Shell Exploration & Production Company
3601 C Street, Suite 1334
Anchorage, AK 99503

February 7, 2007

National Marine Fisheries Service
Office of Protected Resources
Marine Mammal Division
Attn: James H. Lecky, Director
1315 East - West Highway
Silver Spring, MD 20910-3226

Subject: Request for Approval, Incidental Harassment Authorization for Non-Lethal Taking of Whales and Seals in the Chukchi and Mid and Eastern Beaufort Sea, Alaska During 2007 Open Water Seismic Program – Supplemental Information – 2007 Marine Mammal Monitoring and Mitigation Plan for Seismic Exploration in the Alaskan Beaufort and Chukchi Seas

Dear Mr. Lecky:

Shell Offshore, Inc. (SOI) and its geophysical (seismic) contractor WesternGeco propose to conduct a marine geophysical (deep seismic) survey program during open-water season on various U.S. Minerals Management Service (MMS) Outer Continental Shelf (OCS) lease blocks in the Chukchi and Mid and Eastern Beaufort Seas. On November 22, 2006, SOI and WesternGeco requested an Incidental Harassment Authorization (IHA) pursuant to Section 101 (a) (5) (D) of the Marine Mammal Protection Act (MMPA), 16 U.S.C. § 1371 (a) (5), to allow non-lethal takes of whales and seals incidental to offshore geophysical seismic operations.

Items presented pursuant to 50 C.F.R. § 216.104, "Submission of Requests", and § 216.107, "Incidental Harassment Authorization for Arctic Waters", were attached with the application. SOI is supplementing our 2007 open water seismic program IHA application with the 2007 Marine Mammal Monitoring and Mitigation Plan.

Please contact me at (907) 770-3700 for further information.

Sincerely,
Shell Exploration and Production Co.

Susan Childs
Regulatory Affairs Coordinator, Alaska

Attachment: 2007 Marine Mammal Monitoring and Mitigation Plan for Seismic Exploration in the Alaskan Beaufort and Chukchi Seas

cc w/attachment:

Maggie Ahmaogak, Alaska Eskimo Whaling Commission - Barrow, AK
Jeff Walker, Minerals Management Service – Anchorage, AK
Doug DeMaster, NOAA Fisheries - Seattle, WA
Ken Hollingshead, NOAA Fisheries - Silver Spring, MD
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Project File
Administrative File

15214-D-07-014/07-047

MARINE MAMMAL MONITORING AND MITIGATION PLAN

for

Seismic Exploration in
the Alaskan Chukchi and Beaufort Seas, 2007

Alaska Research Associates, Inc.

Prepared for

Shell Offshore Incorporated

MARINE MAMMAL MONITORING AND MITIGATION PLAN

for

Seismic Exploration in
the Alaskan Chukchi and Beaufort Seas, 2007

Prepared by

LGL Alaska Research Associates, Inc.

Prepared for

Shell Offshore Incorporated

February 2007

TABLE OF CONTENTS

INTRODUCTION

Shell Offshore Incorporated (SOI) has contracted LGL Alaska Research Associates, Inc. (LGL) to design and conduct a Marine Mammal Monitoring and Mitigation Program (MMMMP) for their open-water seismic activities in the Chukchi and Beaufort seas in 2007. The goal of the MMMMP is to develop a program that supports protection of the marine mammal resources in the area, fulfills reporting obligations to the Minerals Management Service (MMS), the National Marine Fisheries Service (NMFS), and the U.S. Fish and Wildlife Service (USFWS), and provides data useful for monitoring and understanding the impacts of seismic exploration activities on cetaceans and pinnipeds.

The program consists of monitoring and mitigation during SOI's seismic activities that will provide information on the numbers of marine mammals potentially affected by the seismic program and real time mitigation to prevent possible injury of marine mammals by seismic sounds. The first portion of this monitoring plan describes the methods that SOI plans to use to accomplish the monitoring and mitigation tasks associated with its offshore seismic program in the Chukchi and Beaufort seas in 2007. The second portion of this plan describes other studies designed to add to current knowledge of marine mammal distribution and abundance to be funded cooperatively by SOI and other industry groups. Monitoring efforts will be initiated to collect data to address the following specific objectives:

- improve the understanding of the distribution and abundance of marine mammals in the Chukchi and Beaufort sea project areas;
- understand the propagation and attenuation of anthropogenic sounds in the waters of the project areas;
- determine the ambient sound levels in the waters of the project areas;
- assess the effects of sound on marine mammals inhabiting the project areas and their distribution relative to the local people that depend on them for subsistence hunting.

These objectives and the monitoring and mitigation goals will be addressed by

- vessel-based marine mammal observers on the seismic source and other support vessels;
- an acoustic program to predict and then measure the sounds produced by the seismic operations and the possible responses of marine mammals to those sounds;
- aerial monitoring and reconnaissance of marine mammals available for subsistence harvest along the Chukchi Sea coast; and
- bottom-founded autonomous acoustic recorder arrays along the Alaskan coast and offshore in the Chukchi and Beaufort seas to record ambient sound levels, vocalizations of marine mammals, and received levels of seismic operations should they be detectable.

UNDERWATER SEISMIC ACOUSTIC MEASUREMENT PROGRAM

Background

As part of the IHA application process for similar seismic acquisition in 2006, SOI contracted JASCO Research Ltd. to model the distances from WesternGeco's airgun array on the SOI source vessel, the MV *Gilavar*, to various broadband received levels of 190, 180, 170, 160, and 120 dB_{rms} re 1 μPa. The model estimated the broadband received sound level in water in relation to properties of the airgun array along with various environmental and physical characteristics. These modeled radii were used to define temporary safety radii that were used prior to and during measurements of the actual sounds produced by the airgun array at the beginning of the field season. These measured radii were used to establish actual safety radii that were used for mitigation during the 2006 seismic exploration activities in the Chukchi Sea.

In 2007 SOI plans to again use the *Gilavar* as its seismic source vessel. Assuming that an airgun array identical to the one used in 2006 (WesternGeco's 3147 in^3 Bolt-Gun Array) is used during 2007, and that SOI's seismic acquisition during 2007 occurs in the same general location in the Chukchi Sea as the 2006 surveys, SOI does not plan to make empirical measurements of the airgun array in 2007 in the Chukchi Sea. For this scenario SOI would use the same safety radii that were developed during 2006 for marine mammal mitigation during the 2007 field season. However, SOI will measure the sound propagation of the airgun array if (1) an airgun array different from the array used during 2006 is used during the 2007 surveys, (2) the 2007 surveys in the Chukchi Sea are conducted in a different location than the surveys in 2006, or (3) if there is some other compelling reason to re-measure the sound propagation from the airgun array used during 2006.

SOI will conduct measurements of the sound produced from the airgun array in the Beaufort Sea. This was not accomplished in 2006 due the presence of ice and other logistical considerations which precluded the *Gilavar* from entering the Beaufort Sea. Sound source measurements will be conducted by JASCO, Greeneridge, or other qualified contractor in the general area where seismic activities are planned. Results of the measurements will be used to determine the actual safety radii to be used for mitigation during the seismic activities.

Objectives

The objectives of the planned work in 2007 in the Beaufort Sea (and Chukchi Sea if necessary) will be (1) to measure the distances from the airguns to broadband received levels of 190, 180, 170, 160, and 120 dB_{rms} re 1 μPa for various airgun array combinations that may be used during the seismic acquisition process and for a single airgun used during power downs, and (2) to measure the radiated sounds vs. distance from the source and support vessels. The measurements will be made at the beginning of the survey and the distances to the various radii will be reported within 72 hours of completing the measurements. The primary radii of concern will be the 190 and 180 dB safety radii for pinnipeds and cetaceans, respectively, and the 160 dB disturbance radii.

In addition to reporting the radii of specific regulatory concern, distances to other sound isopleths down to 120 dB_{rms} (if measurable) will be reported in increments of 10 dB.

Technical Approach

Airgun Source and Vessel Measurement

For the airgun array, the source measurement program will be designed to capture high resolution recordings from the airgun array source pressure waveforms as a function of distance and direction from the array. Measurements will be made by qualified acousticians using on-bottom hydrophone (OBH) systems. The systems provide an autonomous recorder that is deployed on the seabed using an acoustic release system. The recorder will be deployed along a survey track ahead of the vessel to capture the airgun array sound as the survey vessel approaches, passes over, and departs from the recording location. The units will also be deployed to the side of the survey lines at various distances to measure airgun sounds in relation to distance in the broadside direction (at right angles to tow direction). In addition to the airgun array, the bottom founded units will also measure noise from the seismic vessel and support (chase) vessels. The bottom founded units are ideal for the water depths present over the entire survey region. These systems were used during measurements of sound propagation of the SOI airgun array at the beginning of the 2006 field season.

Field analysis and reporting: Data will be previewed in the field immediately after download from the instruments. This approach will ensure that good-quality data are being received throughout the field program. Brief daily reports will be issued to the seismic operators by electronic mail when that capability is available. An initial sound source analysis will be supplied to NMFS and the seismic operators within 72 hours of completion of the measurements, if possible. A detailed report will be issued to NMFS as part of the 90 day report following completion of the seismic program.

VESSEL–BASED MARINE MAMMAL MONITORING PROGRAM

Introduction

Vessel–based marine mammal observers will be the core of the program for the SOI seismic program in the Chukchi and Beaufort seas. The MMMMP will be designed primarily to meet the requirements of the IHAs issued by the NMFS and USFWS for this project, and to meet any other stipulations or requests agreed to between SOI and other agencies or groups such as the MMS and the AEWC. The objectives of the stipulations or agreed actions are to ensure that disturbance of marine mammals and subsistence hunts are minimized, that effects on cetaceans and pinnipeds are documented, and to monitor the occurrence and distribution of all marine mammals encountered in the study area including cetacean and pinniped species. Those objectives will be achieved, in part, through the vessel-based monitoring and mitigation program.

The Program will be implemented by a team of experienced marine mammal observers (MMOs), including both biologists and Inupiat personnel. The MMOs will be

stationed aboard the seismic source vessel and other support vessels (chase boats, supply vessel) throughout the seismic exploration period. The duties of the MMOs will include watching for and identifying cetaceans and pinnipeds (as well as seabirds when possible); recording their numbers, distances, and reactions to the seismic operations; initiating mitigation measures when appropriate; and reporting the results. MMOs aboard the seismic source vessel will be on watch during all daylight periods when the airguns are in operation, and when airgun operations are to start up at night (details below). Reporting of the results of the vessel-based monitoring program will include the estimation of the number of "takes", as stipulated in the IHAs. Take estimates will be based on data collected from the source vessel during periods with and without seismic activities, and on data collected by MMOs from the dedicated vessel surveys, from chase boats and other support vessels.

Source Vessel Monitoring

Vessel-based operations of the MMMMP will be required to support the 3-D seismic source vessels prior to and during operations in the Chukchi (approximately mid-July to late August) and Beaufort (approximately late August to October) seas. The dates will depend upon ice and weather conditions, along with industry's arrangements with agencies and stakeholders. Vessel-based monitoring for cetaceans and pinnipeds will be done throughout the period of seismic operations to comply with anticipated provisions in the IHAs that SOI expects to receive from NMFS and USFWS.

The vessel-based work will provide

- the basis for real-time mitigation (airgun power downs and, as necessary, shut downs), as called for by the IHAs,
- information needed to estimate the "take" of marine mammals by harassment, which must be reported to NMFS and USFWS,
- data on the occurrence, distribution, and activities of marine mammals in the areas where the seismic program is conducted,
- information to compare the distances, distributions, behavior, and movements of marine mammals relative to the source vessels at times with and without seismic activity,
- a communication channel to Inupiat whalers through the Communications Coordination Center in coastal villages, and
- continued employment and capacity building for local residents, with one objective being to develop a larger pool of experienced Inupiat MMOs.

The Program will be operated and administered consistent with MMS NTL 2004-G01 or such alternative requirements as may be specified in the IHAs or other authorizations issued by NMFS and MMS for this project. Any other stipulations or agreements made between SOI and agencies or groups such as MMS, USFWS, and AEWC will also be fully taken into account. All MMOs will be certified through a training program approved by NMFS and industry participants, as described below. At least one observer on each vessel will be an Inupiat who will have the additional responsibility of communicating with the Inupiat community and (during the whaling season) directly

with the Communications Coordination Center in coastal villages. Details of the vessel-based marine mammal monitoring program are described below.

Mitigation Measures

The proposed seismic exploration program incorporates both design features and operational procedures for minimizing potential impacts on cetaceans and pinnipeds and on subsistence hunts. The design features and operational procedures have been described in the IHA applications submitted to NMFS and USFWS and are summarized below. Survey design features include:

- timing and locating seismic activities to avoid interference with the annual fall bowhead whale hunts;
- configuring the airgun arrays to maximize the proportion of energy that propagates downward and minimizes horizontal propagation;
- limiting the size of the seismic energy source to only that required to meet the technical objectives of the seismic survey; and
- conducting pre-season modeling and early season field assessments to establish and refine (as necessary) the appropriate 180 dB and 190 dB safety zones, and other radii relevant to behavioral disturbance.

The potential disturbance of cetaceans and pinnipeds during seismic operations will be minimized further through the implementation of several ship-based mitigation measures.

Safety and Disturbance Zones

Under current NMFS guidelines (e.g., NMFS 2000), "safety radii" for marine mammals around airgun arrays are customarily defined as the distances within which received pulse levels are ≥180 dB re 1 μPa (rms) for cetaceans and ≥190 dB re 1 μPa (rms) for pinnipeds. The ≥190 dB re 1 μPa (rms) guideline was also employed by the USFWS for the animals under its jurisdiction (polar bears and walruses) in its IHA issued to SOI in 2006. These safety criteria are based on an assumption that seismic pulses at lower received levels will not injure these animals or impair their hearing abilities, but that higher received levels *might* have some such effects. Marine mammals exposed to ≥160 dB (rms) are assumed by NMFS to be potentially subject to behavioral disturbance.

SOI anticipates that monitoring similar to that conducted in the Chukchi Sea in 2006 will also be required in the Chukchi and the Beaufort seas in 2007. SOI plans to use MMOs onboard the seismic vessel to monitor the 190 and 180 dB (rms) safety radii for pinnipeds and cetaceans, respectively and to implement appropriate mitigation as discussed below. SOI also plans to monitor the 160 dB (rms) disturbance zone with MMOs onboard the chase vessel in 2007 as was done in 2006. There has also been concern that received pulse levels as low as 120 dB (rms) may have the potential to disturb some whales. In 2006, there was a requirement in the Incidental Harassment Authorization issued to SOI by NMFS to implement special mitigation measures if specified numbers of bowhead cow/calf pairs might be exposed to ≥120 dB rms or if large groups (≥12 individuals) of bowhead or gray whales might be exposed to ≥160 dB rms . Monitoring of the 120 dB (rms) zone was required in the Chukchi Sea after 25

September. SOI anticipates that it will not be operating in the Chukchi Sea after 25 September, and it is likely that SOI will not need to monitor the 120 dB (rms) zone in the Chukchi Sea in 2007. However, it is likely that SOI will be operating in the Beaufort Sea after 1 September in 2007, and SOI anticipates the need to monitor the 120 dB zone. Mitigation and monitoring methods are discussed in the sections below.

If the seismic acquisition equipment used in 2007 is the same as the equipment used during the 2006 field season, SOI plans to use the same safety radii developed during 2006 for marine mammal mitigation in the Chukchi Sea during 2007. Initial safety radii for the Chukchi and Beaufort seas were modeled and estimated by JASCO Research Ltd. prior to seismic exploration activities in 2006. Modeling of the sound propagation was based on the size and configuration of the airgun array and on available oceanographic data. If the airgun array used in 2007 is different from the array used in 2006, JASCO will model and estimate new radii based on the specifications of the new array for both the Chukchi and Beaufort seas. Those safety zones will be used for mitigation purposes until direct measurements are available early during the seismic survey. If the same seismic acquisition equipment used in 2006 is used during 2007, then measurements of the sound produced by the airgun array will only be conducted in the Beaufort Sea. An acoustics contractor will perform the direct measurements of the received levels of underwater sound versus distance and direction from the airgun arrays using calibrated hydrophones. The acoustic data will be analyzed as quickly as reasonably practicable in the field and used to verify (and if necessary adjust) the safety distances. The mitigation measures to be implemented will include ramp ups, power downs, and shut downs as described below.

RampUps

A ramp up of an airgun array provides a gradual increase in sound levels, and involves a step-wise increase in the number and total volume of airguns firing until the full volume is achieved. The purpose of a ramp up (or "soft start") is to "warn" cetaceans and pinnipeds in the vicinity of the airguns and to provide the time for them to leave the area and thus avoid any potential injury or impairment of their hearing abilities.

During the proposed seismic program, the seismic operator will ramp up the airgun arrays slowly. Full ramp ups (i.e., from a cold start after a shut down, when no airguns have been firing) will begin by firing a small airgun in the arrays. The minimum duration of a shut-down period, i.e., without air guns firing, which must be followed by a ramp up typically is the amount of time it would take the source vessel to cover the 180-dB safety radius. That depends on ship speed and the size of the 180-dB safety radius, which are not known at this time. We estimate that period to be about 8-10 minutes.

A full ramp up, after a shut down, will not begin until there has been a minimum of a one half hour period of observation by MMOs of the safety zone to assure that no marine mammals are present. The entire safety zone must be visible during the 30-minute lead-in to a full ramp up. If the entire safety zone is not visible, then ramp up from a cold start cannot begin. If a marine mammal(s) is sighted within the safety zone during the 30-minute watch prior to ramp up, ramp up will be delayed until the marine mammal(s) is sighted outside of the safety zone or the animal(s) is not sighted for at least 15-30

minutes: 15 minutes for small odontocetes and pinnipeds, or 30 minutes for baleen whales and large odontocetes.

During periods of turn around and transit between seismic transects, at least one airgun will remain operational. The ramp-up procedure still will be followed when increasing the source levels from one air gun to the full arrays. However, keeping one air gun firing will avoid the prohibition of a cold start during darkness or other periods of poor visibility. Through use of this approach, seismic operations can resume upon entry to a new transect without a full ramp up and the associated 30-minute lead-in observations. MMOs will be on duty whenever the airguns are firing during daylight, and during the 30-min periods prior to ramp-ups as well as during ramp-ups. Daylight will occur for 24 h/day until mid-August, so until that date MMOs will automatically be observing during the 30-minute period preceding a ramp up. Later in the season, MMOs will be called out at night to observe prior to and during any ramp up. The seismic operator and MMOs will maintain records of the times when ramp-ups start, and when the airgun arrays reach full power.

Power Downs and Shut Downs

A power down is the immediate reduction in the number of operating airguns from all guns firing to some smaller number. A shut down is the immediate cessation of firing of all airguns. The airgun arrays will be immediately powered down whenever a marine mammal is sighted approaching close to or within the applicable safety zone of the full airgun arrays, but is outside the applicable safety zone of the single airgun. If a marine mammal is sighted within the applicable safety zone of the single airgun, the airgun array will be shut down (i.e., no airguns firing). Although observers will be located on the bridge ahead of the center of the airgun array, the shutdown criterion for animals ahead of the vessel will be based on the distance from the bridge (vantage point for MMOs) rather than from the airgun array – a precautionary approach. For marine mammals sighted alongside or behind the airgun array, the distance is measured from the array.

Operations at Night and in Poor Visibility

When operating under conditions of reduced visibility attributable to darkness or to adverse weather conditions, infra-red or night-vision binoculars will be available for use. However, it is recognized that their effectiveness is limited. For that reason, MMOs will not routinely be on watch at night, except in periods before and during ramp-ups.

Note that if one small airgun has remained firing, the rest of the array can be ramped up during darkness or in periods of low visibility. Seismic operations may continue under conditions of darkness or reduced visibility.

Marine Mammal Observers

Vessel-based monitoring for marine mammals will be done throughout the period of seismic operations to comply with provisions in the IHAs. Those provisions will be implemented during the seismic program by a team of trained MMOs. The observers will monitor the occurrence and behavior of marine mammals near the seismic vessel during all daylight periods when the airgun arrays are operating, and during most daylight periods when they are not operating. Their duties will include watching for and

identifying marine mammals; recording their numbers, distances, and reactions to the seismic operations; advising seismic survey personnel of the presence of mammals within or approaching the designated "safety zones"; initiating mitigation measures (ramp ups, power downs, shut downs) when appropriate; and documenting "take by harassment" as defined by NMFS.

Number of observers

A sufficient number of MMOs will be required onboard each seismic source vessel to meet the following criteria if stipulated in the IHAs:

- 100% monitoring coverage during all periods of seismic operations in daylight, and for the 30 minutes prior to full ramp ups;
- coverage during darkness for 30-min before and during ramp-ups;
- maximum of 4 consecutive hours on watch per MMO;
- maximum of approx. 12 hours on watch per day per MMO;
- two-observer coverage during ramp ups and the 30 minutes prior to full ramp ups, and for as large a fraction of the other operating hours as possible.

To meet those criteria, SOI plans to place from three to five MMOs aboard the source vessel at any one time during all seismic operations. The specific number of MMOs during any period would depend on day length, berthing availability, lifeboat space, IHAs and other permit requirements, and the planned seismic operations. NMFS requirements specify that MMOs not be on duty for more than 4 consecutive hours although more than one 4-hour shift per day is acceptable. MMOs also require sufficient time for daily data entry, data checking, and other tasks aside from visual watches, and for sleep and meals.

MMO teams aboard seismic vessels will consist of at least one Inupiat observer (two are preferable if available) and one to three biologists. An experienced field crew leader will be a member of every MMO team onboard seismic source vessels at all times during the seismic program. The total number of MMOs aboard may decrease later in the season as the duration of daylight decreases and if there is no requirement for continuous nighttime monitoring. If operations occur during the whaling season, the Inupiat observer(s) also will serve as a part-time Communicator with an industry/whaler coordination center in the coastal villages. The requirement for, and role of, the Inupiat observers are expected to be defined in the "Conflict Avoidance Agreement" between SOI and the AEWC.

Crew Rotation

SOI anticipates that there will be provision for crew rotation every six weeks. To facilitate monitoring consistency during MMO crew changes, detailed hand-over notes will be prepared for the oncoming crew leader. If possible, there will also be communications (e.g., email, fax, and/or phone) between the current and oncoming crew leaders during each cruise.

Observer Qualifications and Training

Crew leaders and most other biologists serving as observers in 2007 will be individuals with experience as observers during one or more of the 1996-2001 and 2006 seismic monitoring projects for WesternGeco or BP, and/or subsequent seismic monitoring projects for other clients in Alaska, the Canadian Beaufort, or other offshore areas if feasible.

Biologist-observers to be assigned will have previous marine mammal observation experience, in many cases aboard seismic vessels, and field crew leaders will be highly experienced with previous vessel-based seismic monitoring projects. Résumés for those individuals will be provided to NMFS so that NMFS can review and accept their qualifications. Inupiat observers will be experienced in the region, and familiar with the marine mammals of the area. A marine mammal observers' handbook, adapted for the specifics of the proposed seismic program from the handbooks created for previous seismic monitoring projects will be prepared and distributed beforehand to all MMOs (see below).

Most observers, including Inupiat observers, will also complete a two-day training and refresher session on marine mammal monitoring, to be conducted shortly before the anticipated start of the 2007 open-water season. (Any exceptions will have or receive equivalent experience or training.) The training session(s) will be conducted by marine mammalogists with extensive crew-leader experience during previous vessel-based seismic monitoring programs.

Primary objectives of the training include:

- review of the marine mammal monitoring plan for this project, including any amendments specified by NMFS or USFWS in the IHAs, by MMS, or by the Conflict Avoidance Agreement with the AEWC;
- review of marine mammal sighting, identification, and distance estimation methods, including any amendments specified by NMFS or USFWS in the 2007 IHAs;
- review of operation of specialized equipment (reticle binoculars, night vision devices, and GPS system);
- review of, and classroom practice with, data recording and data entry systems, including procedures for recording data on mammal sightings, seismic and monitoring operations, environmental conditions, and entry error control. These procedures will be implemented through use of a customized computer database and laptop computers;
- review of the 2007 Conflict Avoidance Agreement, including the specific tasks of the Inupiat part-time Communicator.

MMO Handbook

A Marine Mammal Observers' Handbook has been prepared for use by MMOs onboard the seismic source and support vessels. The handbook contains maps, illustrations, and photographs as well as text and is intended to provide guidance and reference information to trained individuals who will participate as MMOs. The

following topics will be covered in the MMO Handbook for the seismic monitoring project in the Chukchi and Beaufort seas:

- summary overview descriptions of the project, marine mammals and underwater noise, seismic operations, the marine mammal monitoring program (vessel-based, aerial, acoustic measurements, special studies), the NMFS and USFWS IHAs and other regulations/permits/agencies, the Marine Mammal Protection Act, issues (e.g., subsistence hunt), the Plan of Cooperation, and the Conflict Avoidance Agreement;
- monitoring and mitigation objectives and procedures, safety radii;
- responsibilities of staff and crew regarding the marine mammal monitoring plan and the operations of the seismic vessel;
- instructions for ship crew regarding the marine mammal monitoring plan;
- data recording procedures: codes and coding instructions, common coding mistakes, electronic database; navigational, marine physical, and seismic data recording, field data sheet;
- use of specialized field equipment (reticle binoculars, NVDs, laser rangefinders);
- reticle binocular distance scale;
- table of wind speed, Beaufort wind force, and sea state codes;
- data storage and backup procedures;
- list of species that might be encountered: identification, natural history;
- safety precautions while onboard;
- crew and/or personnel discord; conflict resolution among MMOs and crew;
- drug and alcohol policy and testing;
- scheduling of cruises and watches;
- communications;
- list of field gear that will be provided;
- suggested list of personal items to pack;
- suggested literature, or literature cited.
- copies of the NMFS and USFWS IHAs and the Conflict Avoidance Agreement will be made available.

Monitoring Methodology

The observer(s) will watch for marine mammals from the best available vantage point on the operating source vessel, which is usually the bridge or flying bridge. The observer(s) will scan systematically with the naked eye and 7 × 50 reticle binoculars, supplemented with night-vision equipment when needed (see below). Personnel on the bridge will assist the marine mammal observer(s) in watching for pinnipeds and whales.

The observer(s) will give particular attention to the areas within the "safety zone " around the source vessel. These zones are the maximum distances within which received levels may exceed 180 dB re 1 μPa (rms) for cetaceans, or 190 dB re 1 μPa (rms) for other marine mammals.

Information to be recorded by marine mammal observers will include the same types of information that were recorded during WesternGeco's 1998-2001 and 2006 seismic monitoring projects in the Chukchi and Beaufort seas (Moulton and Lawson 2002, Patterson et al. 2007). When a mammal sighting is made, the following information about the sighting will be recorded:

- Species, group size, age/size/sex categories (if determinable), behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from seismic vessel, apparent reaction to seismic vessel (e.g., none, avoidance, approach, paralleling, etc.), closest point of approach, and behavioral pace.
- Time, location, heading, speed, and activity of the vessel, and seismic state (e.g., operating airguns, ramp-up, etc.), sea state, ice cover, visibility, and sun glare.
- The positions of other vessel(s) in the vicinity of the source vessel. This information will be recorded by the MMOs at times of whale (but not seal) sightings.

The ship's position, heading, and speed, the seismic state (e.g., number and size of operating airguns), and water temperature (if available), water depth, sea state, ice cover, visibility, and sun glare will also be recorded at the start and end of each observation watch and, during a watch, every 30 minutes and whenever there is a change in one or more of those variables.

Distances to nearby marine mammals, e.g., those within or near the 190 dB (or other) safety zone applicable to pinnipeds, will be estimated with binoculars (7 × 50) containing a reticle to measure the vertical angle of the line of sight to the animal relative to the horizon.

Observers will use a laser rangefinder to test and improve their abilities for visually estimating distances to objects in the water. Previous experience showed that this Class 1 eye-safe device was not able to measure distances to seals more than about 70 m (230 ft) away. However, it was very useful in improving the distance estimation abilities of the observers at distances up to about 600 m (1968 ft)—the maximum range at which the device could measure distances to highly reflective objects such as other vessels. In our experience, humans observing objects of more-or-less known size via a standard observation protocol, in this case from a standard height above water, quickly become able to estimate distances within about ±20% when given immediate feedback about actual distances during training.

When a marine mammal is seen within the safety radius applicable to that species, the geophysical crew will be notified immediately so that mitigation measures called for by the IHAs can be implemented. As in 1996-2001 and in 2006, it is expected that the airgun arrays will be shut down within several seconds—often before the next shot would be fired, and almost always before more than one additional shot is fired. The marine mammal observer will then maintain a watch to determine when the mammal(s) appear to be outside the safety zone such that airgun operations can resume.

Monitoring At Night and In Poor Visibility

Night-vision equipment ("Generation 3" binocular image intensifiers, or equivalent units) will be available for use when needed. (Prior to mid-August, there will be no hours of total darkness.) However, our past experience with night-vision devices (NVDs) in the Beaufort Sea and elsewhere shows that NVDs are not nearly as effective as visual observation during daylight hours (e.g., Harris et al. 1997, 1998; Moulton and Lawson 2002). Tests of NVDs during seismic surveys in other areas have provided similar results.

Specialized Field Equipment

The operators will provide or arrange for the following specialized field equipment for use by the onboard MMOs: reticle binoculars, laser rangefinders, inclinometer, laptop computers, night vision binoculars, and possibly digital still and digital video cameras.

Field Data-Recording, Verification, Handling, and Security

The observers on the seismic source vessel will record their observations onto datasheets or directly into handheld computers. During periods between watches and periods when operations are suspended, those data will be entered into a laptop computer running a custom computer database. The accuracy of the data entry will be verified in the field by computerized validity checks as the data are entered, and by subsequent manual checking of the database printouts. These procedures will allow initial summaries of data to be prepared during and shortly after the field season, and will facilitate transfer of the data to statistical, graphical or other programs for further processing. Quality control of the data will be facilitated by (1) the start-of-season training session, (2) subsequent supervision by the onboard field crew leader, and (3) ongoing data checks during the field season.

The data will be backed up onto CDs and USB keys, and stored at separate locations on the vessel. If possible, data sheets will be photocopied daily during the field season. Data will be secured further by having data sheets and backup data CDs carried back to the LGL Anchorage office during crew rotations.

In addition to routine MMO duties, Inupiat observers will be encouraged to record comments about their observations into the "comment" field in the database. Copies of these records will be available to the Inupiat observers for reference if they wish to prepare a statement about their observations. If prepared, this statement would be included in the 90-day and final reports documenting the monitoring work.

Field Reports

Throughout the seismic program, the lead MMO will prepare a report each week (or at such other interval as the IHAs or SOI may require) summarizing the recent results of the monitoring program. The reports will be provided to NMFS and will summarize the species and numbers of marine mammals sighted during periods with and without various seismic operations, and the number of shut downs and power downs by species.

Chase Boat Monitoring

Marine mammal observers will also be present on smaller support vessels that travel with the seismic source vessel. These support vessels are commonly known as "guard

boats" or "chase boats". During seismic operations, a chase boat remains very near to the stern of the source vessel anytime that a member of the source vessel crew is on the back deck deploying or retrieving equipment related to the seismic array. Once the seismic array is deployed the chase boat then serves to keep other vessels away from the seismic source vessel and the seismic array itself (including hydrophone streamer) during production of seismic data and provide additional emergency response capabilities.

In the Chukchi and Beaufort seas in 2007, SOI's seismic source vessel will have one associated chase boat and possibly an additional supply vessel. The chase boat and supply vessel (if present) will have two MMOs onboard to collect marine mammal observations and to monitor the 160 dB (rms) disturbance zone. MMOs on the chase boats will be able to contact the seismic ship if marine mammals are sited. To maximize the amount of time during the day that an observer is on duty, the two observers aboard the chase boat or supply vessel will rarely work at the same time. As on the source vessels, shifts will be limited to 4 hrs in length and 12 hrs total in a 24 hr period.

SOI plans to monitor the 160 dB (rms) disturbance radius in 2007 using MMOs onboard the chase vessel as was done in 2006. The 160 dB radius in the Chukchi Sea in 2006 was determined by Blackwell (2006) to extend ~8.4 km from the airgun source on the *Gilavar* (the seismic vessel) and was monitored by MMOs onboard the *Kilabuk* (the chase vessel). During monitoring of the 160 dB zone the *Kilabuk* followed a zig-zag pattern ~6–8 km ahead of the *Gilavar* (Fig. 1). MMOs onboard the *Kilabuk* searched the area ahead of the *Gilavar* within the 160 dB zone for marine mammals. Mitigation (i.e., power down or shut down of the airgun array) was to be implemented if a group of 12 or more bowhead or gray whales entered the 160 dB zone. SOI will use this same protocol in the Beaufort Sea after the 160 dB radius has been determined by direct measurement.

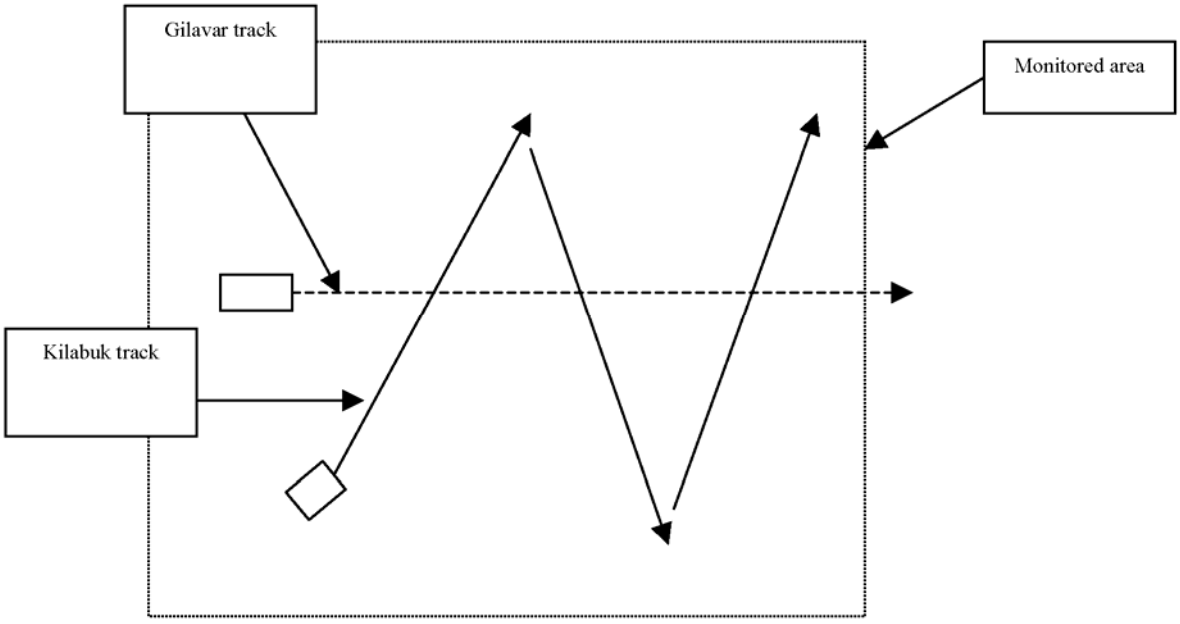

FIGURE 1. Diagram of the path of the *Kilabuk* in front of the *Gilavar* during monitoring of the 160 dB zone.

Reporting

The results of the 2007 vessel-based monitoring, including estimates of "take by harassment", will be presented in the "90-day" and final technical reports. Reporting will address the requirements established by NMFS, USFWS, and other agencies and stakeholders in their negotiations with SOI.

The technical reports will include:

- summaries of monitoring effort: total hours, total distances, and marine mammal distribution through study period versus seismic state, sea state, and other factors affecting visibility and delectability of marine mammals;
- summaries of the occurrence of power-downs, shutdowns, ramp-ups, and ramp-up delays;
- analyses of the effects of various factors influencing delectability of marine mammals: sea state, number of observers, and fog/glare;
- species composition, occurrence, and distribution of marine mammal sightings including date, water depth, numbers, age/size/gender categories, group sizes, and ice cover;
- analyses of the effects of seismic operations including
    - sighting rates of marine mammals versus seismic state (and other variables that could affect detectability);
    - initial sighting distances versus seismic state;
    - closest point of approach versus seismic state;
    - observed behaviors and types of movements versus seismic state;
    - numbers of sightings/individuals seen versus seismic state; and
    - distribution around the seismic source vessel versus seismic state.

Estimates of "take by harassment" will be calculated using two different methods to provide minimum and maximum estimates. The minimum estimate will be based on the numbers of marine mammals directly seen within the relevant safety radii by observers on the seismic source vessel, or nearby support vessels, during seismic activity. The maximum estimate will be calculated using densities of marine mammals determined for non-seismic areas and times. These density estimates will be calculated from data collected during a) vessel based surveys in non-seismic areas, or b) observations from the source vessel or supply boats during non-seismic periods. The estimated densities in areas without seismic activity will be applied to the amount of area exposed to the relevant levels of sound to calculate the maximum number of animals potentially exposed or deflected.

AERIAL SURVEY PROGRAM

Objectives

An aerial survey program will be conducted in support of the seismic exploration program in the Beaufort Sea during summer and fall of 2007. The objectives of the aerial survey will be:

- to advise operating vessels as to the presence of marine mammals in the general area of operation;
- to collect and report data on the distribution, numbers, movement and behavior of marine mammals near the seismic operations with special emphasis on migrating bowhead whales;
- to support regulatory reporting and Inupiat communications related to the estimation of impacts of seismic operations on marine mammals;
- to monitor the accessibility of bowhead whales to Inupiat hunters and
- to document how far west of seismic activities bowhead whales travel before they return to their normal migration paths, and if possible, to document how far east of seismic operations the deflection begins.

Survey Considerations

Different aerial survey designs will be implemented during the summer (August) and fall (late August–October) periods because the numbers and distributions of marine mammal species of primary interest are different during those periods. During the early summer, few cetaceans are expected to be encountered in the Beaufort Sea, and those that are encountered are expected to be either along the coast (gray whales) or among the pack ice (bowheads and belugas) north of the area where seismic surveys and drilling activities are to be conducted. During some years a few gray whales are found feeding in shallow nearshore waters from Barrow to Kaktovik but most sightings are in the western part of that area.

During the late summer and fall, the bowhead whale is the primary species of concern, but belugas and gray whales are also present. Bowheads and belugas migrate through the Alaskan Beaufort Sea from summering areas in the central and eastern Beaufort Sea and Amundsen Gulf to their wintering areas in the Bering Sea. Small numbers of bowheads are sighted in the eastern Alaskan Beaufort Sea starting mid-August and near Barrow starting late August but the main migration does not start until early September. The bowhead migration tends to be through nearshore and shelf waters, although in some years small numbers of whales are seen near the coast and/or far offshore. Bowheads frequently interrupt their migration to feed and their stop-overs vary in duration from a few hours to a few weeks. A commonly used feeding area is in and near Smith Bay, east of Barrow. Less consistently used feeding areas are in coastal and shelf waters near and east of Kaktovik.

The aerial survey procedures will be generally consistent with those during earlier industry studies (Miller et al. 1997, 1998, 1999; Patterson et al. 2007). This will facilitate comparison and pooling of data where appropriate. However, the specific survey grids will be tailored to SOI's operations and the time of year. During the 2007 field season we will coordinate and cooperate with the aerial surveys conducted by MMS and any other groups conducting surveys in the same region, as we have when conducting aerial surveys on behalf of industry and MMS.

It is understood that the timing, duration, and location of SOI's seismic operations are subject to change as a result of unpredictable weather and ice issues, as well as regulatory and stakeholder concerns. The recommended approach is flexible and able to adapt at short notice to changes in the seismic operations.

Safety Considerations

Safety considerations will be of primary importance in all decisions regarding the planning and conduct of the aerial surveys. Safety-related considerations during planning have included choice of aircraft, aircraft operator, and pilots; outfitting of the aircraft; lengths and locations of survey grids; and safety training. Safety-related considerations during aerial survey operations will include careful and judicious consideration of weather; and avoidance of flight in questionable conditions. Although the pilots will have ultimate authority, the aerial survey crew will also be required to make their own judgments and to avoid flying in questionable circumstances. To this end, the aerial survey teams will have extensive experience (~5000 h in the case of the team leader) with this type of survey flying in arctic conditions, and will have the authority to cancel or (in agreement with the pilots) amend flight operations as necessary for safety.

Survey Procedures

Flight and Observation Procedures

Standard aerial survey procedures as used by ourselves and others in many previous marine mammal projects will be followed. This will facilitate comparisons and (as appropriate) pooling with other data, and will minimize any controversy about the chosen survey procedures. The aircraft will be flown at 120 knots ground speed and usually at an altitude of 1000 ft. Surveys in the Beaufort Sea are directed at bowhead whales and an altitude of 900-1000 ft is the lowest survey altitude that can normally be flown without concern about potential aircraft disturbance; it is also the altitude recommended for IHA monitoring efforts for bowhead whales. Aerial surveys at an altitude of 1000 ft do not provide much information about seals but are suitable for both bowhead and beluga whales. The need for a 900-1000+ ft cloud ceiling will limit the dates and times when surveys can be flown. Selection of a higher altitude for surveys would result in a significant reduction in the number of days where surveys would be possible, impairing the ability of the aerial program to meet its objectives.

One of the observers will be seated behind the copilot. Safety guidelines by Shell Aviation require that the copilot occupy the copilot's seat. This is a variation from most earlier surveys where a primary observer was seated in the copilot's seat allowing for better forward visibility and access to radio and navigation equipment. The bubble windows that are currently available in survey aircraft largely mitigate for the reduced visibility in the rear seat; during earlier surveys bubble windows were not available, or if they were available, they were not as well designed and visibility was not as good.

The second observer will be seated behind the pilot and a third observer will be seated behind the copilot's position. The third observer will observe part time and record data the rest of the time. All observers need bubble windows to facilitate downward viewing. For each marine mammal sighting, the observer will dictate the species, number, size/age/sex class when determinable, activity, heading, swimming speed category (if traveling), sighting cue, ice conditions (type and percentage), and inclinometer reading. The inclinometer reading will be taken when the animal's location is 90° to the side of the aircraft track, allowing calculation of lateral distance from the aircraft trackline.

Transect information, sighting data and environmental data will be entered into a GPS-linked data logger by the third observer, and simultaneously recorded on audiotape for backup and validation. At the start of each transect, the observer recording data will record the transect start time and position, ceiling height (ft), cloud cover (in 10ths), wind speed (knots), wind direction (°T) and outside air temperature (°C). In addition, each observer will record the time, visibility (subjectively classified as excellent, good, moderately impaired, seriously impaired or impossible), sea state (Beaufort wind force), ice cover (in 10ths) and sun glare (none, moderate, severe) at the start and end of each transect, and at 2-min intervals along the transect. This will provide data in units suitable for statistical summaries and analyses of effects of these variables (and position relative to seismic vessel) on the probability of detecting animals (see Davis et al. 1982; Miller et al. 1999; Thomas et al. 2002).

The data logger will automatically record time and aircraft position (latitude and longitude) for sightings and transect waypoints, and at preselected intervals along the transects. The primary data logger will be a laptop computer with Garmin Mapsource (ver 6.9) data logging software. Mapsource automatically stores the time and aircraft position at pre-selected intervals (typically between 2-6 sec for straight-line transect surveys) as they are obtained from the GPS unit.

If marine mammals are seen within any "safety zone" around the seismic source vessel or drill ship, or heading toward that zone, the aerial observers will notify personnel on the vessel by radio so that the sighting can be monitored and a power down or shut down the airgun array initiated if necessary.

Selection of Aircraft

Specially-outfitted Twin Otter aircraft are expected to be the survey aircraft. These aircraft will be specially modified for survey work and have been used extensively by NMFS, ADF&G, COPAC, NSB, and LGL during many marine mammal projects in Alaska, including LGL projects as recent as 2006. These types of aircraft have been found to be very suitable for survey work, and are safer than potential alternatives. Among the essential or desirable features are standard IFR instrumentation, STOL kit, radar altimeter with output for computerized data recording, high wing, dual GPS systems with output for computerized data recording, bubble windows, VHF/SSB/FM radios, AC inverter, high-quality intercom, active noise-canceling headsets, adjustable seating positions, and movable computer desk. Endurance depends on fuel tank configuration, load and airspeed, but is generally 3.25 to 6.5 h after allowance for one hour of fuel reserves. The aircraft needs a comprehensive set of survival equipment appropriate to offshore surveys in the Arctic; the suggested aircraft are provided with the appropriate gear. For safety reasons, the aircraft should be operated with two pilots.

Avoiding Fatigue

The size of the survey grids planned for late August–October 2007 are comparable in total length to grids flown during earlier industry surveys. The planned surveys will require up to 8 hours of flying per day, depending on the survey grid. A single team of observers cannot survey for that many hours on a daily basis without becoming fatigued

and missing more mammals than normal. This is especially so when good flying weather persists for 2 or 3 days in a row. Fatigue is exacerbated by the need to spend considerable time on the ground coordinating with other vessel-based and aerial field crews in the morning and evening, and organizing each day's data for the required evening transmissions to MMS and NMFS. To minimize the fatigue problem, during periods when daily surveys are required (mid-September–October), a four or five-person aerial survey crew will be used: two primary observers; data-logger/secondary observer; and one or two additional alternate observers. The alternates will rotate observation duties with the other three observers, and will share the coordination and data summarization responsibilities. It will often be feasible for the "extra" observers to remain on the ground, with rotation occurring when the aircraft lands to refuel or for a brief break. However, at some times the off-duty observers will need to ride in the aircraft and rotate while in flight. During times when surveys are less intensive, e.g., August and early September, a three-person survey crew will be used. Inupiat observers were trained as observers during our 2006 surveys and one or more Inupiat observers will be present during surveys. Use of additional Inupiat observers (trainees) will further reduce fatigue associated with conducting the long survey routes.

Supplementary Data

Weather, ice and sightability data will be recorded systematically during all surveys. Percent ice cover and severity of sun glare will be recorded by each primary observer for every 2-minute interval along transects. Ice observations during aerial surveys will be mapped when ice is present and satellite imagery will be used, where available, to document ice conditions adjacent to the survey area. These are standard practices for surveys of this type, and are necessary in order to interpret factors responsible for variations in sighting rates.

We will, as a high priority, assemble the information needed to relate marine mammal observations to the shooting schedule and locations of the seismic vessel or drillship, and to the estimated received levels of industrial sounds at mammal locations. Data on the shooting schedule, seismic tracklines, and heading of the seismic vessel will be obtained from records maintained by the seismic contractor and some of the information will be available from data recorded by the marine mammal observers on the seismic source vessel (see earlier). During the aerial surveys, we will record relevant information on other industry vessels, whaling vessels, low-flying aircraft, or any other human activities that are seen in the survey area.

Coordination with MMS Aerial Surveys

The Minerals Management Service is planning to continue its wide-ranging aerial surveys of bowhead whales and other marine mammals in the Beaufort Sea during the autumn of 2007 (Dr. C. Monnett, MMS, pers. comm.). Their surveys include the Beaufort Sea part of the SOI study area. SOI will co-ordinate with MMS to obtain access to their data, both during the field season and for use in analyses and reports.

SOI will also consult with MMS regarding coordination during the field season and real-time sharing of data. The aims will be

- to ensure aircraft separation when both crews conduct surveys in the same general region [note this would also apply to the UAS described below];
- to coordinate the 2007 aerial survey projects in order to maximize consistency and minimize duplication;
- to use data from MMS's broad-scale surveys to supplement the results of the more site-specific SOI surveys for purposes of assessing seismic effects on whales and estimating "take by harassment";
- to maximize consistency with previous years' efforts insofar as feasible;

It is expected that raw bowhead sighting and flightline data will be exchanged between MMS and LGL on a daily basis during the field season, and that each team will also submit its sighting information to NMFS in Anchorage each day. After the SOI and MMS data files have been reviewed and finalized, they will be exchanged in digital form. These practices will be consistent with what has been done in the past, and will likely be required by permits and authorizations.

We are not aware of any other related aerial survey programs presently scheduled to occur in the Alaskan Beaufort Sea in areas where SOI is anticipated to be conducting seismic during Jul./Oct. 2007. However, one or more other programs are possible in support of other anticipated industry and research operations. If another aerial survey project were planned, SOI or LGL (with SOI's approval) would seek to coordinate with that project to ensure aircraft separation, maximize consistency, minimize duplication, and share data.

Surveys during Seismic Acquisition

Survey Design in Beaufort Sea in Summer

The main species of concern in the Beaufort Sea is the bowhead whale but small numbers of belugas, and in some years, gray whales, are present in the Beaufort Sea during summer (see above). Few bowhead whales are expected to be found in the Beaufort Sea during early August; however, a reduced aerial survey program is proposed during the summer prior to seismic operations to confirm the distribution and numbers of bowheads, gray whales and belugas, because no recent surveys have been conducted at this time of year. The few bowheads that were present in the Beaufort Sea during summer in the late 1980s were generally found among the pack ice in deep offshore waters of the central Beaufort Sea (Moore and DeMaster 1998; Moore et al. 2000). Although gray whales were rarely sighted in the Beaufort Sea prior to the 1980's (Rugh and Fraker 1981), sightings appear to have become more common along the coast of the Beaufort Sea in summer and early fall (Miller et al. 1999; Treacy 1998, 2000, 2002; Patterson et al. 2007) possibly because of increases in the gray whale population and/or reductions in ice cover in recent years. Because no summer surveys have been conducted in the Beaufort Sea since the 1980s, the information on summer distribution of cetaceans will be valuable for planning future seismic or drilling operations. The grid that will be flown in the summer will have more-widely-spaced lines than the grid that will be flown during the fall period and will extend farther offshore to document the offshore distribution of bowhead whales and belugas (Fig. 2). If cetaceans are encountered in the vicinity of planned seismic operations, then in consultation with SOI, we would consider

flying the survey grid proposed for later in the season (see Fig. 3) rather than the one shown in Fig. 2. Surveys will be conducted 2 days a week until the period one week prior to the start of seismic operations in the Beaufort Sea. Beginning approximately one week prior to the start of seismic operations, daily surveys would be initiated and they would be conducted using the grid shown in Figure 3.

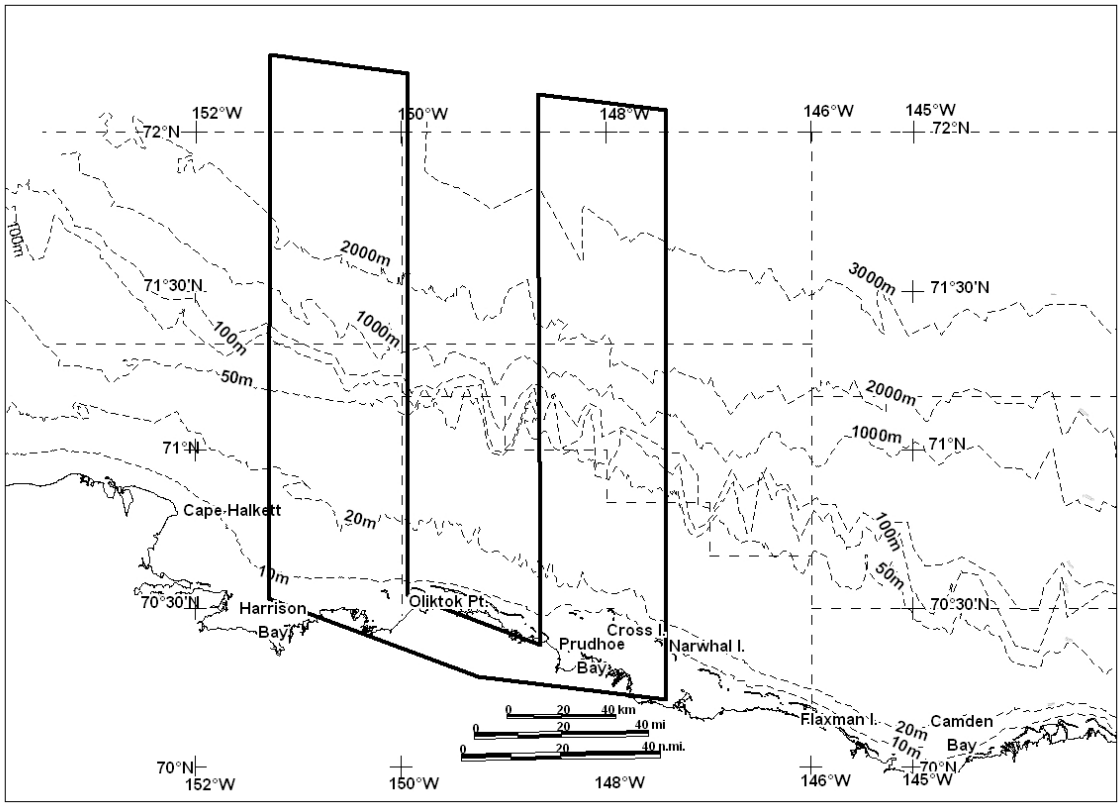

FIGURE 2. Central Alaskan Beaufort Sea showing aerial survey lines that will be flown 2 days a week during summer if seismic surveys were centered on the middle of the grid. Survey grids will be moved east or west depending on the location of the seismic surveys.

Survey Design in Beaufort Sea in Fall

Aerial surveys during the late August-October period will be designed to ensure that large aggregations of mother-calf bowheads do not approach to within the 120 dB re 1µPa radius from the active seismic operation. At the same time, they will obtain detailed data (weather permitting) on the occurrence, distribution, and movements of marine mammals, particularly bowhead whales, within an area that extends about 100 km to the east of the primary seismic vessel to a few km west of it, and north to about 65 km offshore (Fig. 2). This site-specific survey coverage will complement the simultaneous MMS/BWASP survey coverage. The proposed survey grid will provide data both within and beyond the anticipated immediate zone of influence of the seismic program, as identified by Miller et al. (1999). Miller et al. (1999) were not able to determine how far upstream and downstream (i.e., east and west) of the seismic operations bowheads began deflecting and then returned to their "normal" migration corridor. That is a key concern

for the Inupiat whalers and to some degree to NMFS. The proposed survey grid is not able to address that concern because of the mitigation need to extend flights well to the east to detect mother-calf pairs before they are exposed to seismic sounds >120 dB re 1 μPa.

It is possible that the east-west extent of seismic surveys will change during the season due to ice or other operational restrictions. If so, the aerial survey grid will have to be modified to maintain observations to 100 km east of the seismic survey area, but the total km of survey that can be conducted each day are limited by the fuel capacity of the aircraft. The only alternative to ensure adequate aerial survey coverage over the entire area where seismic activities might influence bowhead whale distribution is to space the individual transects farther apart. For each 15-20 km increase in the east-west size of the seismic survey area, the spacing between lines will need to be increased by 1 km to maintain survey coverage from 100 km east to 20 km west of the seismic activities.

Data from the easternmost transects of the proposed grid will document the main bowhead whale migration corridor east of the seismic exploration area and will provide the baseline data on the location of the migration corridor relative to the coast.

We do not propose to fly a smaller "intensive" survey grid in 2007. In most previous years, a separate grid of 4-6 shorter transects was flown, whenever possible, to provide additional survey coverage within about 20 km of the seismic operations. This coverage was designed to provide additional data on marine mammal utilization of the actual area of seismic exploration and immediately adjacent waters. The 1996-98 studies showed that bowhead whales were almost entirely absent from the area within 20 km of the active seismic operation (Miller et al. 1997, 1998, 1999). Thus, the flying-time that (in the past) would have been expended on flying the intensive grid will be used to extend the coverage farther to the east and west of the seismic activity.

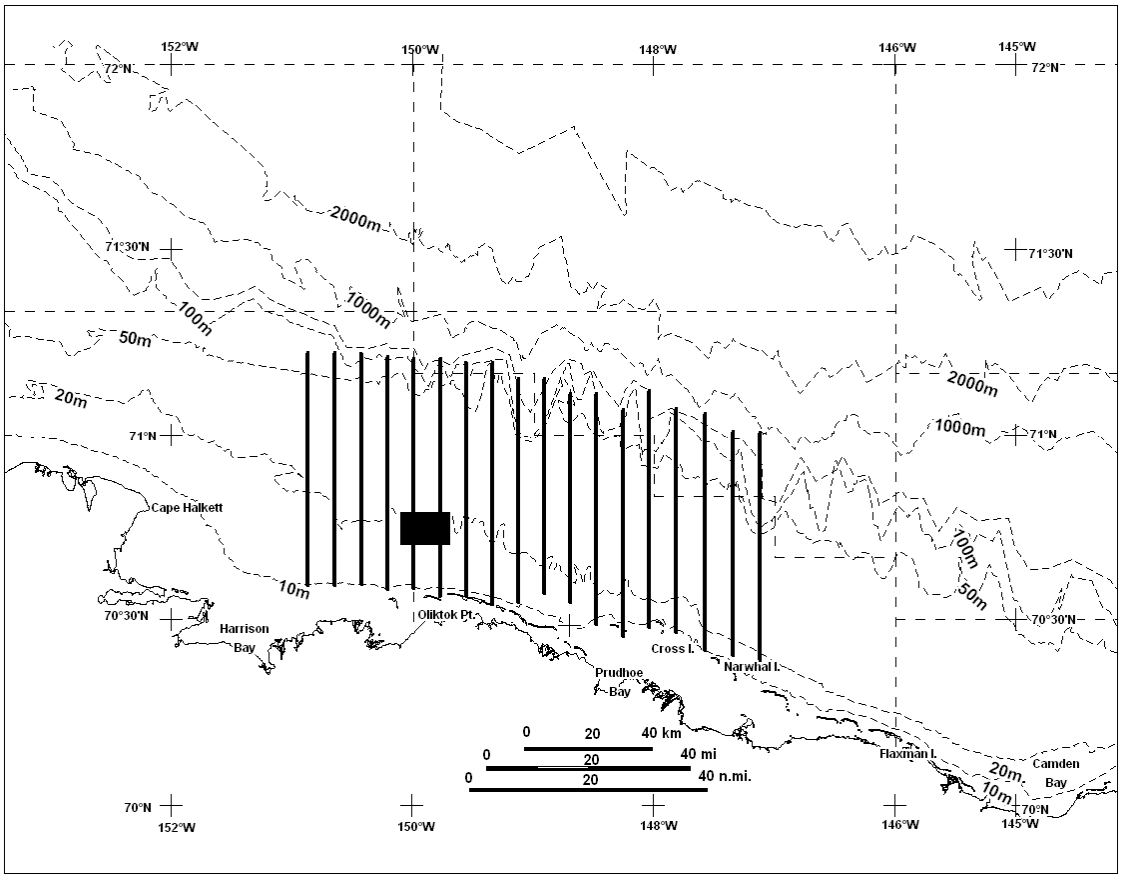

FIGURE 3. Central Alaskan Beaufort Sea showing aerial survey lines during fall if seismic surveys were conducted in the area of the back square (seismic survey area). Survey grids will be moved east or west depending on the location of the seismic surveys.

If seismic surveys of the Beaufort Sea end while substantial numbers of bowhead whales are still migrating west, aerial survey coverage of the area of most recent seismic operations will continue for several days after seismic surveys have ended. This will provide "post-seismic" data on whale distribution for comparison with whale distribution during seismic periods. These data will be used in analyses to estimate the extent of deflection during seismic activities and the duration of deflection after surveys end. Post-seismic coverage will not be conducted if the bowhead migration has ended by that time, but it is expected that due to freeze-up, seismic operations will move out of the Beaufort Sea before the end of the bowhead whale migration.

Survey Grids

Two different aerial survey grids are proposed depending on whether surveys are being conducted during summer (July to late August) or fall (late August–October). During summer, four north-south lines spaced 48 km apart and centered on the planned seismic exploration area would be flown 2 times each week (Fig. 2). They would extend from the barrier islands (or 10-m contour in areas with no barrier islands) north to about 72°N which may be well within the pack ice at that time of year. The proposed survey grid for late August–October consists of up to 18 north-south lines spaced 8 km apart and

will extend to 100 km east of the then-current seismic exploration area. Lines will extend from the barrier islands (or 10-m contour) north to approximately the 100 m depth contour. As previously described, when the seismic program moves east or west, the aerial survey grids will also be relocated a corresponding distance along the coast. This grid will be flown 2 times each week until one week prior to the start of seismic surveys. They will then be flown daily until one week after the end of seismic surveys in the Beaufort Sea. The eastern boundary of the survey area will extend eastward beyond the 120 dB radius of seismic sounds in order to detect aggregations of mother-calf pairs approaching the seismic operation.

Depending on the distance offshore where seismic is being conducted, the survey grid that is shown may not extend far enough offshore to document whales deflecting north of the operation. In this case, the north ends of the transects will be extended farther north so that they extend 30-35 km north of the seismic operation and the two most westerly lines will not be surveyed. This will mean that the survey lines will only extend as far west as the seismic operation. It is not possible to move the survey grid north without surveying areas south of the seismic operation because some whales may deflect south of the seismic operation and that deflection must be monitored. During previous studies of offshore drilling operations, bowhead whales were documented migrating near the coast <20 km south of a drilling operation (Koski and Johnson 1987). It would be desirable to monitor whale movements west of the seismic operation to document how far west bowheads move before returning to their normal migratory corridor. It is not possible, however, to monitor the 120 dB radius east of the seismic operation and obtain information on the distribution of whales west of the operation because of the large area that must be surveyed to the east.

The summer grid will total about 1000 km in length, requiring 4.6 h to survey at a speed of 220 km/h (120 knots), plus ferry time which will vary according to the location of the survey grid relative to the logistics base. The late August–October grid will total about 1300 km in length, requiring 6 h to survey at a speed of 220 km/h (120 knots), plus ferry time. Exact lengths and durations will vary somewhat depending on the east-west position of the seismic operations area and thus of the grid, the sequence in which lines are flown (often affected by weather), and the number of refueling/rest stops.

As during previous studies, we propose that, while whaling is underway we will not survey the southern portions of survey lines over or near hunting areas unless the whalers agree that this can be done without interfering with their activities. This will reduce (but not eliminate) the potential for overflying whalers and whales that are being approached by whalers. Some of the autumn bowhead sightings in the region do occur in this "nearshore" area, and these whales will not be documented if the survey aircraft remains 15+ km offshore in this area at all times. If we do not survey this area while whaling is occurring, we will reduce the potential for aircraft-whaler interactions at the expense of reducing our ability to assess seismic effects on bowheads, other marine mammals, and subsistence activities in that nearshore area.

Transect Positions and Sequence

For the purposes of this project, which primarily concern migrating bowheads, the transect lines in the grid should be oriented north-south, equally spaced, and at consistent

locations from day to day relative to the location of seismic operations. Bowhead whale movements during the late summer/autumn are generally from east to west, and transects should be designed to intercept rather than parallel whale movements.

Weather permitting, transects making up the grid in the Beaufort Sea will be flown in sequence from east to west. Although this increases difficulties associated with double counting of whales that are (predominantly) migrating westward, the main purpose of these surveys is to detect concentrations of mother-calf pairs that might be approaching the seismic survey area. If we start on the western side we would minimize our potential to detect those animals before they were exposed to seismic sounds >120 dB. However, if cloud, fog or high sea-state prevents coverage of the eastern part of the grid early in the day, the western portion will be surveyed first. If, after that is done, conditions on the eastern portion have become tractable, they would then be surveyed from east to west.

Analysis of Aerial Survey Data

During the field program preliminary maps and summaries of the daily surveys will be provided to NMFS and AEWC, as normally required by the terms of the IHA and Conflict Avoidance Agreement. While in the field, data will be checked, data files will be backed up onto CDs, and data files will be transferred each day (if possible) to a secure FTP site where they can be accessed by LGL data analysts for validation and further processing of the data. Two levels of analyses will be conducted. The first level will consist of basic summaries that are required for the 90-d report(s) specified by the IHA(s). These include summaries of numbers of marine mammals seen, survey effort by date, maps summarizing sightings, and estimates of numbers of marine mammals that are "taken" according to NMFS criteria. The second level of analyses will be presented in the subsequent technical report. The technical report will provide more detailed analyses of the data to quantify the effect of the seismic program on the distribution and movements of marine mammals. The latter analyses will emphasize the bowhead whale, which is the primary species of concern to NMFS and AEWC in the Beaufort Sea region.

Estimation of Numbers "Taken"

LGL has developed methods for estimating the numbers of marine mammals that are "taken" (as defined by NMFS) for past studies in the Beaufort Sea and Chukchi regions (Miller et al., 1999; Haley and Ireland 2006) and for other areas of the world (Lawson et al. 1998; Holst et al. 2005; Ireland et al. 2005). These estimates require estimating the numbers of animals present near or passing the seismic and drilling programs during periods without seismic or drilling and assuming that similar numbers would have passed during those activities if the activities were not conducted. The planned approach has been accepted by NMFS as satisfying the requirements for "take" estimates for numerous previous seismic monitoring programs.

The main purposes of the 2007 aerial programs insofar as the IHA requirements are concerned are to monitor the area east of the seismic operation to prevent large numbers of mother-calf pairs from being subjected to seismic sounds >120 dB re 1 µPa, to provide the data needed to determine how many marine mammals of each species were "taken by harassment" by the seismic and drilling programs, to document the nature of those "takes", to estimate their likely consequences for the marine mammal populations, and to

determine whether there was any effect on the accessibility of marine mammals to subsistence hunters. NMFS requires these data to ensure that the seismic and drilling programs had no more than a negligible impact on species or stocks of marine mammals, and no unmitigable adverse impact on their availability for subsistence hunting. The data to be collected by the vessel-based observers, aerial surveys, and acoustic programs, and the associated analyses of these data, in conjunction with prior years' data, will provide the needed information.

The criteria to be used in tabulating and estimating numbers of cetaceans potentially exposed to various sound levels will be consistent with those used during previous related projects in 1996-2005 unless otherwise directed by NMFS. Only cetaceans will be addressed using the aerial survey data because the altitude of the surveys is too high to reliably detect and identify pinnipeds. As in previous studies, we anticipate that there will be four components:

1. *Numbers of cetaceans observed within the area ensonified strongly by the seismic vessel and drilling operations.* For cetaceans, we will estimate the numbers of animals exposed to received rms levels of seismic sounds exceeding 120, 160 dB and 180 dB re 1 µPa, as required by NMFS. In the Beaufort Sea, received levels may exceed 160 dB (rms) out to several kilometers from a seismic vessel (Greene and Richardson 1988; Greene and Moore 1995; Greene 1997). We will also estimate the number of cetaceans exposed to received levels ≥180 dB (rms). This is the received level above which there is some suspicion that seismic pulses might affect hearing sensitivity or perhaps some other physiological processes of baleen whales (NMFS 1995, 2000; HESS 1999).

2. *Numbers of cetaceans observed showing apparent reactions to seismic pulses or drilling operations, e.g., heading in an "atypical" direction.* Animals exhibiting apparent responses to the activities will be counted as affected by the programs if they were exposed to sounds from those activities.

3. *Numbers estimated to have been subject to sound levels ≥120, ≥160 and ≥180 dB re 1µ Pa (rms) when no monitoring observations were possible*. This will involve using the observations from the survey aircraft (SOI/LGL and MMS), supplemented by relevant vessel-based observations, to estimate how many cetaceans were exposed, over the full course of SOI's 2007 seismic and drilling programs, to situations where exposures to ≥120, ≥160 and ≥180 dB were likely. In the case of the bowhead whale, we will estimate the proportions of the observed whales that were, simultaneously, close enough to shore to have passed through the area where exposure might occur, and could have passed while seismic or drilling operations were underway. Our aerial survey design, together with the complementary aerial surveys to be conducted by MMS, will provide the needed data.

4. *The number of bowheads whose migration routes came within 20 km of the operating seismic vessel or drilling activity, or would have done so if they had not been displaced farther offshore, will be estimate*d. If the 2007 data indicate that the avoidance distance exceeds 20 km, the larger avoidance distance will also be used. These estimates will be obtained by determining the displacement distance based on the aerial survey results, and then estimating how many bowheads were likely to approach the avoided area during times while the airgun array was operating or the drillship and

support vessels were present. This method was used in previous years to estimate the number of bowheads that may have avoided the area within 20 km of the seismic operations (Miller et al. 1998, 1999).

Location of Migration Corridor

The location of the bowhead migration corridor in 2007 will be determined by examining data from periods with no seismic or drilling activities and data from east of those operations. The MMS aerial survey data will be a useful supplement for areas well east of the seismic program. We will contrast the numbers of bowhead sightings and individuals vs. distance from shore

- during periods with vs. without operations, and
- near vs. east vs. west of the exploration areas.

The distance categories will be linked to received sound levels based on the results from the acoustic measurement task. Analyses will be done on a sightings-per-unit effort basis to allow meaningful interpretation even though aerial survey effort is inevitably inconsistent at different distances offshore.

Effects of Seismic Program on Bowhead Migration Corridor

To determine how far east, north and west displacement effects extend, additional analyses will be conducted on bowhead sightings and survey effort in relation to distance and bearing from the operations during times with and without operations. We anticipate applying a logistic or Poisson regression approach to assess the effects of distance and direction from the operating airguns and drilling operations on sighting probability of bowhead whales, allowing for the confounding influence of sightability (sea state, ice conditions, etc) and other covariates. We have already used that approach extensively in analyses of whale and seal distribution in the Beaufort Sea (Manly et al. 2004; Moulton et al. 2005). Biostatistician Dr. Trent McDonald of WEST, who was instrumental in some of these past analyses, will assist with analyses of marine mammal data. Other analyses that may be useful to describe the effects of the seismic operation on the bowhead migration path, including summaries of headings, behavior and swimming speeds, will be included in the technical report.

The data from the current survey may not provide enough sightings to be able to quantify the effects of SOI's 2007 activities on the bowhead whale migration path. That could occur if SOI's operations in the Beaufort Sea during the bowhead whale migration season were limited due to ice or other factors, or if 2007 is a year when weather conditions were poorer than average, which would limit the periods when surveys could be conducted. The 2007 data collection will be nearly identical to earlier seismic programs in 1985-2006, which will allow future pooling of data from all studies.

The aerial survey data pertaining to other species of marine mammals will also be mapped and analyzed insofar as this is useful. However, the main migration corridor of belugas is far offshore, and generally north of the area to be surveyed in the surveys proposed here. Few gray whales and walruses are likely to be seen because of their rarity in the Beaufort Sea area (although gray whales were seen in the area in 1998[Miller et al. 1999] and small numbers have been seen during several recent surveys by MMS (Treacy 1998, 2000, 2002) and Patterson et al. 2007). Therefore, the proposed aerial surveys are

expected to document the infrequent use of continental shelf waters of the Beaufort Sea by beluga whales, gray whales and walruses, and detailed analyses for these species probably will not be warranted. Seals cannot be surveyed quantitatively by aerial surveys at altitudes 900 to 1500 ft over open water. The aerial surveys will provide only incidental data on the occurrence of bearded and especially ringed seals in the area.

JOINT INDUSTRY STUDIES PROGRAM

This section describes studies that were undertaken in 2006 in the Chukchi Sea that will be continued during seismic operations in 2007. SOI plans to conduct aerial surveys consistent with the 2006 program along the Chukchi Sea coast. Additionally, the acoustic net array will be used to monitor industry sounds and marine mammals along the Chukchi Sea coast. This program may be modified to include recorders at different or additional locations depending upon the results obtained from the 2006 program, which are still being analyzed. Once these results are available final determination of the numbers and placements of the recorders will occur in consultation with industry partners, agencies, and other stakeholders. In addition to the aerial and acoustical components of the study program in the Chukchi Sea, SOI plans to also establish an acoustic net array in the Beaufort Sea in 2007.

Chukchi Sea Coastal Aerial Survey

The only recent aerial surveys of marine mammals in the Chukchi Sea were conducted along coastal areas of the Chukchi Sea to approximately 20 n. mi offshore in 2006 in support of SOI's summer seismic exploration. These surveys, funded jointly by several industry groups, provided relatively sparse data on the distribution and abundance of marine mammals in nearshore waters of the Chukchi Sea, and the current distribution and densities of marine mammals there are unknown. Population sizes of several species found there may have changed considerably since earlier surveys were conducted and their distributions may have changed because of changes in ice conditions. SOI in cooperation with other industry groups, plans to conduct an aerial survey program in the Chukchi Sea in 2007 that will be similar to the 2006 program.

Alaskan Natives from several villages along the east coast of the Chukchi Sea hunt marine mammals during the summer and Native communities are concerned that offshore oil and gas development activities such as seismic exploration may negatively impact their ability to harvest marine mammals. Of particular concern are potential impacts on the beluga harvest at Point Lay and on future bowhead harvests at Point Hope, Wainwright and Barrow. Other species of concern in the Chukchi Sea include the gray whale, bearded, ringed, and spotted seals, and walrus. Gray whale is expected to be the most numerous cetacean species encountered during the proposed summer seismic activities, although beluga whales also occur in the area. The ringed seal is likely to be the most abundant pinniped species. The current aerial survey program will be designed to collect distribution data on cetaceans and will be limited in its ability to collect similar data on pinnipeds.

Objectives

The aerial survey program will be conducted in support of the SOI seismic program in the Chukchi Sea during summer and fall of 2007. The objectives of the aerial survey will be

- to address data deficiencies in the distribution and abundance of marine mammals in coastal areas of the eastern Chukchi Sea; and
- to collect and report data on the distribution, numbers, orientation and behavior of marine mammals, particularly beluga whales, near traditional hunting areas in the eastern Chukchi Sea.

Survey Considerations

With agreement from hunters in the coastal villages, aerial surveys of coastal areas to approximately 20 miles offshore between Point Hope and Point Barrow will begin in early July and will continue until seismic operations in the Chukchi Sea are completed. Weather and equipment permitting, surveys will be conducted twice per week during this time period. In addition, during the 2007 field season, we will coordinate and cooperate with the aerial surveys conducted by MMS and any other groups conducting surveys in the same region.

Safety Considerations

Safety considerations as discussed above in the Aerial Survey Program for the Chukchi Sea will be implemented for the Beaufort Sea Aerial Program.

Survey Procedures

Transect Positions and Sequence

Transects will be flown in a saw-toothed pattern extending from Point Barrow to Point Hope (Fig. 4). This design will permit completion of the survey in one to two days and will provide representative coverage of the nearshore area from the mainland or outer barrier island shore to 20 n. mi. offshore. The surveyed area will include waters where belugas would be available to subsistence hunters. Survey altitude will be at least 305 m (1,000 ft) with an average survey speed of 100-120 knots. Survey transects were designed by placing transect start/end points every 30 n.mi along the offshore boundary of this 20-n.mi.-wide nearshore zone, and at midpoints between those points along the coast. The transect line start/end points will be shifted along both the coast and the offshore boundary for each survey based upon a randomized starting location, but overall survey distance will not vary substantially. As with past surveys of the Chukchi Sea coast, coordination with coastal villages to avoid disturbance of the beluga whale subsistence hunt will be extremely important. "No-fly" zones around coastal villages or other hunting areas established during communications with village representatives will be in place until the end of the hunting season.

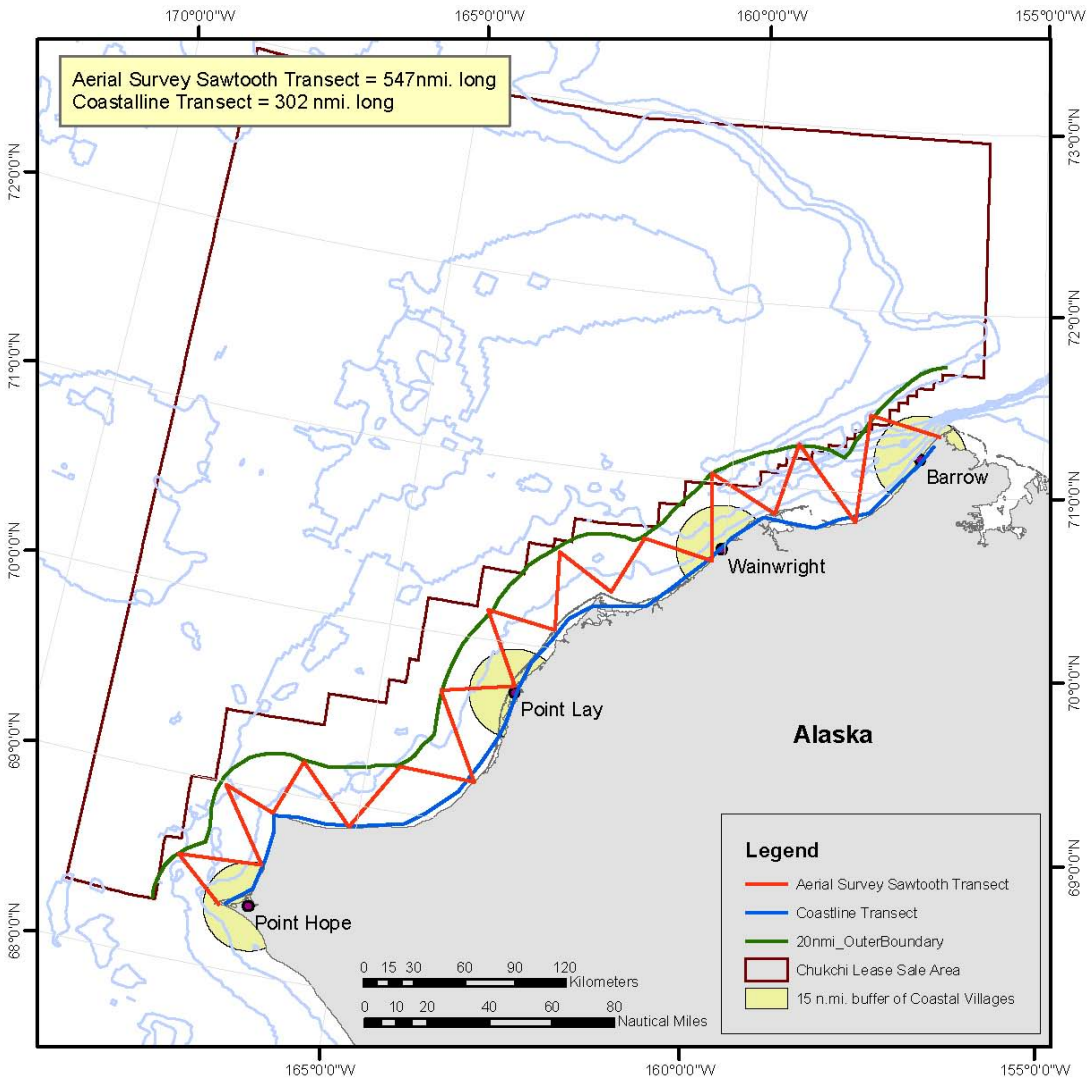

Figure 4. Aerial survey transects location and general pattern for the eastern Chukchi Sea, summer 2007. Specific transect start-/end-points will be altered randomly from survey to survey, and hunting areas will be avoided when hunting is occurring.

Flight and Observation Procedures

Standard aerial survey procedures used in previous marine mammal projects (by us as well as by others) will be followed. This will facilitate comparisons and (as appropriate) pooling with other data, and will minimize any controversy about the chosen survey procedures. The aircraft will be flown at 120 knots ground speed and usually at an altitude of 1000 ft. In accordance with the IHAs issued to SOI in 2006, after 1 July the survey aircraft will be flown at 1500 ft over the Ledyard Bay spectacled eider critical habitat area. Aerial surveys at an altitude of 1000 ft do not provide much information about seals but are suitable for bowhead, beluga, and gray whales. The need for a 1000+ ft cloud ceiling will limit the dates and times when surveys can be flown. Selection of a higher altitude for surveys would result in a significant reduction in the number of days where surveys would be possible, impairing the ability of the aerial program to meet its objectives.

Three marine mammal observers will be aboard the aircraft during surveys during key hunting periods. Two observers will be looking for marine mammals within 1 km of the survey track line; one each at windows on either side of the aircraft. The third person will record data. When sightings are made, observers will notify the data recorder of the species or species class of the animal(s) sighted, the number of animals present, and the lateral distance (inclinometer angle) of the animals from the flight path of the aircraft. This information, along with time and location data from an onboard GPS, will be entered into a database. Environmental data that affect sighting conditions including wind speed, sea state, cloud cover or fog, and severity of glare will be recorded for each transect line or whenever conditions change substantially.

Nearshore surveys

If weather conditions permit and if approved by hunters, the return flight will be flown at 10,000 ft and the lagoon systems used by belugas will be photographed to document numbers of belugas in the lagoon. If weather conditions do not permit flying at 10,000 ft, a more direct route will be flown during the return trip from Point Hope to Barrow. When large concentrations of belugas are encountered during the saw-toothed pattern surveys or during return flights, we will interrupt the survey to photograph the groups to obtain complete and accurate counts of the number of animals present. If whales are photographed in lagoons or other shallow-water concentration areas, we will climb to 10,000 feet altitude to avoid disturbance to whales that may cause them to leave the area. If whales are in offshore areas, we will climb high enough to include all whales within a single photograph; that is typically about 3,000 feet altitude. When in shallow water, belugas and other marine mammals are more sensitive to aircraft over flights and other forms of disturbance than when they are offshore. They frequently leave shallow estuaries when over flown at altitudes of 2–3000 feet, whereas they rarely react to aircraft at 1500 feet when offshore in deeper water.

At the start of each transect, the primary observer will record the transect start time and position, ceiling height (ft), cloud cover (in 10ths), wind speed (knots), wind direction (°T) and outside air temperature (°C). In addition, each observer will record the time, visibility (subjectively classified as excellent, good, moderately impaired, seriously impaired or impossible), sea state (Beaufort wind force), ice cover (in 10ths) and sun glare (none, moderate, severe) at the start and end of each transect, and at 2-min intervals along the transect. This will provide data in units suitable for statistical summaries and analyses of effects of these variables (and position relative to seismic vessel) on the probability of detecting animals (see Davis et al. 1982; Miller et al. 1999; Thomas et al. 2002, Manley et al. 2004).

The data logger will automatically record time and aircraft position (latitude and longitude) for sightings and transect waypoints, and at pre-selected intervals along the transects. The primary data logger will be a laptop computer with Garmin Mapsource (ver 6.9) data logging software. Mapsource automatically stores the time and aircraft position at pre-selected intervals (typically at 6 sec for straight-line transect surveys) and stores the records to a file as they are obtained. If the computer or data logger malfunctions, the file is terminated and a new file is started when the program is restarted. This prevents loss of already-recorded data. A second laptop computer will

log the aircraft position and altitude using a custom written software program (Visual Basic, ver 5.0) as a back-up to the primary data logger. The altitude input will be from the aircraft's radar altimeter.

Selection of Aircraft

Criteria used for selection of aircraft as discussed in the Aerial Survey Program for the Chukchi Sea will be implemented for the Aerial Survey Program for the Beaufort Sea.

Supplementary Data

Weather, ice and sight ability data will be recorded systematically during all surveys. Percent ice cover and severity of sun glare will be recorded by each primary observer for every 2-minute interval along transects. Ice observations during aerial surveys will be mapped when ice is present and satellite imagery will be used, where available, to document ice conditions adjacent to the survey area. These are standard practices for surveys of this type, and are necessary in order to interpret factors responsible for variations in sighting rates. During the aerial surveys, we will also record relevant information on other industry vessels, whaling vessels, low-flying aircraft, or any other human activities that are seen in the survey area.

Coordination with Other Aerial Surveys

The MMS, the NSB, or other organizations may conduct aerial surveys in the Chukchi Sea during the summer and/or autumn field season. SOI will consult with any groups or organizations conducting aerial surveys along the eastern Chukchi Sea coast regarding coordination during the field season. The objectives will be:

- to ensure aircraft separation when both crews conduct surveys in the same general region;
- to coordinate the 2007 aerial survey projects in order to maximize consistency and minimize duplication; and
- to maximize consistency with previous years' efforts insofar as feasible.

Analysis of Aerial Survey Data

While in the field, data will be checked, data files will be backed up onto CDs, and data files will be transferred each day (if possible) to a secure FTP site where they can be accessed by data analysts for validation and further processing of the data. An end of season technical report will provide detailed analyses of the data and characterize the pattern of distribution and movements of marine mammals in the coastal zone of the Chukchi Sea during the open-water season. The latter analyses will emphasize the beluga whale, which is the primary species of concern to NMFS and local hunters in the Chukchi Sea region. The report will also include analyses on other whale species such as bowhead and gray whales, and seals to the extent possible from surveys at the required survey altitudes.

Acoustic data, with a focus on beluga whale vocalizations during the early to mid-summer, will be collected by bottom-founded recorders in the 20 n. mi. coastal zone (described below in the Acoustic "Net" Array section) if operationally feasible. The

aerial survey data will be integrated with the acoustic data to provide a more complete assessment of the distribution and abundance of marine mammals, primarily beluga whales, along the Chukchi Sea coast. If enough data are acquired, the combined acoustic and aerial survey data may provide information about the distribution of beluga whales in relation to seismic survey activity. The effects will be analyzed by comparing the sighting rates of beluga whales (or seals) observed during aerial surveys in areas where airgun sounds were detectable, or above some specific received level, to sighting rates in comparable areas where seismic sounds were not as strong.

Acoustic "Net" Array

Chukchi Sea

The acoustic "net" array used during the 2006 field season in the Chukchi Sea was designed to accomplish two main objectives. The first was to collect information on the occurrence and distribution of beluga whales that may be available to subsistence hunters near villages located on the Chukchi Sea coast. The second objective was to measure the ambient noise levels near these villages and record received levels of sounds from seismic survey activities should they be detectable. The work was performed by Cornell Laboratories during the 2006 field season. If allowed by local villages, and equipment, ice and weather conditions permitting, an acoustic program in the Chukchi Sea from July—October will again be conducted. The basic components of this effort consist of bottom-mounted equipment for long-duration passive acoustic recording, technical field support, post-processing data analysis, and report writing.

A suite of autonomous seafloor recorders will be deployed in the Chukchi Sea to collect acoustic data from strategically situated sites. Figure 5 shows the locations of the acoustic arrays in 2006. The 2007 program may be similar but may also modify the locations and types of recorders used to attempt to answer specific questions about the movement of bowhead whales through the Chukchi Sea during fall. The acoustic contractor will provide technical personnel support and equipment for the field deployment, refurbishment and recovery of recorders. The basic plan will be to deploy Acoustic recorders at strategic locations within the Chukchi Sea in locations where they can deliver broad area information on the acoustic environment of this basin. The specific geometries and placements of the arrays are primarily driven by the objectives of (a) detecting the occurrence and approximate offshore distributions of beluga and possibly bowhead whales during the July to mid-August period and primarily bowhead whales during the mid-August to late October period, (b) measuring ambient noise, and (c) measuring received levels of seismic survey activities.

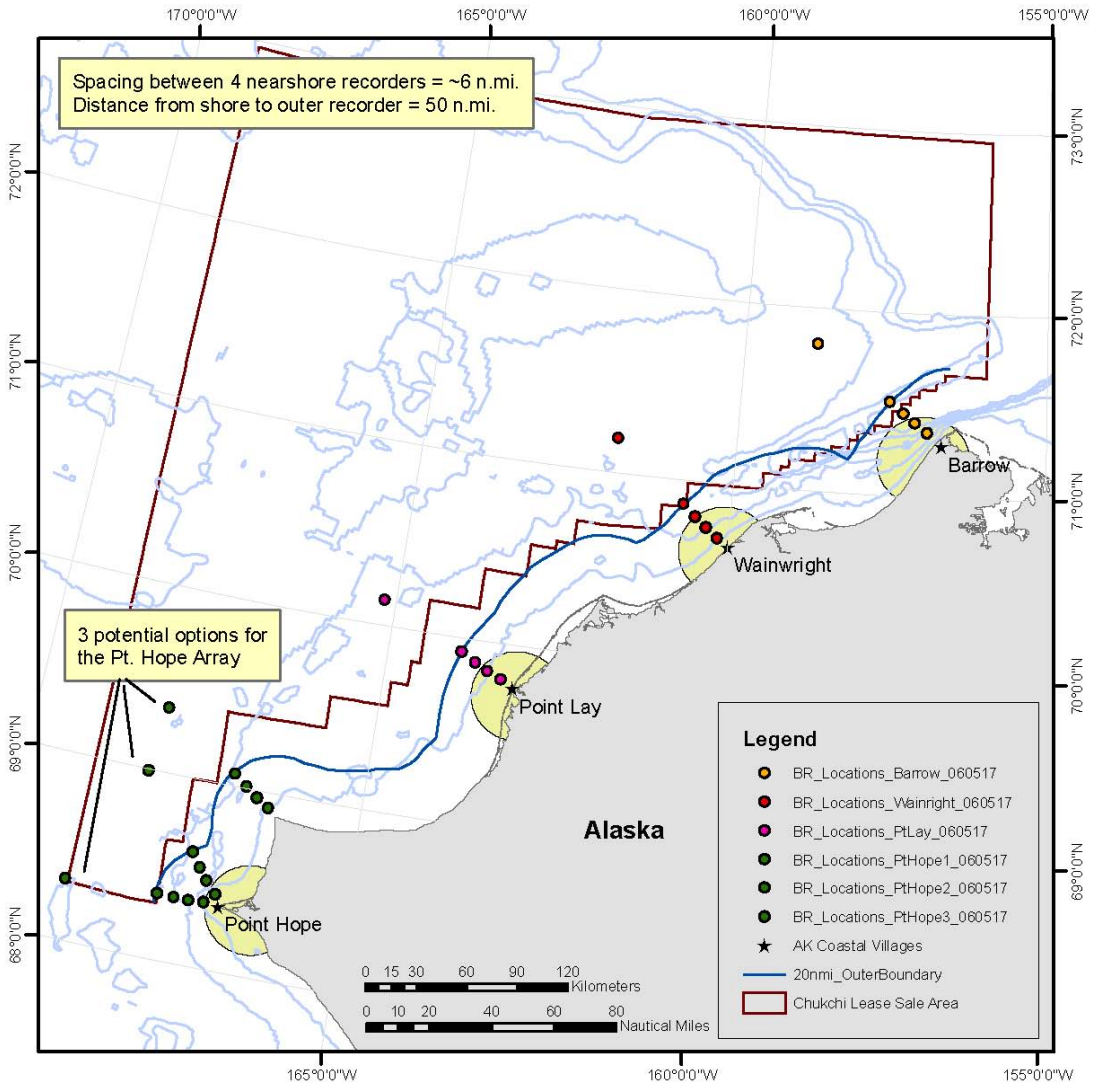

Fig. 5. Approximate location of acoustic net array along the coast of the eastern Chukchi Sea, Alaska 2007. One recording device may be located along the coast in the western Beaufort Sea east of Barrow.

Timing of deployment, number of recorders, and final positions will be subject to equipment availability, weather and ice conditions, and consultation with local villages to reduce or eliminate interference with subsistence hunting or fishing activities.

Beaufort Sea

In addition to the continuation of the acoustic net array program in the Chukchi Sea in 2007, SOI plans to develop a similar acoustic component in the Beaufort Sea. The purpose of the array will be to further understand, define, and document sound characteristics and propagation resulting from offshore seismic and vessel-based drilling operations that may have the potential to cause deflections of bowhead whales from anticipated migratory pathways. Of particular interest will be the east-west extent of deflection (i.e. how far east of a sound source do bowheads begin to deflect and how far to the west beyond the sound source does deflection persist). Of additional interest will be the extent of offshore deflection that occurs.

In previous work around seismic and drill-ship operations in the Alaskan Beaufort Sea, the primary method for studying this question has been aerial surveys. Acoustic localization methods provide a possible alternative to aerial surveys for addressing these questions. As compared with aerial surveys, acoustic methods have the advantage of providing a vastly larger number of whale detections, and can operate day or night, independent of visibility, and to some degree independent of ice conditions and sea state—all of which prevent or impair aerial surveys. However, acoustic methods depend on the animals to call, and to some extent assume that calling rate is unaffected by exposure to industrial noise. Bowheads do call frequently in fall, but there is some evidence that their calling rate may be reduced upon exposure to industrial sounds, complicating interpretation. Also, acoustic methods require development and deployment of instruments that are stationary (preferably mounted on the bottom) to record and localize the whale calls. Acoustic methods would likely be more effective for studying impacts related to a stationary sound source, such as a drilling rig that is operating within a relatively localized area, than for a moving sound source such as that produced by a seismic source vessel.

Bottom-founded acoustic recorders that have the ability to record calling whales will be deployed around SOI's seismic and drilling activities during the 2007 drilling program. Fig. 6 shows potential locations of the bottom-founded recorders and an array layout in relation to the proposed seismic and drilling locations. The actual locations of the bottom-founded recorders will depend on specifications of recording equipment chosen for the project, and on the acoustical characteristics of the environment, which are yet to be determined. The results of these data will be used to determine the extent of deflection of migrating bowhead whales from the sound sources produced by the vessel-based drill rig.

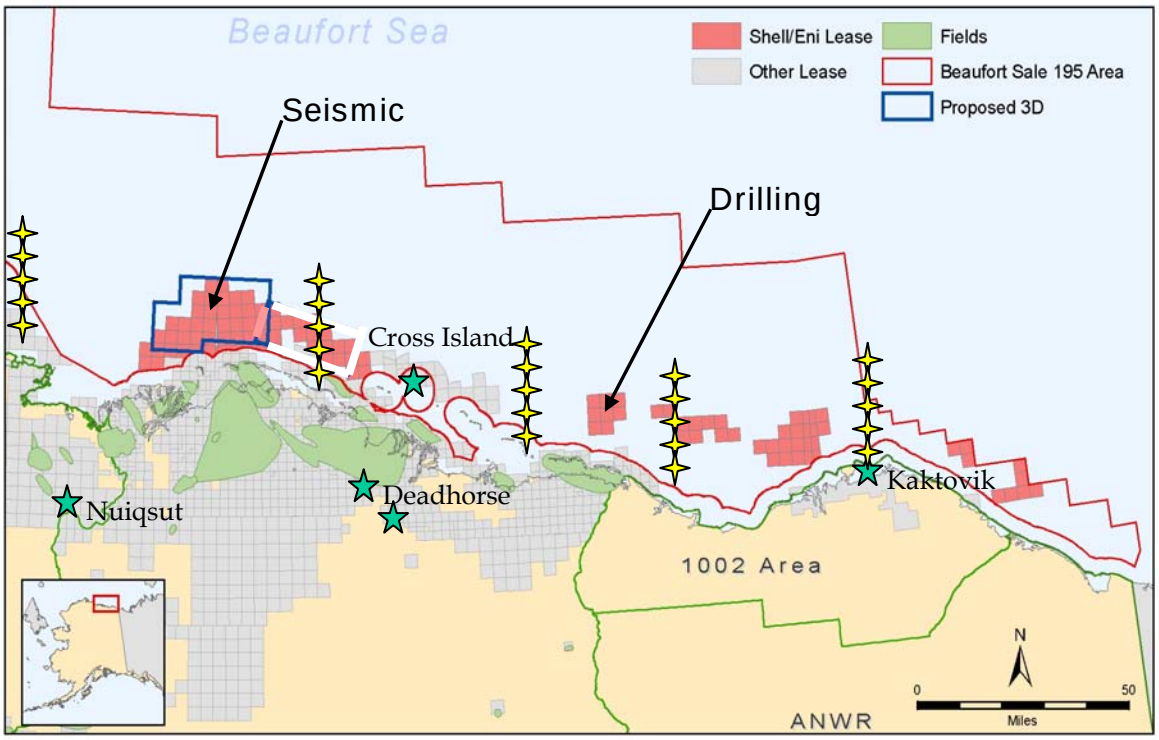

Figure 6. Proposed location of acoustic net array in the Beaufort Sea.

After recovery of the pop-ups in the Chukchi and Beaufort seas, data will be extracted from each unit's hard drive and organized into a networked acoustic database system. For every day of data from every pop-up, 24-h spectrographic images, ambient noise order statistics (5%, 25%, 50%, 75%, 95%), and 1/3 octave received levels will be computed and saved as Matlab files. These will be used to evaluate data quality, assess noise conditions, and assess if and when seismic survey activity was evident at each pop-up location. A sub-sample of days (ca. 10%) will be processed for the occurrence of beluga and bowhead whale calls using automatic detection software tailored for the specific noise conditions. Approximately 10% of these data will be screened by bioacoustic personnel with expertise in species identification, and used to develop estimates for true and false detections.

Post-90-day Report Analysis

Analysis of all acoustic data will be prioritized to address the primary questions. In both the beluga and bowhead phases, the primary data analysis questions are to (a) determine when animals are acoustically detected on each pop-up, (b) determine their offshore distributions, (c) estimate the number of vocally active animals per unit of time, (d) quantify spatial and temporal variability in the ambient noise, and (e) measure received levels of seismic survey events. The detection data will be used to develop spatial and temporal animal detection distributions that can then be applied to test for the statistical significance of changes in animal detections and distributions as a function of

different variables (e.g., time of day, time of season, environmental conditions, ambient noise, vessel type, operation conditions).

Report Writing

The acoustics consultant responsible for the net arrays will be responsible for writing reports describing all aspects of the above tasks. This effort will be conducted in close coordination with other consultants providing expertise to the Program. This will include a quick-look report within 90 days after completion of the field work (for inclusion in the 90-day report to NMFS), an interim report within 6 months after completion of the field work, and a final report.

COMPREHENSIVE REPORT ON INDUSTRY ACTIVITIES AND MARINE MAMMAL MONITORING EFFORTS IN THE BEAUFORT AND CHUKCHI SEAS

Following the 2007 open water season a comprehensive report describing the acoustic, vessel-based, and aerial monitoring programs will be prepared. The comprehensive report will describe the methods, results, conclusions and limitations of each of the individual data sets in detail. The report will also integrate (to the extent possible) the studies into a broad based assessment of industry activities and their impacts on marine mammals in the Chukchi Sea during 2007. The report will help to establish long term data sets that can assist with the evaluation of changes in the Chukchi Sea ecosystem. The report will also incorporate studies being conducted in the Beaufort Sea and will attempt to provide a regional synthesis of available data on industry activity in offshore areas of northern Alaska that may influence marine mammal density, distribution and behavior.

This report will consider data from many different sources including two relatively different types of aerial surveys; several types of acoustic systems for data collection (net array and OBH systems), and vessel based observations. Collection of comparable data across the wide array of programs will help with the synthesis of information. However, interpretation of broad patterns in data from a single year is inherently limited. Many of the 2007 data will be used to assess the efficacy of the various data collection methods and to help establish protocols that will provide a basis for integration of the data sets over a period of years.

Data protocols for all of the seismic operations will be similar regardless of operator. Similar protocols have been developed for barging operations. To truly capture 'cumulative' effects of offshore activities would involve collecting data on operations supporting NSB villages, research vessels, and other activities occurring in the Chukchi Sea. Data will be presented and discussed at a workshop this fall/winter on cumulative effects associated with offshore activities. This will provide an opportunity for all stakeholders to engage in the development of a cumulative effects strategy for future activities.

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