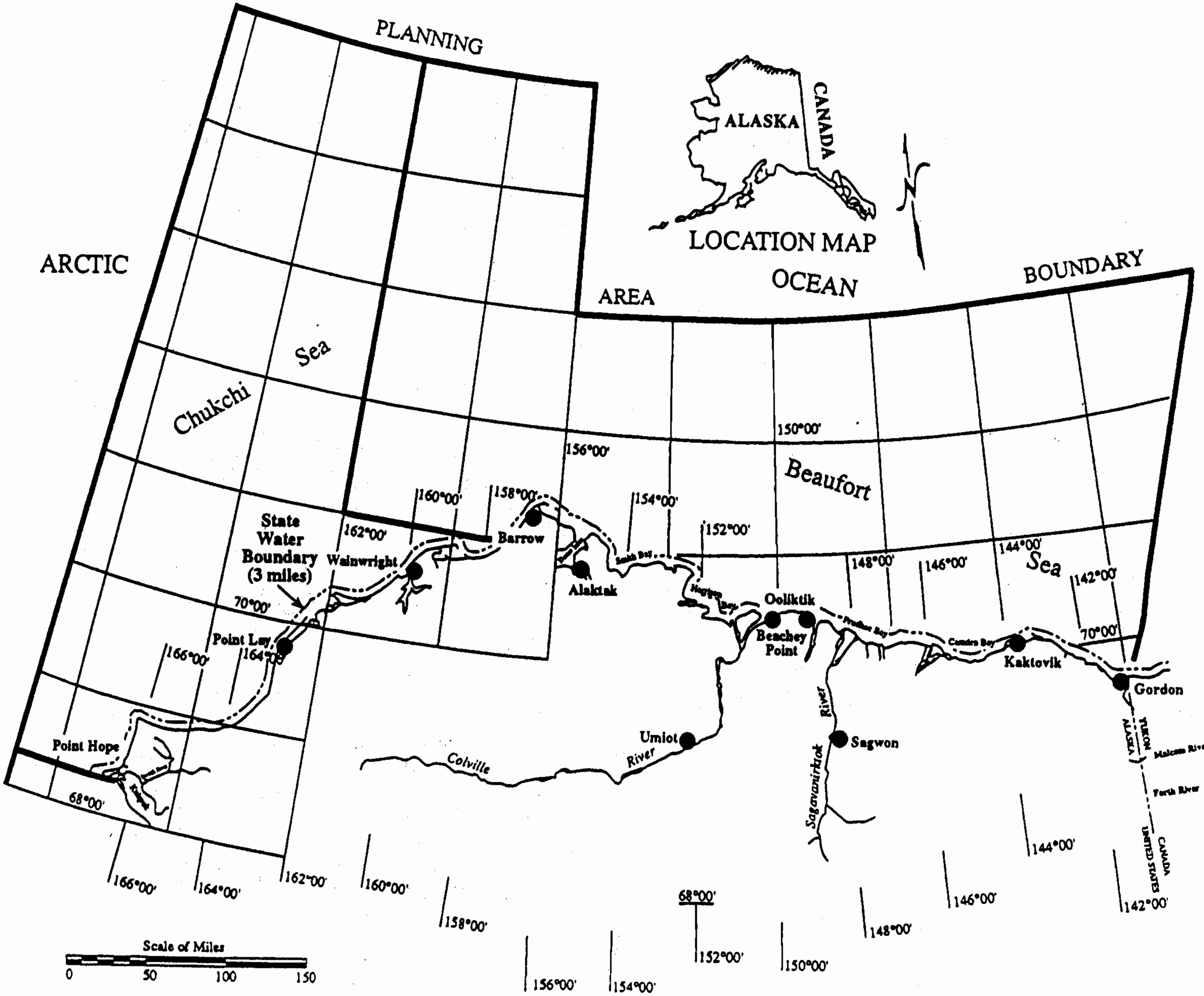

Figure 1. Arctic NPDES General Permit area.

The drilling muds/cuttings waste stream is the primary discharge from exploratory oil and gas operations. The key limits for this discharge include: 1) flow limit which is a function of depth, 2) no discharge of diesel, free oil or oil-based fluids, 3) drilling mud toxicity limit, and 4) limits on mercury and cadmium in stock barite. Other conditions which apply to drilling muds/cuttings include, among others, a requirement for development of a drilling mud management plan, areal and seasonal restrictions, and environmental monitoring requirements.

Areal and seasonal restrictions on the drilling muds/cuttings discharge include the following no discharge areas: 1) waters shallower that five meters, 2) Steffansson Sound Boulder Patch, 3) Omalik and Kasegaluk Lagoons, and 4) near river mouths or deltas. Environmental monitoring is required in certain areas identified as requiring further information on the fate and, in some cases, the effects of discharged drilling muds.

To apply for authorization to discharge under the Arctic general permit, operators must request for coverage at least 60 days prior to the initiation of discharge. EPA will assign a permit number to the operation. The permittee must notify EPA at least seven days in advance of discharges.

TAKE HOME POINTS

The take home points from this presentation are the following:

- The Arctic general NPDES waste water discharge permit for exploratory offshore oil and gas activities is in place.
- First oil and gas general permit to require Best Management Practice Plans.
- The permit has a new procedure for drilling muds.
- The permit has new provisions to protect sensitive areas.
- Permit has not been legally challenged.

QUESTIONS AND DISCUSSION

Tom Newbury: You mentioned that the permit is only for exploration, that production is under a different permit. Is the latter permitting procedure in place?

Anne Dailey: No, that permit is not in place for the Arctic because there were no production operations. If there is a production operation, (I have already talked to folks at BP about this with respect to Northstar), we anticipate that they would send in an application for an individual NPDES permit. EPA would handle that as an individual permit for that facility. The reason for that is that there were no production operations when we were developing this permit. Plus, exploratory operations are likely to be there one, two, or maybe three months. Production operations are expected to be there for a very long time. So it is appropriate to look more specifically at the site that they are actually talking about and figuring out what sort of monitoring is needed for that site, giving that site more attention than you would in a general permit. In a general permit, you have to address the whole area. I gather that there may or may not be discharges of mud or produced water discharges under Northstar. BP is examining available options. If there are no or few discharges, then NPDES permit requirements may be slight to even non-existent for Northstar.

But let me follow up also that the Cook Inlet permit, which has expired but the draft permit is open for public comment right now, does cover all exploratory development and production operations because there are many production operations there. Specific limits are proposed for each of the platforms given their specific location.

John Bridges: You say that monitoring is required. Is the applicant required to submit a monitoring plan of what will be specifically monitored?

Anne Dailey: Yes, they are. If an operator is going to propose to discharge in an area where monitoring is required, they are required to develop a plan. EPA and ADEC and the North Slope Borough all will have an opportunity to review those plans.

John Bridges: And are the monitoring results submitted to EPA and to the North Slope Borough?

Anne Dailey: Yes, and to the State. It will be public information.

John Bridges: Is that per year or per five years?

Anne Dailey: Well, the discharge would be there for a short period of time, so there is a requirement that they monitor during the discharge and for a period afterwards.

Appendices

Appendix A
Agenda

MINERALS MANAGEMENT SERVICE - ALASKA OCS REGION

ARCTIC SYNTHESIS MEETING
Sheraton Anchorage Hotel

FINAL AGENDA

MONDAY, 23 OCTOBER 1995 - KUSKOKWIM ROOM

8:30 am Registration and Coffee

INTRODUCTORY SESSION

9:00 am Opening and Welcome

Dr. Cleve Cowles, Chief, Environmental Studies Section, MMS, Anchorage

Major initiatives by the MMS Alaska OCS Region, including responsibilities for the development units

Judith Gottlieb, Regional Director, MMS, Anchorage

Cynthia Quarterman, Director, MMS, Washington, DC

Jeff Walker, MMS, Anchorage, moderator of following session

9:15 am Northstar Development Project

Terry Obeney, BP Exploration (Alaska) Inc., Anchorage

10:00 am 30 MINUTE BREAK

10:30 am Kuvlum Unit - Development Options

Jim Watt, Union Texas Petroleum, Houston, TX

10:45 am State of Alaska leasing program and development unit responsibilities

James Hansen, Alaska Dept. of Natural Resources, Anchorage

11:00 am Arctic offshore production - a Canadian perspective

Nick Vanderkooy, CANMAR, Ltd., Calgary, Alberta

11:30 am Session summary, including MMS Stakeholder Task Force processes

Jeff Walker, MMS, Anchorage

12:00 to 1:30 pm LUNCH

MINERALS MANAGEMENT SERVICE - ALASKA OCS REGION

ARCTIC SYNTHESIS MEETING
Sheraton Anchorage Hotel

FINAL AGENDA

MONDAY, 23 OCTOBER 1995 - KUSKOKWIM ROOM

SOCIOCULTURAL SESSION

Co-chaired by Delbert Rexford, Office of the Mayor, North Slope Borough (NSB) and Dr. Steve J. Langdon, Dept. of Anthropology, University of Alaska Anchorage (UAA)

1:30 pm An overview of North Slope society: past and future

Dr. Steve J. Langdon, Dept. of Anthropology, UAA

2:00 pm History of subsistence whaling during the fall migration at Kaktovik, Nuiqsut, and Barrow

Joseph Kaleak, Whaling Captain, Kaktovik

Frank Long, Jr., President, Nuiqsut Whaling Captains Assn.

Burton Rexford, Chair, Alaska Eskimo Whaling Commission (AEWC), Barrow, with Thomas Agiak, AEWC Commissioner of Kaktovik and Thomas Napageak, AEWC Commissioner of Nuiqsut

3:30 pm 30 MINUTE BREAK

4:00 pm Overview of recent sociocultural studies in Nuiqsut and Kaktovik, Alaska

Sverre Pedersen, Division of Subsistence, Alaska Dept. of Fish and Game, Fairbanks

4:30 pm Summary of session

Dr. Steve J. Langdon, Dept. of Anthropology, UAA

5:00 pm ADJOURN

MINERALS MANAGEMENT SERVICE - ALASKA OCS REGION

ARCTIC SYNTHESIS MEETING
Sheraton Anchorage Hotel

FINAL AGENDA

TUESDAY, 24 OCTOBER 1995 - KUSKOKWIM ROOM

7:30 am Registration and Coffee

BOWHEAD WHALE SESSION

Chaired by: Dr. Thomas Albert, Dept. of Wildlife Management, North Slope Borough (NSB), Barrow

8:00 am The bowhead whale migration of Fall 1994

Steve Treacy and Warren Horowitz, MMS, Anchorage

8:30 am Tracking the habits of bowhead whales with satellite-monitored radio tags

Dr. Bruce Mate, Oregon State University, Newport, OR

9:00 am Acoustic effects on bowhead whales: overview

Dr. W. John Richardson, LGL Ltd., environmental research associates (LGL), King City, Ontario

9:20 am Industrial sources of underwater noise

Dr. Charles Greene, Jr., Greeneridge Sciences, Inc., Santa Barbara, CA

9:50 am Acoustic effects on bowheads and belugas during spring migration

Dr. W. John Richardson, LGL, King City, Ontario

10:10 am 20 MINUTE BREAK

10:30 am Letters of Authorization for Incidental Take of Marine Mammals

Ron Morris, National Marine Fisheries Service, Anchorage

11:00 am BP's bowhead whale monitoring near the Northstar Unit, August 1995

Dr. Christopher J. Herlugson, BP, Anchorage

11:15 am Summary of session, including overview of NSB bowhead whale research

Dr. Thomas Albert, Department of Wildlife Management, NSB, Barrow

11:30 am 15 MINUTE BREAK

11:45 am GUEST SPEAKER

Arctic Marine Pipelines

David S. McKeehan, INTEC Engineering, Houston, TX

12:30 to 1:30 pm LUNCH

MINERALS MANAGEMENT SERVICE - ALASKA OCS REGION

ARCTIC SYNTHESIS MEETING
Sheraton Anchorage Hotel

FINAL AGENDA

TUESDAY, 24 OCTOBER 1995 - KUSKOKWIM ROOM

GENERAL BIOLOGY SESSION

Chaired by Lori Quakenbush, Fish and Wildlife Service (FWS), Fairbanks

1:30 pm Overview of species that may be affected by development within the Arctic Alaska OCS Region

Lori Quakenbush, FWS, Fairbanks

1:50 pm Summary of Polar Bear Habitat Conservation Strategy and implications for future oil and gas development

Scott Schliebe, FWS, Anchorage

2:10 pm Overview of research and monitoring in the OCS conducted by the National Biological Service (NBS)

Lyman Thorsteinson, NBS, Seattle, WA

2:30 pm Preliminary research on Pacific Walrus to evaluate potential effects of disturbance by OCS related oil and gas activities in the Chukchi Sea

Chadwick V. Jay, NBS, Anchorage

2:50 pm Using implanted satellite transmitters to track the movements of murres and puffins

Dr. Scott Hatch, NBS, Anchorage

3:10 pm 20 MINUTE BREAK

3:30 pm Population studies of murres and kittiwakes at Cape Lisburne and Cape Thompson

David Roseneau, FWS, Homer

3:50 pm University of Alaska Coastal Marine Institute sponsored studies in the Arctic OCS

Dr. John J. Goering, School of Fisheries and Ocean Sciences, University of Alaska, Fairbanks

4:10 pm Overview of the U.S. Fish and Wildlife Service's Ecosystem Approach to the management of fish and wildlife

Larry Bright, FWS, Fairbanks

4:30 pm Summary of session

Lori Quakenbush, FWS, Fairbanks

5:00 pm ADJOURN

MINERALS MANAGEMENT SERVICE - ALASKA OCS REGION

ARCTIC SYNTHESIS MEETING
Sheraton Anchorage Hotel

FINAL AGENDA

WEDNESDAY, 25 OCTOBER 1995 - KUSKOKWIM ROOM

7:30 am Registration and Coffee

PHYSICAL AND GEOLOGICAL SESSION

Chaired by Dr. Dick Prentki, MMS, Anchorage

8:00 am Overview of physical and geological processes that would be affected by operations at the development units

Dr. Dick Prentki, MMS, Anchorage

8:15 am A coupled ice-ocean model of the Beaufort and Chukchi Seas

Dr. Kate Hedstrom, Rutgers University, New Brunswick, NJ

8:45 am Trends in occurrence rates for offshore oil spills and the Beaufort Sea

Dr. Dick Prentki, MMS, Anchorage

9:15 am Analysis and forecasting of sea ice conditions of the Alaskan North Slope

Jeff Andrews, National Ice Center, Washington, DC

9:45 am 30 MINUTE BREAK

10:15 am Modeling and prediction of ice hazards near the OCS development prospects in the Beaufort Sea

Dr. Igor Appel, Fairweather Forecasting, Inc., Anchorage

10:45 am New Arctic National Pollutant Discharge Elimination System (NPDES) general permit

Anne Dailey, Environmental Protection Agency, Seattle, WA

CONCLUDING SESSION

11:15 am Concluding Synthesis by panel, including Conference Chair and all Session Chairs.

12:00 NOON ADJOURN

Appendix B
Attendee List

MMS/AOCS REGION ARCTIC SYNTHESIS MEETING

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The Department of the Interior Mission

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering sound use of our land and water resources; protecting our fish, wildlife, and biological diversity; preserving the environmental and cultural values of our national parks and historical places; and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people by encouraging stewardship and citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

The Minerals Management Service Mission

As a bureau of the Department of the Interior, the Minerals Management Service's (MMS) primary responsibilities are to manage the mineral resources located on the Nation's Outer Continental Shelf (OCS), collect revenue from the Federal OCS and onshore Federal and Indian lands, and distribute those revenues.

Moreover, in working to meet its responsibilities, the **Offshore Minerals Management Program** administers the OCS competitive leasing program and oversees the safe and environmentally sound exploration and production of our Nation's offshore natural gas, oil, and other mineral resources. The MMS **Royalty Management Program** meets its responsibilities by ensuring the efficient, timely, and accurate collection and disbursement of revenue from mineral leasing and production due to Indian tribes and allottees, States, and the U.S. Treasury.

The MMS strives to fulfill its responsibilities through the general guiding principles of: (1) being responsive to the public's concerns and interests by maintaining a dialogue with all potentially affected parties and (2) carrying out its programs with an emphasis on working to enhance the quality of life for all Americans by lending MMS assistance and expertise to economic development and environmental protection.