Shell Offshore Inc.
3601 C Street, Suite 1314
Anchorage, AK 99503

October 16, 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 Seas, Alaska During 2008 Open Water Seismic and Marine Survey Programs

Dear Mr. Lecky:

Shell Offshore Inc. (SOI) is planning a variety of seismic and survey programs in the Chukchi and mid- and eastern Beaufort Seas during the 2008 open water season. Collectively, these various individual programs are referred to as the "*Proposed Open Water Seismic and Marine Survey Program, hereinafter referred to as the "Program"* on various U.S. Department of Interior, Minerals Management Service (MMS) Outer Continental Shelf (OCS) lease blocks in the Chukchi and mid- and eastern Beaufort Seas. The Program will commence during the open water season in mid July and will continue until mid November depending on ice and weather conditions. SOI and its deep sea seismic contractor WesternGeco request 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.

All of these individual programs, or activities, will require marine vessels to accomplish the work. Only vessels which are currently under contract to SOI, or a contractor to SOI, to conduct these various activities, at the time of this IHA application are specifically named. The remainder of proposed vessels are to be determined (TBD). In this IHA application, SOI describes the tasks that TBD vessels are anticipated to conduct, and where possible, SOI mentions the name of a vessel previously contracted to perform such tasks. Also, the phrase: "or similar vessel" is included when a vessel for a specific task remains TBD, because the vessel named in this application may or may not eventually be selected to conduct the work.

The only type of incidental taking sought in this IHA application is that of takes by noise harassment. The only sources of Program-created noise will be those stemming from the deep 3D seismic data acquisition vessel which is the *M/V Gilavar*, plus energy sources on the site clearance and shallow hazard survey vessels for the Beaufort and Chukchi Seas, and ice gouge surveys in the Beaufort Sea. Vessels for the site clearance and shallow hazard surveys, and ice gouge surveys have not yet been selected. Sound sources other than vessels will include; operation of the seismic air guns and other acoustic registration equipment used in the site clearance program.

Items presented pursuant to 50 C.F.R. § 216.104, "Submission of Requests", and § 216.107, "Incidental Harassment Authorization for Arctic Waters", are attached along with the Marine Mammal Monitoring and Mitigation Plan.

Please contact me at (907) 770-3700 or e-mail: susan.childs@shell.com or Walt Sandel at (907) 646-7154 or e-mail: walt.sandel@shell.com for further information.

Sincerely,
Shell Offshore Inc.

Susan Childs
Regulatory Affairs Manager, Alaska

Attachments:

- Application for Incidental Harassment Authorization for the Non-Lethal Taking of Whales and Seals in Conjunction with a Proposed Open Water Seismic and Marine Survey Program in the Chukchi and Beaufort Seas, Alaska, During 2008 and 2009
- Marine Mammal Monitoring and Mitigation Plan for Seismic Exploration in the Alaskan Chukchi and Beaufort Seas, 2008

cc w/attachments:

Doug DeMaster, NOAA Fisheries - Seattle, WA
Ken Hollingshead, NOAA Fisheries - Silver Spring, MD
Brad Smith, NOAA Fisheries - Anchorage, AK
Harry Brower, Alaska Eskimo Whaling Commission - Barrow, AK
Jessica LeFevre, Alaska Eskimo Whaling Commission – Washington, D.C.
Arnold Brower, Jr., Inupiat Community of the Arctic Slope
Taqulik Hepa, North Slope Borough Department of Wildlife Management
Rance Wall, Minerals Management Service – Anchorage, AK
Jeff Walker, Minerals Management Service – Anchorage, AK
Don Perrin, Alaska Department of Natural Resources
Mark Stone, Shell
Chandler Wilhelm, Shell
A. Michael Macrander, Shell
Walt Sandel, Shell
Greg Horner, ASRC Energy Services
Project File
Administrative File

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Application for Incidental Harassment Authorization for the Non-Lethal Taking of Whales and Seals in Conjunction with a Proposed Open Water Seismic and Marine Survey Program in the Chukchi and Beaufort Seas, Alaska, During 2008-2009

October 2007

Submitted to:

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Prepared by:

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Shell Offshore Inc. (SOI) used the following guidance to prepare its request for Incidental Harassment Authorization (IHA).

50 CFR 216.104 "Submission of Requests"

(a) In order for the National Marine Fisheries Service (NMFS) to consider authorizing the taking by U.S. citizens of small numbers of marine mammals incidental to a specified activity (other than commercial fishing), or to make a finding that incidental take is unlikely to occur, a written request must be submitted to the Assistant Administrator. All requests must include the following information for their activity.

Information required by 50 CFR§216.104 (a):

1. A detailed description of the specific activity or class of activities that can be expected to result in incidental taking of marine mammals:

Overview of Program

SOI is planning a variety of programs in the Chukchi and Beaufort Seas during the 2008 open water season. Collectively, these various individual programs are referred to as the "*Proposed Open Water Seismic and Marine Survey Program, hereinafter referred to as the "Program"*. The variety of individual, proposed activities, for 2008-2009 include:

- Chukchi Sea Deep 3D Seismic Survey;
- Chukchi Sea Marine Surveys (including site clearance and shallow hazards);
- Beaufort Sea Deep 3D Seismic Survey; and
- Beaufort Sea Marine Surveys – this includes three activities:
  1. Site Clearance and Shallow Hazards
  2. Ice Gouge Survey
  3. Strudel Scour Survey

All of these individual activities will require marine vessels to accomplish the work. Only vessels which are currently under contract to SOI, or a contractor to SOI, for these various activities, at the time of this IHA application are specifically named. The remainder of proposed vessels are to be determined (TBD). In this IHA application, SOI describes the tasks which TBD vessels are anticipated to conduct and, where possible, SOI may mention the name of a vessel previously contracted to perform such tasks. Also, the phrase: "or similar vessel" is included when a vessel for a specific task remains TBD, because the vessel named in this application may eventually be selected to conduct the work, but perhaps not. Table 1-1 provides a comprehensive list of proposed vessel tasks to support the various open water activities planned for Aug 2, 2008 to Aug 1, 2009.

Chukchi Sea Deep 3D Seismic

Description of Proposed Activity: SOI and its geophysical (seismic) contractor WesternGeco propose to conduct a marine geophysical (deep 3D seismic) survey program during open water season on various U.S Minerals Management Service (MMS) Outer Continental Shelf (OCS) lease blocks in the northern Chukchi Sea (Figure 1). The geographic region where the proposed deep seismic survey will occur is in the MMS OCS Chukchi Sea Lease Sale 193 (LS 193) area (Figure 1). Because the Chukchi Sea 3D Deep Seismic survey most likely will be conducted on leases obtained in LS 193, scheduled to occur February 2008, the exact locations where operations will occur are not known at this time. However, in general seismic data acquisition will occur at least 25 miles offshore of the coast and in waters averaging depths greater than 40 meters (m).

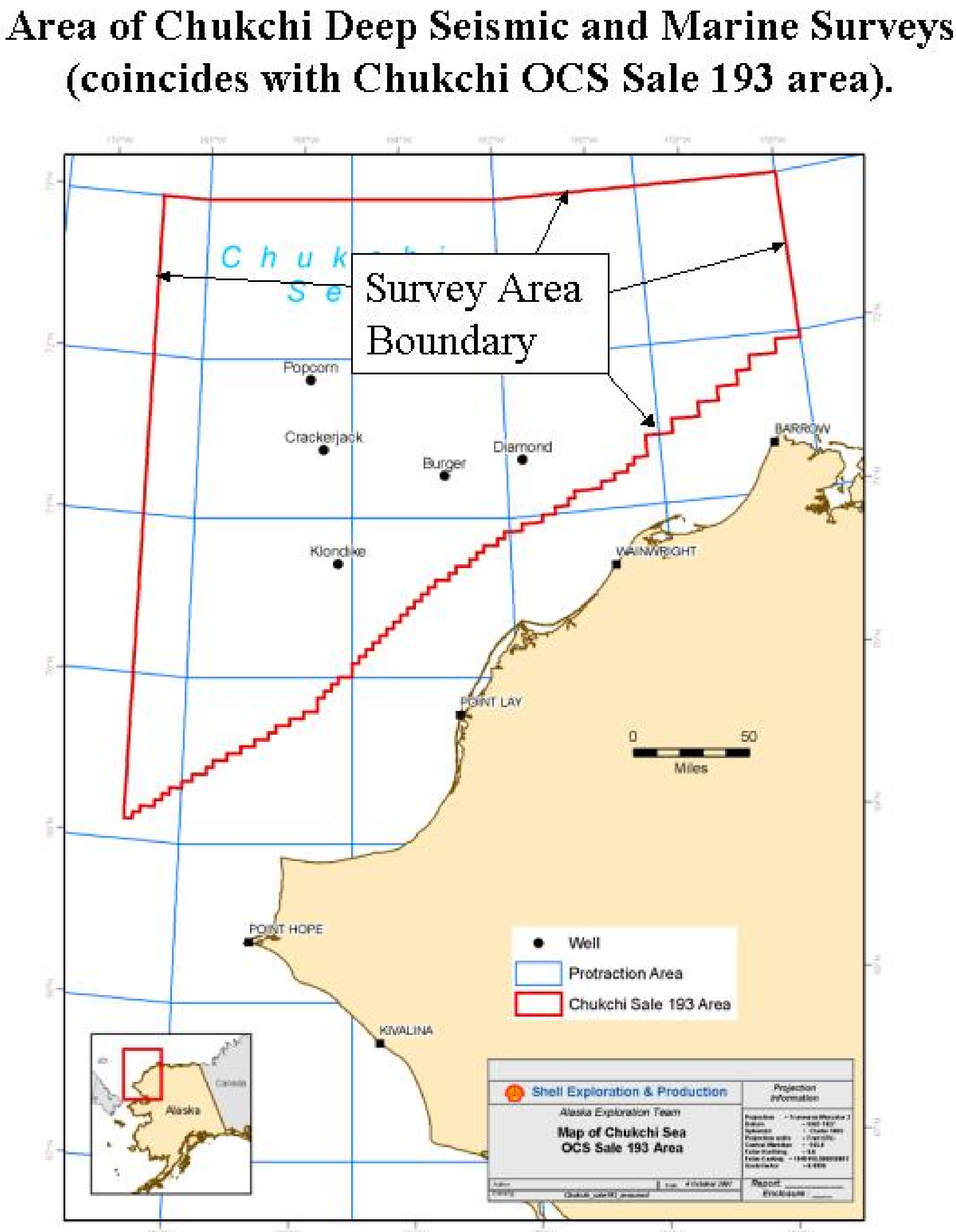
The deep 3D seismic survey is proposed to be conducted from WesternGeco's vessel *M/V Gilavar*. Two "chase boats" will accompany the seismic vessel. These two chase boats will provide the following functions: (1) re-supply, (2) re-fueling, (3) marine mammal monitoring, (4) ice scouting, and (5) general support for the *M/V Gilavar*. One chase boat is proposed to be the *M/V Gulf Provider* and the other is not yet contracted , but will have similar specifications to the *M/V Gulf Provider*. The chase boats will not deploy seismic data acquisition gear. In addition, a crew change vessel and a landing craft, such as the *M/V Peregrine* or similar vessel, will support the *M/V Gilavar*, and the two chase boats in the Chukchi Sea. The crew change vessel will be used to move personnel and supplies from the seismic vessel, and two chase boats to the nearshore areas. In turn, the landing craft will move personnel and supplies from the crew change vessel, when it is located in nearshore areas, to the beach (most likely this will be at Barrow). Lastly, the marine mammal monitoring and mitigation program (4MP) will have a separate vessel for the proposed 2008 Program. The crew change vessel also will be used to move personnel and equipment from the 4MP vessel to the near shore areas.

Primary Contractor: WesternGeco

Description of the Seismic Vessel and Survey Equipment: *M/V Gilavar*: 84.9 m (278.5 ft) length and 5.3 m (17.4 ft) draft. Detailed specifications of this purpose-built seismic survey vessel are provided in Attachment A. These specifications include: (1) complete descriptions of the number and lengths of the streamers which form the hydrophone arrays; (2) air gun quantity, size, and sound propagation properties (3) additional detailed data on the *M/V Gilavar* characteristics and capacities as a vessel.

Description of the Chase Boats and Crew Change Vessel: One of the chase boats will be the *M/V Gulf Provider*. This vessel was used for this purpose in the 2007 program. The *M/V Gulf Provider* has the following dimensions: 57.6 m (189ft) length and 4.26m (14ft) draft. Additional specifications for the *M/V Gulf Provider* are contained in Attachment A. The second chase boat and the crew change vessel have not yet been selected, but will both have similar specification to the *M/V Gulf Provider*. A vessel to serve as landing craft has also not been selected, but will probably be similar to the *M/V Peregrine*, which was used last year. The specifications for that vessel are as follows: 27.4 m length, (90 feet) and 1 m draft (3 ft). Lastly, a vessel to serve as the 4MP vessel has not yet been selected, but likely will be similar to the specifications of the *M/V Norseman* which was used in 2007.

Figure 1 Chukchi Sea Deep 3D Seismic and Marine Survey Area



Planned Mitigation: The *M/V Gilavar* and all support vessels will operate in accordance with the provisions of a Plan of Cooperation (POC). The POC is developed to mitigate effects of SOI's proposed programs where activities would occur in or near a traditional Arctic subsistence hunting area and/or may affect the availability of a species or stock of marine mammal for Arctic subsistence uses. SOI will consult with affected Chukchi and Beaufort Seas communities and marine mammal associations for the development of a POC. It is the intention of SOI to negotiate in good faith to reach a Conflict Avoidance Agreement (CAA) with the Alaska Eskimo Whaling Commission (AEWC), and Whaling Captains' Associations of affected Beaufort and Chukchi Seas villages, as a component of the POC. If a CAA is negotiated with AEWC, then the provisions of the CAA can be included in the POC.

The POC will specify times and areas to avoid to minimize any possible conflict with traditional subsistence hunts by the villages of Pt. Hope, Barrow, or Wainwright. Regardless of whether a CAA is successfully negotiated, SOI is committed to the mitigation measures described in Section 12 (iii) of this IHA application and will implement these measures which are intended to minimize any adverse effects on the availability of marine mammals for subsistence uses. SOI and WesternGeco will extend mitigation to avoid impacts to the traditional beluga whale hunt annually practiced by the village of Pt. Lay during June or July. Because the Chukchi Sea 3D Seismic and Marine Surveys would not commence until July 15, it is unlikely that either program will be conducted during the Pt. Lay Beluga hunt which typically concludes before that date.

Chukchi Sea Marine Surveys

Description of Activity: Marine surveys will include site clearance and shallow hazards surveys of potential exploratory drilling locations as required by MMS regulations. These surveys gather data on: (1) bathymetry, (2) seabed topography and other seabed characteristics (e.g., boulder patches), (3) potential geohazards (e.g., shallow faults and shallow gas zones), and (4) the presence of any archeological features (e.g., shipwrecks). Marine surveys for site clearance and shallow hazards can be accomplished by one vessel with acoustic sources. No other vessels, such as chase boats, are necessary to accomplish the proposed work. Any necessary crew changes or 4MP coordinated activities under this activity will utilize the same crew change, landing craft, or 4MP vessel mentioned under the Chukchi Sea deep 3D seismic.

The Chukchi Sea Marine Surveys will be conducted on leases that will be leased in the upcoming OCS LS 193, which is scheduled to be held February 2008. Site clearance surveys are confined to small specific areas within OCS blocks. Actual locations of site clearance and shallow hazard surveys have not been definitively set as of this date, although these will occur within the area outlined in Figure 1. Before the commencement of operations, survey location information will be supplied to NMFS, MMS, and other affected agencies as it becomes available.

The vessel which will be conducting these marine surveys may also be involved in the deployment and retrieval of Ocean Bottom Hydrophones (OBHs) as described in the 4MP in Attachment B. These OBHs are anchored buoys that record mammal vocalizations and seismic sounds.

Primary Contractor: The contractor has not yet been selected.

Description of the site clearance and shallow hazard vessel and survey equipment: These surveys are confined to small specific areas within OCS blocks. The vessel which will be conducting this activity is TBD. The vessel will be similar to a vessel contracted during 2007, the *R/V Norseman II*, which is a diesel-powered crabbing boat, 34.5 m (113 ft) long, 8.5 m (28 ft) wide, and with 4.0 m (13 ft) draft (Attachment A).

It is proposed that the following acoustic instrumentation, or something similar, be used. This is the same equipment as was used on the *M/V Henry Christofferson* (Henry C) during 2007:

- Dual frequency subbottom profiler Datasonics CAP6000 Chirp II (2 to7 kiloHertz [kHtz] or 8 to 23 kHz) or similar;
- Medium penetration subbottom profiler, Datasonics SPR-1200 Bubble Pulser (400 (hertz [Hz]) or similar;
- High resolution multi-channel 2D system, 20 cubic inches (in^3) (2 by 10) gun array (0 to 150 Hz) or similar;
- Multi-beam bathymetric sonar, Seabat 8101 (240 Hz); or similar and
- Side-scan sonar system, Datasonics SIS-1500 (190 to 210 kHz) or similar.

Planned Mitigation: The proposed mitigations, via a POC, are the same as described above for the Chukchi Sea Deep 3D Seismic Survey.

Beaufort Sea Deep 3D Seismic Survey

Description of Activity: The same seismic vessel (*M/V Gilavar*), seismic equipment, and two chase boats that are described for the Chukchi Sea Deep 3D Seismic survey, will be used to conduct deep 3D seismic surveys in the central and eastern Beaufort Sea (Figure 2). The focus of this activity will be on SOI's existing leases, but some activity in the Beaufort Sea may occur outside of SOI's existing leases. The landing craft, which will be used to move personnel and supplies from vessels in the near shore to docking sites will most likely use West Dock, or Oliktok Dock. Smaller vessels such as the Alaska Clean Seas (ACS) bay boats, or similar vessels, may be used to assist in the movement of people and supplies and support of the 4MP in the Beaufort Sea.

Planned Mitigation: The proposed mitigations, via a POC, which may or may not include a CAA with the AEWC are the same as described above for the Chukchi Sea Deep 3D Seismic Survey.

This POC will specify times and areas to avoid in order to minimize any possible conflicts with marine subsistence activities, including the bowhead whale subsistence hunts by the villages of Kaktovik, Nuiqsut (Cross Island), and Barrow. Regardless of whether a CAA is successfully negotiated, SOI is committed to meeting its regulatory requirements by implementing the mitigation measures described in Section 12 (iii) of this IHA application and will implement these measures which are intended to minimize any adverse effects on the availability of marine mammals for subsistence uses.

Beaufort Sea Marine Surveys

Overview of Beaufort Marine Surveys: Three marine survey activities are proposed for the Beaufort Sea: (1) Site Clearance and Shallow Hazards (2) Ice Gouge Surveys, and (3) Strudel Scour Surveys. Marine surveys for site clearance and shallow hazards, ice gouge, or strudel scour can be accomplished by one vessel with acoustic sources. No other vessels, such as chase boats, are necessary to accomplish the proposed work. Any necessary crew changes or 4MP coordinated activities under this activity will utilize the same crew change, landing craft, or 4MP vessel mentioned under the Beaufort Sea Deep 3D Seismic survey.

1. Site Clearance and Shallow Hazards

Description of Activity: Marine surveys will include site clearance and shallow hazards surveys of potential exploratory drilling locations. These surveys gather data on: (1) bathymetry, (2) seabed topography and other seabed characteristics (e.g., boulder patches), (3) potential geohazards (e.g., shallow faults and shallow gas zones), and (4) the presence of any archeological features (e.g., shipwrecks).

The focus of this activity will be on SOI's existing leases in the central and eastern Beaufort Sea, but some activity may occur outside of SOI's existing leases. Actual locations of site clearance and shallow hazard surveys have not been definitively set as of this date, although these will occur within the area outlined in Figure 2. Before the commencement of operations, survey location information will be supplied to NMFS, MMS, and other affected agencies as it becomes available.

Primary Contractor: Geo LLC

Description of the site clearance and shallow hazards vessel and survey equipment: This program will use the *M/V Henry C*, or a similar vessel. The *M/V Henry C* is the same vessel used during SOI's 2006 and 2007 site clearance and shallow hazard surveys in the Beaufort Sea. She is a diesel-powered tug, 45.23 m (148 ft) long, 15.87 m (52 ft) wide, with 1.3 m (4 ft) draft (see Attachment A).

It is proposed that the following acoustic instrumentation, or something similar, be used. This is the same equipment as was used on the *M/V Henry C* during 2007:

- Dual frequency subbottom profiler Datasonics CAP6000 Chirp II (2 to 7kHz or 8 to 23 kHz) or similar;
- Medium penetration subbottom profiler, Datasonics SPR-1200 Bubble Pulser (400 (hertz [Hz]) or similar;
- High resolution multi-channel 2D system, 20 in^3 (2 by 10) gun array (0 to 150 Hz) or similar;
- Multi-beam bathymetric sonar, Seabat 8101 (240 Hz); or similar and
- Side-scan sonar system, Datasonics SIS-1500 (190 to 210 kHz) or similar

2. Ice Gouge Survey

Description of Activity: Ice Gouge surveys are a type of marine survey to determine the depth and distribution of ice gouges in the sea bed. Ice gouge is created by ice keels which project from the bottom of moving ice that gouge into seafloor sediment. Remnant ice gouge features are mapped to aid in predicting the prospect of, orientation, depth, and frequency of future ice gouge. These surveys will focus on the potential, prospective pipeline corridor between the Sivulliq Prospect in Camden Bay and the nearshore Point Thomson area. The Sivulliq area will be surveyed to gather geotechnical and seafloor hazard information as well as data on ice gouges.

Contractor: A contractor has not been yet been selected.

Description of the Ice Gouge vessel and survey equipment: The vessel has not been selected, but it is anticipated that the vessel would be similar to the *M/V Henry C* which is a diesel-powered tug with the following dimensions: 45.23 m (148 ft) long, 15.87 m (52 ft) wide, and 1.3 m (4 ft) draft (Attachment A).

It is proposed that the following acoustic instrumentation, or something similar, be used. This is the same equipment as was used on the *M/V Henry C* during 2007:

- Dual frequency subbottom profiler Datasonics CAP6000 Chirp II (2 to 7kHz or 8 to 23 kHz) or similar;
- Medium penetration subbottom profiler, Datasonics SPR-1200 Bubble Pulser (400 (hertz [Hz]) or similar;
- High resolution multi-channel 2D system, 20 in^3 (2 by 10) gun array (0 to 150 Hz) or similar;
- Multi-beam bathymetric sonar, Seabat 8101 (240 Hz); or similar and
- Side-scan sonar system, Datasonics SIS-1500 (190 to 210 kHz) or similar

Actual locations of the ice gouge surveys have not been definitively set as of this date, although these will occur within the area outlined in Figure 2. Before the commencement of operations, survey location information will be supplied to NMFS, MMS, and other affected agencies as it becomes available.

3. Strudel Scour Survey

Description of Activity: During the early melt on the North Slope, the rivers begin to flow and discharge water over the coastal sea ice near the river deltas. That water rushes down holes in the ice ("strudels") and scours the seafloor. These erosional areas are called "strudel scours". Information on these features is required for prospective pipeline planning. Two proposed activities are required to gather this information: aerial survey via helicopter overflights during the melt to locate the strudels; and strudel scour marine surveys to gather bathymetric data. The overflights investigate possible sources of overflood water and will survey local streams that discharge in the vicinity of Point Thomson including the Staines River, which discharges to the east into Flaxman Lagoon and the Canning River, which discharges to the east directly into the Beaufort Sea. These helicopter overflights will occur during late May/early June 2008 and, weather permitting, should take no more than four days. There are no planned landings during these overflights other than at the Deadhorse or Kaktovik airports. Areas that have strudel scour identified during the aerial survey will be verified and surveyed with a marine vessel after the breakup of nearshore ice. This proposed activity is not anticipated to take more than 5 days to conduct. The operation is conducted in the shallow water areas near the coast in the vicinity of Point Thomson. This vessel will use the following equipment:

- Multi-beam bathymetric sonar, Seabat 8101 (240 Hz); or similar
- Side-scan sonar system, Datasonics SIS-1500 (190 to 210 kHz) or similar

Primary Contractor: Coastal Frontiers Corporation

Description of the Studel Survey Vessel: The vessel has not been contracted; however, it is anticipated that it will be the diesel-powered *R/V Annika Marie* which measures 13.1 m (43 ft) long, or similar vessel.

Planned Mitigation for the Beaufort Shallow Hazards/Site Clearance Survey, Ice Gouge Survey, and Strudel Scour Survey: The proposed mitigations, via a POC, which may or may not include a CAA with the AEWC are the same as described above for the Chukchi and Beaufort Seas Deep 3D Seismic Surveys.

This POC will specify times and areas to avoid to minimize any possible conflicts with marine subsistence activities, including the bowhead whale subsistence hunts by the villages of Kaktovik, Nuiqsut (Cross Island), and Barrow. Regardless of whether a CAA is successfully negotiated, SOI is committed to meeting its regulatory requirements by implementing the mitigation measures described in Section 12 (iii) of this IHA application and will implement these measures which are intended to minimize any adverse effects on the availability of marine mammals for subsistence uses.

List of Proposed Marine Vessels for the Beaufort and Chukchi Seas Open Water Seismic and Marine Surveys

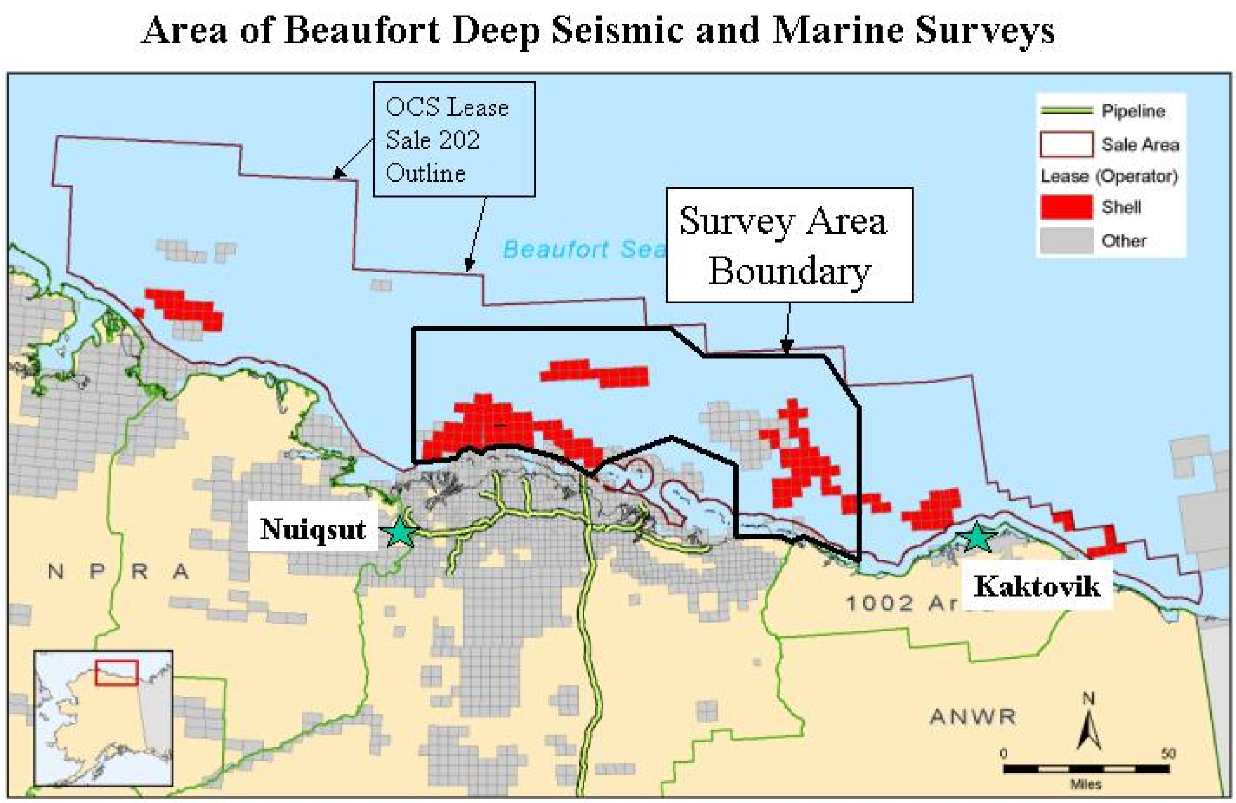
TABLE 1-1
Shell Offshore Inc. Proposed Marine Vessels 2008 Open Water Program

Chukchi Sea Deep 3D Seismic			
Vessel Task	**Maximum Operating Timeframe**	**SSV***	**Proposed Vessel**
3D Seismic Source	July 15 to Nov 15	Y	Gilavar
Chase Boat	July 15 to Nov 15	N	Gulf Provider
Chase Boat	July 15 to Nov 15	N	TBD
Crew Change Vessel	July 15 to Nov 15	N	TBD
Landing Craft	July 15 to Nov 15	N	TBD
4MP Support	July 15 to Nov 15	N	TBD
Beaufort Sea Deep 3D Seismic			
Vessel Task	**Maximum Operating Timeframe****	**SSV***	**Proposed Vessel**
3D Seismic Source	mid-August to the end of October	Y	Gilavar
Chase Boat	mid-August to the end of October	N	Gulf Provider
Chase Boat	mid-August to the end of October	N	TBD
Crew Change Vessel	mid-August to the end of October	N	TBD
Landing Craft	mid-August to the end of October	N	TBD
4MP	mid-August to the end of October	N	TBD
Chukchi Sea Marine Surveys			
Vessel Task	**Maximum Operating Timeframe**	**SSV***	**Proposed Vessel**
Site Clearance	August and September	Y	TBD
Beaufort Sea Marine Surveys			
Vessel Task	**Maximum Operating Timeframe**	**SSV***	**Proposed Vessel**
Site Clearance	mid July to early-October	Y	Henry C, or similar vessel
Ice Gouge	late-July and early-October.	Y	TBD
Strudel Scour	mid-July or August.	N	Annika Marie, or similar vessel
4MP	August to late-October	N	TBD

* Sound Source Verification Test required if this vessel or a similar vessel and source equipment has not been previously tested.

** If the Beaufort Deep 3D Seismic Survey is conducted, then the duration of the Chukchi Sea program will be reduced.

Figure 2 Beaufort Sea Deep 3D Seismic and Marine Survey Area



2. The dates and duration of such activity and the specific geographic region where it will occur:

Duration of time that this application is proposed to cover

SOI's existing IHA for open water activities in the Chukchi and Beaufort Seas is valid until August 1, 2008. This request for IHA application is intended for the period between August 2, 2008 and August 1, 2009.

Dates and Duration of the Chukchi Sea Deep 3D Seismic Survey

The proposed deep 3D seismic survey in the Chukchi Sea could commence July 15, 2008 and conclude on November 15, 2008. As proposed, this survey will last a maximum of 100 days of active data acquisition (excluding downtime due to weather and other unforeseen delays). If ice conditions allow, the seismic and associated vessels may transit to the Beaufort Sea to conduct seismic operation for part of the this time which would shorten the duration of the proposed Chukchi Sea program from the 100 day maximum.

Dates and Duration of the Chukchi Sea Marine Surveys

This proposed program will probably occur in August and September, and as proposed the total program will last a maximum of 45 days of active data acquisition (excluding downtime due to weather and other unforeseen delays). This vessel also may be used to perform other activities such as deploying and retrieving the OBHs (sonabuoys). Time for deploying and retrieving OBHs (sonabuoys) is not included in the 45-day estimate.

Dates and Duration of the Beaufort Sea Deep 3D Seismic Survey

The program is proposed to occur in open water from mid-August to the end of October. As proposed, this program will last a maximum of 60 days of active data acquisition (excluding downtime due to weather and other unforeseen delays).

Dates and Duration of the Beaufort Sea Marine Surveys

Site Clearance and Shallow Hazard Surveys

This program is proposed to commence as soon as the ice clears substantially in the Beaufort Sea which is normally in mid-July. The program will end when the ice starts to reappear which is normally early-October. As proposed, this program will last a maximum of 70 days of active data acquisition (excluding downtime due to weather and other unforeseen delays).

Ice Gouge Surveys

This proposed activity is proposed to be conducted sometime between late July and early October. The total program will last a maximum of 40 days (excluding downtime due to weather and other reasons).

Strudel Scour Survey: This proposed activity is not anticipated to take more than 5 days to conduct (excluding downtime due to weather and other unforeseen delays). It is anticipated to occur in late July or August.

3. Species and numbers of marine mammals in area:

The species and numbers of marine mammals likely to be found within the eastern Beaufort Sea activity areas are listed in Table 4-1.

A total of three cetacean species (bowhead, gray, and beluga whale), and three species of pinnipeds (ringed, spotted, and bearded seal) are known to occur in or near the proposed study area. The harbor porpoise and killer whale are more likely to occur in the Chukchi Sea than the eastern portion of the Beaufort Sea. Because of the rarity of the harbor porpoise and killer whale in the eastern part of the Beaufort Sea, they are not expected to be exposed to or affected by any activities associated within the area of proposed seismic work. Discussions of harbor porpoise and killer whale are more applicable to the Chukchi Sea activities and these species are addressed in Section 4. Only the bowhead whale is listed as “Endangered” under the Endangered Species Act (ESA). Other ESA-listed species which are known to occur in the adjacent Bering Sea include Steller sea lion, sperm whale, humpback whale, fin whale, blue whale, and northern right whale. However, these species are considered to be extralimital in the Chukchi and Beaufort Seas. Because of the very remote chance of interaction or potential impact, these species are not discussed further under this IHA application.

In an effort to reduce redundancy, we have included the required information about these species and abundance estimations (to the extent known) of these species in Section 4 below.

4. Status, distribution and seasonal distribution of affected species or stocks of marine mammals:

The following six species of cetaceans and seals can be expected to occur in the region of the proposed seismic activity: bowhead, gray and beluga whales, and ringed, spotted and bearded seals. These six species are the species for which general regulations governing potential incidental takes of small numbers of marine mammals are sought. The geographic boundaries and distribution, primary habitats, and population trends and risks are discussed under each species.

In addition, harbor porpoise and killer whale are addressed here as they are more likely to occur in the Chukchi Sea, rather than the Beaufort Sea.

Three species of marine mammals—the Pacific walrus, sea otter, and polar bear—are managed by the U.S. Fish and Wildlife Service (USFWS) and are not discussed further under this IHA application to NMFS.

Bowhead Whale (*Balaena mysticetus*)

The Western Arctic stock (discussed below) is distributed in seasonally ice-covered waters of the Arctic and near-arctic, generally between 60 and 75 degrees N latitudes in the western Arctic Basin (Moore and Reeves 1993). Currently, five bowhead whale stocks are recognized by the International Whaling Commission (IWC 1992). Small stocks occur in the Canadian Arctic and West Greenland (Baffin Bay, Davis Strait, and Hudson Bay), the Okhotsk Sea (eastern Russia), and the Northeast Atlantic from Spitzbergen westward to eastern Greenland (Zeh et al. 1993). The largest population is the Western Arctic stock, also know as the Bering, Chukchi, and Beaufort Sea stock (Rugh et al. 2003), and is the focus of this IHA.

In Alaskan waters, the majority of bowhead whales winter in the central and northwestern Bering Sea (November to March), migrate through the Chukchi Sea in the spring (March through June) following offshore ice leads around the coast of Alaska, and summer in the Canadian Beaufort Sea (mid-May through September) (Braham et al. 1980; Moore and Reeves 1993).

Bowheads tend to migrate west in deeper water (farther offshore) during years with higher than average ice coverage than in years with less ice (Moore 2000). During fall migration, most bowheads migrate west in water ranging from 15 to 200 m deep (Miller et al. 2002 *in* Richardson and Thomson 2002); some individuals enter shallower water, particularly in light ice years, but very few whales are ever seen shoreward of the barrier islands.

TABLE 4-1

Species that May be Encountered During Activities

A list of species that may be encountered during activities within the Beaufort Sea, including their habitats, conservation status, and estimated abundance numbers.

Species (Stock)	Habitat	Beaufort Sea Stock and/or ESA Status [1]	Estimated Abundance [2]
Cetaceans			
bowhead whale (*Balaena mysticetus*) (Western Arctic stock)	Pack ice and coastal	ESA listed as Endangered, listed as depleted under MMPA, and classified as a strategic stock	10,545
gray whale (*Eschrichtius robustus*) (eastern north Pacific)	Coastal, lagoons	Not listed under ESA, not listed as depleted under MMPA, and not classified as a strategic stock	18,813
beluga whale (*Delphinapterus leucas*) (Beaufort Sea/eastern Chukchi Sea)	Offshore, coastal, ice edges	Not listed under ESA, not listed as depleted under MMPA, and not classified as a strategic stock	39,258/3,710
killer whale (*Orcinus orca*) (eastern North Pacific Alaska resident stock)	Widely distributed	Not listed under ESA, not listed as depleted under MMPA, and not classified as a strategic stock	1,123
Harbor porpoise (*Phocoena phocoena*) (Bering Sea Stock)	Coastal, inland waters	Not listed under ESA, not listed as depleted under MMPA, and not classified as a strategic stock	47,356
Pinnipeds			
ringed seal (*Phoca hispida*) (Alaska)	Landfast and pack ice	Not listed under ESA, not listed as depleted under MMPA, and not classified as a strategic stock	Up to 3.6 million; Currently, no reliable abundance estimate is available for the Beaufort Sea; however, combined with surveys from the Chukchi Sea, approximately 249,000 are estimated.
spotted seal (*Phoca largha*)	Pack ice	Not listed under ESA, not listed as depleted under MMPA, and not classified as a strategic stock	Several thousand and several tens of thousands. An estimate with correction using 1992 data = 59,214 seals but is preliminary at best.
bearded seal (*Erignathus barbatus*)	Pack ice	Not listed under ESA, not listed as depleted under MMPA, and not classified as a strategic stock	Currently, no reliable abundance estimate is available for this stock. Early estimates of the Bering-Chukchi Seas ranged from 250,000 to 300,000.

1. ESA = Endangered Species Act. Stocks listed as depleted under the MMPA (Marine Mammal Protection Act) is described as any stock that falls below its optimum sustainable population (OSP) must be classified as "depleted," 16 U.S.C. § 1362(1)(A). The numeric threshold for OSP has been interpreted by NMFS and USFWS as being above 0.6 K (i.e. greater than 60 percent of K, or carrying capacity). In other words, a stock that dropped in numbers to below 60 percent of K would qualify as "depleted" under the MMPA. The term "strategic stock" is defined as a marine mammal stock: (A) for which the level of direct human-caused mortality exceeds the Potential Biological Removal level; (B) which, based on the best available scientific information, is declining and is likely to be listed as a threatened species under the ESA of 1973 . . . within the foreseeable future; or (C) which is listed as a threatened species or endangered species under the ESA of 1973 . . ., or is designated as depleted under [the MMPA].
2. See text under individual species for population estimate sources

Bowhead whales typically reach the Barrow area during their westward migration from the feeding grounds in the Canadian Beaufort Sea in mid-September to late-October. Although, over the years local residents report having seen a small number of bowhead whales feeding off Barrow or in the pack-ice off Barrow during the summer, indicating that this area may be an important feeding area. Autumn bowhead whaling near Barrow normally begins in mid-September, but may begin as early as August if whales are observed and ice conditions are favorable (USDI/BLM 2005). Whaling can continue into October, depending on the quota and conditions.

The pre-exploitation population of bowhead whales in the Bering, Chukchi, and Beaufort Seas is estimated to be 10,400 to 23,000 individual whales, and was reduced by commercial whaling to perhaps 3,000 individuals (Woodby and Botkin 1993). Up to the early 1990s, the population size was believed to be increasing at a rate of about 3.2 percent per year (Zeh et al. 1996; Angliss and Lodge 2002) despite annual subsistence harvests of 14 to 74 bowheads from 1973 to 1997 (Suydam et al. 1995) and 42, 35, 49, 37, and 35 in 1999 through 2003, respectively (Suydam and George 2004). This is consistent with an annual population growth rate of 3.4 percent (95 percent CL 1.7-5 percent) from 1978 to 2001 reported by George et al. (2004) who estimated the population in 2001 at approximately 10,470 animals. Based on the most recent abundance estimates using 2001 data, approximately 10,545 bowhead whales make up the Western Arctic stock, with a minimum estimate [coefficient of variation [CV](N) = 0.128] of 9,472 whales (Angliss and Outlaw 2005).

The inclusion of the abundance estimate for 2001 results in a rate of increase of 3.5 percent (confidence intervals [CI] = 2.2 to 4.9 percent) (Brandon and Wade 2004 *cited in* Angliss and Outlaw 2005). Calf counts in 2001 were the highest recorded at 121 individuals, and lends building evidence of a growing population.

This bowhead population is currently listed as Endangered under the ESA and is classified as a strategic stock by NMFS (Angliss and Outlaw 2005).

Gray Whale (*Eschrichtius robustus*)

Gray whales originally inhabited both the North Atlantic and North Pacific oceans. The Atlantic populations are believed to have become extinct by the early 1700s, while a relic population survives in the western North Pacific. The eastern North Pacific or California gray whale population has recovered significantly from commercial whaling, and now numbers about 18,813 individuals, and this stock is the focus for this IHA (Angliss and Outlaw 2005).

The eastern North Pacific population of the gray whale ranges from the Bering, Chukchi, and Beaufort Seas (in summer) to the Gulf of California (in winter) (Rice 1998). Gray whales have also been documented foraging during summer in waters off of Southeast Alaska, British Columbia, Washington, Oregon, and California (Rice and Wolman 1971; Berzin 1984; Darling 1984; Quan 2000; Calambokidis et al. 2002). Most of the eastern North Pacific population migrates annually from Alaska waters to Baja California in Mexico, more than 8,000 km (5,000 miles) roundtrip. From late May to early October, the majority of the population concentrates in the northern and western Bering Sea and the Chukchi Sea.

Gray whales are found primarily in shallow water, and usually remain closer to shore than any other large cetacean. Gray whales are considered common in the nearshore waters of the eastern Chukchi Sea, and occasionally are seen east of Point Barrow in late-spring and summer. On wintering grounds, mainly along the west coast of Baja California, gray whales utilize shallow, nearly land-locked lagoons and bays (Rice et al. 1981). From late February to June, the population migrates back to arctic and subarctic seas (Rice and Wolman 1971).

Most summering gray whales congregate in the northern Bering Sea, and in the southern Chukchi Sea (Moore et al. 2000). More recently, Moore et al. (2003) suggested that gray whale use of Chirikov Basin was reduced, likely as a result of the combined effects of changing currents resulting in altered secondary productivity dominated by lower quality food. The northeastern-most of the recurring feeding areas is in the northeastern Chukchi Sea southwest of Barrow (Clarke et al. 1989).

Small numbers of gray whales have been observed entering the Beaufort Sea east of Point Barrow. Maher (1960) reported hunters at Cross Island took one gray whale in 1933. Aerial surveys conducted in the central Alaskan Beaufort Sea documented only one gray whale between 1979 to 1997. Since 1997, small numbers of gray whales have been documented on several occasions in the central Alaskan Beaufort Sea—mainly in the Harrison Bay area (Miller et al. 1999; Treacy 2000). Other reports of single gray whale sightings have been documented farther east of Harrison Bay (Rugh and Fraker 1981). In August 2001, Williams and Coltrane (2002) reported a single sighting of a gray whale near the Northstar production facility, indicating that small numbers do travel through the waters offshore from the Prudhoe Bay region during some summers. Given their rare occurrence in the eastern portion of the Beaufort Sea in summer, no more than a few are expected during the summer and early fall.

Gray whales have been counted as they migrate southward past Granite Canyon in central California each year since 1967. The most recent abundance estimates are from southbound migration counts in 1997/98, 2000/01, and 2001/02 periods with abundance estimates for the aforementioned periods of 29,758, 19,448, and 18,178, respectively (Rugh et al. [in press] *in* Angliss and Outlaw 2005).

Previous variations in estimates may be attributed to differences in the proportion of the gray whale stock migrating as far as the central California coast each year. The decline in abundance estimates between the 2000/01, and 2001/02 may be an indication that the abundance was responding to environmental limitations as the population approaches carrying capacity (Angliss and Outlaw 2005). The lower counts conducted in 2000/01 and 2001/02 may have been due to a large number of whales that did not migrate as far south as Granite Canyon, or possibly, abundance may have actually declined following high mortality rates documented in 1999 and 2000 (Rugh et al. [in press] *cited in* Angliss and Outlaw 2005; Gulland et al. 2005).

Using the mean of the 2000/01 and 2001/02 abundance estimates noted above is 18,813 animals (Angliss and Outlaw 2005). Gray whale numbers increased steadily until at least 1998, with an estimated annual growth rate of 3.3 percent between 1967 and 1988 (Buckland et al. 1993). More recent estimated growth rates from 1967/68 through 2001/02 indicate and annual growth rate of 1.9 percent (SE = 0.32 percent) (Rugh et al. [in press] *in* Angliss and Outlaw 2005). In addition, Rugh et al. (in press) estimated carrying capacity of 26,290 (CV = 0.059), indicating that recent reductions in abundance estimates may be a function of the population reaching its carrying capacity.

The eastern Pacific stock was removed from the Endangered Species List in 1994 and is not considered by NMFS to be a strategic stock.

Beluga Whale (*Delphinapterus leucas*)

The beluga whale is an arctic and subarctic species with several populations (stocks) occurring in Alaska: Beaufort Sea, eastern Chukchi Sea, eastern Bering Sea, Bristol Bay, and Cook Inlet (O'Corry-Crowe et al. 1997, Angliss and Lodge 2004). For the proposed project, only the Beaufort Sea stock and eastern Chukchi Sea stocks will be encountered. Some eastern Chukchi Sea animals enter the Beaufort Sea in late summer (Suydam et al. 2001).

Beluga whales of the Beaufort stock winter in the Bering Sea, summer in the eastern Beaufort Sea, and migrate around western and northern Alaska (Angliss and Lodge 2002). The majority of belugas in the Beaufort stock migrate into the Beaufort Sea in April or May, although some whales may pass Point Barrow as early as late March and as late as July (Braham et al. 1984; Ljungblad et al. 1984; Richardson et al. 1995).

Much of the Beaufort Sea seasonal population enters in the Mackenzie River estuary for a short period during July and August to molt their epidermis, but they spend most of the summer in offshore waters of the eastern Beaufort Sea and Amundsen Gulf (Davis and Evans 1982; Harwood et al. 1996). Belugas are rarely seen in the central Alaskan Beaufort Sea during the summer. During late summer and autumn, most belugas migrate far offshore near the pack ice front (Hazard 1988; Clarke et al. 1993; Miller et al. 1998) and may select deeper slope water independent of ice cover (Moore et al. 2000b). Small numbers of belugas are sometimes observed near the north coast of Alaska during the westward migration in late summer and autumn (Johnson 1979), but the main fall migration corridor of beluga whales is greater than 100 km (62 miles) north of the coast. Aerial- and vessel-based seismic monitoring programs conducted in the central Alaskan Beaufort Sea from 1996 through 2001 observed only a few beluga whales migrating along or near the coast (LGL and Greeneridge 1996; Miller et al. 1998, 1999). The vast majority of belugas seen during those projects were far offshore. Satellite-linked telemetry data show that some belugas migrate west considerably farther offshore, as far north as 78 degrees N latitude (Richard et al. 1997, 2001).

The Beaufort population was estimated to contain 39,258 individuals as of 1992 (Angliss and Lodge 2002). This estimate is based on the application of a sightability correction factor of 2 times to the 1992 uncorrected census of 19,629 individuals made by Harwood et al. (1996). This estimate was obtained from a partial survey of the known range of the Beaufort Sea population and may be an underestimate of the true population size. This population is not considered by NMFS to be a strategic stock but the current population trend of the Beaufort Sea stock of beluga whales is unknown (Angliss and Outlaw 2005).

The abundance estimate considered the "most reliable" for the eastern Chukchi Sea beluga whale stock is 3,710, a result from 1989–1991 aerial surveys (Frost et al. 1993, Angliss and Lodge 2004). Additional surveys were conducted in 1998 (DeMaster et al. 1998) and again in July 2002 (Lowry and Frost 2002, *cited in* Angliss and Outlaw 2005), but both were partial surveys and therefore, a more recent abundance estimate is not available. This stock will not likely be encountered during the seismic surveys in the eastern Beaufort Sea, the population size is considered stable and not considered to be a strategic stock.

Killer Whale (*Orcinus orca*)

Killer whales are found throughout the world oceans and seas, from tropical waters near the equator to the cooler waters in the high latitudes. They are most common in cooler coastal waters of both hemispheres, but appear in greatest numbers within 800 km from continental coasts (Mitchell 1975). Killer whales are found throughout the North Pacific and along the entire Alaskan coast, extending from the Bering and Chukchi Seas with small numbers possibly occurring in the Beaufort Sea. It is unclear which stock of killer whales may move into the waters of the Chukchi; however small numbers have been reported west of Point Barrow in the late spring and early summer, presumably following the bearded seal migration (pers comm., C. George, NMML, November 8, 2005).

Based on data regarding association patterns, acoustics, movements, and genetic differences, eight killer whale stocks are now recognized within the Pacific U.S.: 1) the Alaska Resident stock - occurring from southeastern Alaska to the Aleutian Islands and Bering Sea; 2) the Northern Resident stock - occurring from British Columbia through part of southeastern Alaska; 3) the Southern Resident stock - occurring mainly within the inland waters of Washington state and southern British Columbia, but also in coastal waters from British Columbia through California; 4) the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock - occurring mainly from Prince William Sound through the Aleutian Islands and Bering Sea; 5) the AT1 transient stock - occurring in Alaska from Prince William Sound through the Kenai Fjords; 6) the West Coast transient stock - occurring from California through southeastern Alaska; and 7) the Offshore stock - occurring from California through Alaska, and 8) the Hawaiian stock.

The Alaska resident stock is a transboundary stock, but is found from southeastern Alaska to the Aleutian Islands and Bering Sea (Angliss and Outlaw 2005). The National Marine Mammal Laboratory (NMML) began killer whale studies in 2001 in Alaskan waters west of Kodiak Island, including the Aleutian Islands and Bering Sea. Line-transect surveys were conducted in July and August in 2001-2003. Based on these surveys an estimated abundance of resident killer whales was 991 (CV = 0.52), with 95 percent confidence interval of 380-2585 (Zerbini et al. in prep. *cited in* Angliss and Outlaw 2005). Because areas such as Prince William Sound and the Bering Sea were outside the line-transect survey area and movement of whales were known to move out of the survey area over the course of the 3-year study, counts of known 'resident' whales in these areas were combined, using photo identification, to produce a minimum number estimate of 1,123 killer whales belonging to the Alaska Resident stock (Angliss and Outlaw 2005). The eastern North Pacific Alaska resident stock of killer whales is not classified as a strategic stock.

Harbor Porpoise (*Phocoena phocoena*)

The harbor porpoise is the smallest cetacean, found in shallow, coastal waters from temperate to arctic zones of the northern hemisphere (Read 1999). In the eastern North Pacific Ocean, the harbor porpoise ranges from Point Barrow, along the Alaska coast, and down the west coast of North America to Point Conception, California (Gaskin 1984). The Bering Sea stock of the harbor porpoise primarily frequents coastal waters, and in the Gulf of Alaska and Southeast Alaska, they occur most frequently in waters less than 100 m in depth (Waite and Hobbs, in review, *cited in* Angliss and Outlaw 2005).

The northern extent of the harbor porpoise's range is the Chukchi Sea near Point Barrow south through the Bering Sea, southeastern shore of Bristol Bay, and south to San Luis Obispo, California (Suydam and George 1992). There are extralimital records of harbor porpoise documented further east of Point Barrow near the mouth of the Mackenzie River in the Northwest Territories, Canada.

Aerial surveys conducted in June and July 1999 in the waters of Bristol Bay provide an abundance estimate (with correction) of 47,356 (CV = 0.223) (Angliss and Outlaw 2005).

The estimate for 1999 can be considered conservative, as the surveyed areas did not include known harbor porpoise range near either the Pribilof Islands or in the waters north of Cape Newenham, approximately 59 degrees N (Angliss and Outlaw 2005). This estimate is higher than the 1991 estimate of 10,946 (Dahlheim et al. 2000), but differences in survey techniques make direct comparisons of the surveys difficult.

Surveys conducted in 1999 were more extensive than during the 1991 surveys, and additional areas (Dahlheim et al. 2000). In addition, the use of a second correction factor for the 1999 estimate confounds direct comparison. The density of harbor porpoise resulting from the 1999 surveys was still substantially higher than that reported in Dahlheim et al. (2000), but it is unknown whether the increase in density is a result of a population increase or is a result of survey design.

Harbor porpoise is unlikely to occur within the seismic data acquisition area as transects will occur well offshore in water depth averaging approximately 250 m in depth. Harbor porpoise are not listed as "depleted" under the MMPA or listed as "threatened" or "endangered" under the ESA. The Bering Sea stock of harbor porpoise is not classified as a strategic stock. Population trends and status of this stock relative to optimum sustainable population (OSP) are currently unknown.

Ringed Seal (*Phoca hispida*)

In the North Pacific, ringed seals are found in the southern Bering Sea and range as far south as the Seas of Okhotsk and Japan. Ringed seals have an affinity for ice-covered waters and are well adapted to occupying seasonal and permanent ice, and are year-round residents throughout the Beaufort, Chukchi, and Bering Seas, as far south as Bristol Bay in years of extensive ice coverage. They tend to prefer large floes (more than 48 m in diameter) and are often found in the interior ice pack where the sea ice coverage is greater than 90 percent (Simpkins et al. 2003), and remain in contact with ice most of the year and pup on the ice in late winter to early spring.

During winter, ringed seals occupy landfast ice and offshore pack ice of the Bering, Chukchi, and Beaufort Seas. Ringed seals maintain breathing holes in the ice and occupy lairs in accumulated snow (Smith and Stirling 1975). They give birth in lairs from mid-March through April, nurse their pups in the lairs for 5 to 8 weeks, and mate in late April and May (Smith 1973; Hammill et al. 1991; Lydersen and Hammill 1993).

During late April through June, ringed seals are distributed throughout their range from the southern ice edge northward (Braham et al. 1984). Preliminary results from recent surveys conducted in the Chukchi Sea in May to June 1999 and 2000 indicate that ringed seal density is higher in nearshore fast and pack ice, and lower in offshore pack ice (Bengtson et al. [in review] *cited in* Angliss and Outlaw 2005). Frost and Lowry (1999) conducted surveys in May and results indicated that, in the Alaskan Beaufort Sea, the density of ringed seals in May to June is greater to the east of Flaxman Island than to the west.

While no accurate estimate for the size of the Alaska ringed seal stock is currently available, a minimum abundance estimate in the eastern Chukchi and Beaufort Sea is 249,000 (Angliss and Outlaw 2005). Past ringed seal population estimates in the Bering-Chukchi-Beaufort area ranged from 1 to 3.6 million (Frost et al. 1988). Frost and Lowry (1981) estimated 80,000 ringed seals in the Beaufort Sea during summer and 40,000 during winter.

Aerial surveys within 20 nautical miles (nm) of shore were conducted in May-June between 1986 and 1987 for a portion of the range of the ringed seal estimated 44,360 +/-9,130 (96 percent CI) (Frost et al. 1988). Spring density estimates in the same area from 1985-1987 ranged from 1.01 to 2.94 seals/km^2 (Frost et al. 1988). Similar surveys for the Alaska Beaufort Sea between Kaktovik and Barrow occurred in the spring during several years in the 1990s with density estimates for all years ranging from 0.81 to 1.17 seals/square kilometers (km^2) (Frost et al. 2002) with a mean of 0.98 seals/km^2 or approximately 18,000 hauled-out ringed seals in the survey area. Surveys conducted in 1999 and 2000 between Shishmaref to Barrow in the eastern Chukchi Sea estimated abundance of ringed seals at 252,488 (SE = 47,204) and 208,857 (SE = 25,502), respectively (Bengtson et al. [in review] *cited in* Angliss and Outlaw 2005). Combining the numbers of Alaska Beaufort Sea ringed seals with the average abundance estimate of 230,673 seals from the eastern Chukchi Sea, results in a total of 249,000 seals.

It is not known whether the more recent lower densities correspond to an actual reduction in the population or are related to earlier survey dates in 1990s. At earlier dates, a higher proportion of the seals are still using their lairs and are unavailable to be counted by aerial surveyors (Kelly et al. 2005). Frost et al. (2002) reanalyzed the earlier estimates for 1985-87 and reported ringed seal densities surveyed between Oliktok Point and Flaxman Island ranged from 0.56 to 1.16 seals/km^2 (about half the density originally reported) during the spring seasons of 1985 to 1987. Based on more recent surveys from 1996 through 1999, ringed seal density in fast-ice areas between Oliktok Point and Flaxman Island ranged from 0.48 to 0.77 seals/km^2 (Frost et al. 2002).

BP Exploration (Alaska), Inc.'s Northstar development project, located near Prudhoe Bay, developed a seal survey and monitoring program to establish a baseline prior to construction and to monitor during initial operations for comparison. Ringed seal densities reported by Moulton et al. (2002) ranged from 0.39 to 0.63 seals/km^2 prior to construction in the Northstar development area. Ringed seal densities close to Northstar in 2000, 2001, and 2002 were not reduced relative to those farther away or to those during the 1997 to 1999 pre-development period (Moulton et al. 2003 a, b); however, because aerial surveys will underestimate actual seal densities, the above density figures should be used as minimum estimates.

During summer, ringed seals are found dispersed throughout open water areas, although in some regions they move into coastal areas (Smith 1987; Harwood and Stirling 1992). During the open water period, ringed seals in the eastern Beaufort Sea are widely dispersed as single animals or small groups (Harwood and Stirling 1992). Marine mammal monitoring in the nearshore central Beaufort Sea confirms these generalities (Moulton and Lawson 2002; Williams et al. 2004).

Large concentrations of ringed seals are not expected to be encountered near each of the proposed activity areas in the eastern Beaufort Sea during the summer and fall time period. The Alaska stock of ringed seals is not classified as a strategic stock by the NMFS.

Spotted Seal (*Phoca largha*)

Spotted seals occur in the Beaufort, Chukchi, Bering and Okhotsk Seas, and south to the northern Yellow Sea and western Sea of Japan (Shaughnessy and Fay 1977). Based on satellite tagging studies, spotted seals migrate south from the Chukchi Sea in October and pass through the Bering Strait in November and overwinter in the Bering Sea along the ice edge (Lowry et al. 1998).

During spring when pupping, breeding, and molting occur, spotted seals tend to prefer small floes (less than 20 m in diameter), and inhabit mainly the southern margin of the ice in the Okhotsk and Bering Seas, with movement to coastal habitats after the retreat of the sea ice (Shaughnessy and Fay 1977; Quakenbush 1988; Rugh et al. 1997; Simpkins et al. 2003).

In summer, the majority of spotted seals are found in the Bering and Chukchi Seas, but do range into the Beaufort Sea (Rugh et al. 1997; Lowry et al. 1998) from July until September. At this time of year, spotted seals haul out on land part of the time, but also spend extended periods at sea. The seals are most commonly seen in bays, lagoons, and estuaries and are typically not associated with pack ice unless it is near to shore.

A small number of spotted seal haul-outs are documented in the central Beaufort Sea near the deltas of the Colville River and, previously, the Sagavanirktok River. Historically, these sites supported as many as 400 to 600 spotted seals, but in recent times less than 20 seals have been seen at any one site (Johnson et al. 1999).

As the ice cover thickens with the onset of winter, spotted seals leave the northern portions of their range and move into the Bering Sea (Lowry et al. 1998).

Previous studies from 1996 to 2001 indicate that few spotted seals (a few tens) utilize the central Alaskan Beaufort Sea (Moulton and Lawson 2002; Treacy 2002 a, b). In total, there are probably no more than a few tens of spotted seals along the coast of the central Alaska Beaufort Sea during summer and early fall with very few, if any, occurring in the eastern portion of the Beaufort Sea.

A reliable abundance estimate for spotted seal is not currently available (Angliss and Outlaw 2005); however, early estimates of the size of the world population of spotted seals was 335,000 to 450,000 animals and the size of the Bering Sea population, including animals in Russian waters, was estimated to be 200,000 to 250,000 animals (Burns 1973 *cited in* Angliss and Lodge 2004). The total number of spotted seals in Alaskan waters is not known (Angliss and Lodge 2004), but the estimate is most likely between several thousand and several tens of thousands (Rugh et al. 1997). Using maximum counts at known haul-outs from 1992 (4,135 seals), and a preliminary correction factor for missed seals developed by the Alaska Department of Fish and Game (Lowry et al. 1994), an abundance estimate of 59,214 was calculated for the Alaska stock (Angliss and Lodge 2004).

The activities associated with the proposed work in the eastern Beaufort Sea are expected to encounter few to no spotted seals. The Alaska stock of spotted seals is not classified as a strategic stock by NMFS.

Bearded Seal (*Erignathus barbatus*)

Bearded seals are associated with sea ice and have a circumpolar distribution (Burns 1981). Bearded seals are predominately benthic feeders, and prefer waters less than 200 m in depth.

Seasonal movements of bearded seals are directly related to the advance and retreat of sea ice and to water depth (Kelly 1988). During winter they are most common in broken pack ice and in some areas also inhabit shorefast ice (Smith and Hammill 1981). In Alaska waters, bearded seals are distributed over the continental shelf of the Bering, Chukchi, and Beaufort Seas, but are more concentrated in the northern part of the Bering Sea from January to April (Burns 1981).

During winter, most bearded seals in Alaskan waters are found in the Bering Sea. In the Chukchi and Beaufort Seas, favorable conditions are more limited, and consequently, bearded seals are less abundant there during winter. From mid- to late April to June, as the ice recedes, some of the bearded seals migrate northward through the Bering Strait and spend the summer along the ice edge in the Chukchi Sea (Burns 1967; Burns 1981).

Recent spring surveys along the Alaskan coast indicate that bearded seals tend to prefer areas of nautical miles between 70 and 90 percent sea-ice coverage, and are typically more abundant greater than 20 nm of shore, with the exception of high concentrations nearshore to the south of Kivalina in the Chukchi Sea (Bengtson et al. 2000; Simpkins et al. 2003).

During the summer in the Chukchi Sea, bearded seals are most associated with the pack ice edge near the continental shelf. The nearshore areas of the central and western Beaufort Sea provide somewhat more limited habitat because the continental shelf is narrower and the pack ice edge frequently occurs seaward of the shelf and over waters greater than 200 m in depth. The preferred habitat in the Beaufort Sea during the open water period is the continental shelf seaward of the scour zone.

A reliable abundance estimate for the Alaska stock of bearded seals is currently not available. The most recent surveys occurred in May to June of 1999 and 2000 between Shismaref and Barrow with average densities of 0.07 seals per km^2 and 0.14 seals per km^2, respectively; however, there is no correction factor available for these data. Early estimates of the Bering-Chukchi Sea population ranged from 250,000 to 300,000 (Burns 1981).

No reliable estimate of bearded seal abundance is available for the Beaufort Sea (Angliss and Lodge 2002). Aerial surveys conducted by Minerals Management Services in fall 2000 and 2001 sighted a total of 46 bearded seals during survey flights conducted between September and October (Treacy 2002 a, b), with all but two sightings recorded east of 147 degrees W longitude and all sightings were within 40 nm of shore. Aerial surveys conducted from 1997 to 2002 in the vicinity of Northstar Island also reported small numbers (up to 15) of bearded seals (Moulton et al. 2003c).

The proposed activity areas may encounter bearded seals during the open water season; however, the number of bearded seals is expected to be small. The Alaska stock of bearded seals is not classified by NMFS as a strategic stock.

5. The type of incidental taking authorization that is being requested (i.e. takes by harassment only; takes by harassment, injury and /or death) and the method of incidental taking:

The only type of incidental taking sought in this application is that of takes by noise harassment. The only sources of Program-created noise will be those stemming from the following vessels: (1) deep 3D seismic vessel which is the *M/V Gilavar*, (2) site clearance and shallow hazard survey vessels, which may be the *M/V Henry C* or similar vessel in the Beaufort Sea, and a vessel TBD in the Chukchi Sea as well and (3) ice gouge survey vessel, that has not yet been selected. Sounds other than vessels will include;

operation of the seismic air guns and other acoustic registration equipment used in the site clearance program. For estimates of takes associated with these noise sources, see Section 6, below.

6. Numbers of marine mammals that may potentially be "taken by harassment"

SOI seeks authorization for potential "taking" of small numbers of marine mammals under the jurisdiction of the NMFS in the proposed region of activity. Species for which authorization is sought are bowhead, fin, gray, humpback, minke, killer and beluga whales, harbor porpoise, and ringed, ribbon, spotted, and bearded seals.

All anticipated takes would be "takes by harassment", involving temporary changes in behavior. The mitigation measures to be applied will minimize the possibility of injurious takes. (However, there is no specific information demonstrating that injurious "takes" would occur even in the absence of the planned mitigation measures.) In the sections below, we describe methods to estimate "take by harassment" and present estimates of the numbers of marine mammals that might be affected during the proposed seismic study in the Beaufort and Chukchi seas. The estimates are based on data obtained during marine mammal surveys in and near the proposed survey area and on estimates of the sizes of the areas where effects could potentially occur. In some cases, these estimates were made from data collected in regions, habitats, or seasons that differ from the activities in the proposed survey. Adjustments to reported population or density estimates were made to account for these differences insofar as possible.

Although several systematic surveys of marine mammals have been conducted in the southern Beaufort Sea, few data (systematic or otherwise) are available on the distribution and numbers of marine mammals in the Chukchi Sea or Beaufort Sea beyond the 200 m bathymetry contour. The main sources of distributional and numerical data used in deriving the estimates are described in the next subsection. There is some uncertainty about the representativeness of those data and the assumptions used below to estimate the potential "take by harassment". However, the approach used here seems to be the best available at this time.

This section provides estimates of the number of individuals potentially exposed to sound levels ≥160 dB re 1 µPa (rms). The estimates are based on a consideration of the number of marine mammals that might be disturbed appreciably by ~7974 kilometers of full array 3D seismic surveys and ~4294 km of mitigation gun activity in the Chukchi Sea and ~4784 km of full array 3D seismic surveys and ~2576 km of mitigation gun activity in the Beaufort Sea. In addition to the 3D seismic program, shallow hazards surveys using a 2 × 10 in^3 airgun array will be performed along ~1237 km in the Beaufort Sea and ~432 km in the Chukchi Sea. The close spacing of neighboring vessel tracklines within the planned 3D seismic survey areas results in a limited amount of total area being exposed to sounds ≥160 dB while much of that area is exposed repeatedly. Within the Chukchi Sea an area of ~15,000 km^2 and within the Beaufort Sea and area of ~10,100 km^2 would be exposed to ≥160 dB.

Basis for Estimating Numbers of Marine Mammals that Might be "Taken by Harassment"

Numbers of marine mammals that might be present and potentially disturbed are estimated below based on available data about mammal distribution and densities at different locations and times of the year. The proposed survey would take place in both the Chukchi and Beaufort seas over two different seasons. The estimates of marine mammal densities have therefore been separated both spatially and temporally in an attempt to represent the distribution of animals expected to be encountered over the duration of the survey.

Density estimates in the Chukchi Sea have been derived for two time periods, the summer period covering July and August, and the late fall period including most of October and November. Animal densities encountered in the Chukchi Sea during both of these time periods will further depend on the habitat zone within which the vessel is operating: (1) open water, or (2) ice margin. The *Gilavar* is not an ice breaker and cannot tow seismic equipment through even small amounts of ice. Under this assumption, densities of marine mammals expected to be observed in or near ice margin areas have been applied to 10% of the proposed survey trackline. Densities of marine mammals expected to occur in open-water areas have been applied to the remaining 90% of the survey trackline.

Approximately 2/3rd of the proposed Chukchi Sea trackline is planned to be completed in July and August so the summer density estimates have been applied to 2/3rd of the trackline falling within each habitat zone. The other 1/3rd of the trackline is planned to be surveyed in October and November, so the fall marine mammal densities have been applied to the remainder of the trackline in each habitat zone.

For the Chukchi Sea, cetacean densities during the summer were estimated from effort and sightings data in Moore (2000) while pinniped densities were estimated from Bengtson et al. (2000). Because few data are available on the densities of marine mammals other than large cetaceans in the Chukchi Sea in the fall, density estimates from the summer and spring have been adjusted to reflect the expected ratio of summer-to-fall densities based on the natural history characteristic of each species.

In the Alaskan Beaufort Sea, marine mammal densities are also likely to vary by season. Thus, different densities have been derived for the summer (August) and fall (September through early October) seasons. Approximately half of the seismic activity in the Beaufort Sea is planned to be completed during the summer period (August and early September) and west of 146°W longitude. Therefore, the nearshore and continental shelf marine mammal densities for the summer period have been applied to 50% of the trackline (2392 km full array and 1288 km mitigation gun). The fall densities have been applied to the remaining 50% of trackline, expected to occur mostly to the east of 146°W longitude.

The 146°W line of longitude has been used to divide the survey area into East and West regions because some species have a longitudinal gradient in their distribution during some seasons. Additionally, the area to be surveyed in the Alaskan Beaufort Sea covers three general habitat zones of the beluga and bowhead whale with varying densities within those zones: (1) nearshore , (2) continental shelf, and (3) offshore. The nearshore habitat zone has been defined as the area between the shoreline and the 50 m line of bathymetry while the continental shelf habitat is in water depths between 50 and 200 m. Three habitat zones have also been defined for all other species: (1) nearshore, (2) open water, and (3) ice margin. For these species, the nearshore region has been defined as the waters between the shoreline and the 200 m line of bathymetry. Sea ice presence and concentration in the Beaufort Sea varies greatly from year to year. If Sea ice is present near planned operations in 2008, the seismic vessels cannot operate within it and will generally avoid operating near it if at all possible. This leads to the assumption that only about 10% of seismic lines would be surveyed in the ice margin habitat. The open water habitat has been defined as water >200m in depth with no ice cover.

As noted above, there is some uncertainty about the representativeness of the data and assumptions used in the calculations. To provide some allowance for the uncertainties, “maximum estimates” as well as “average estimates” of the numbers potentially affected have been derived. For a few marine mammal species, several density estimates were available, and in those cases, the mean and maximum estimates were from the survey data. In other cases only one, or no applicable estimate was available so arbitrary correction factors were used to arrive at “average” and “maximum” estimates. These are described in detail in the following sections. Except where noted, the “maximum” estimates have been calculated as 4× the “average” estimates. The densities presented are believed to be similar to, or in most cases higher than, the densities that will actually be encountered during the survey.

Detectability bias, quantified in part by $f(0)$, is associated with diminishing sightability with increasing lateral distance from the trackline. Availability bias [$g(0)$] refers to the fact that there is <100% probability of sighting an animal that is present along the survey trackline. These correction factors were applied to the data from Moore (2000) and were already included in data provided by Richardson and

Thompson (eds., 2002) on beluga and bowhead whales, and where possible were applied to the data available data for other species.

Chukchi Sea

Estimated densities of marine mammals in the Chukchi Sea project area during the "summer" (July and August) are presented in Table 6-1. Densities of marine mammals estimated for the autumn period of SOI's seismic operations in the Chukchi Sea (October and November) are presented in Table 6-2. Again, "average" and "maximum" densities are shown in the tables. Unless otherwise noted, maximum densities are 4× average densities.

Cetaceans

Eight species of cetaceans are known to occur in the Chukchi Sea area of the proposed SOI project. Only three of these (bowhead, beluga, and gray whale) are expected to be encountered in meaningful numbers during the proposed survey. Three of the 8 species (bowhead, fin, and humpback whales) are listed as endangered under the U.S. Endangered Species Act.

Summer densities of ***beluga whales*** in offshore waters are expected to be very low. Aerial surveys have recorded very few belugas in the offshore Chukchi Sea during the summer months (Moore et al. 2000b). Additionally, no belugas were observed during >30,000 km of useable visual effort from industry vessels operating in the Chukchi Sea in 2006 (Ireland et al. 2007a; 2007b, Patterson et al. 2007) and 2008 seismic activities would be restricted to open-water areas as were the 2006 surveys. Expected densities have been calculated from data in Moore (2000; Table 6-1).

In the fall, beluga whale densities in the Chukchi Sea are expected to be higher than in the summer because individuals of the Beaufort Sea stock will be migrating south to their wintering grounds in the Bering Sea (Angliss and Lodge 2002). Densities are assumed to be similar in open water and ice margin areas although they are probably much higher along the edge of the pack ice than in open-water areas where seismic will be conducted. Densities derived from survey results in the northern Chukchi Sea in Moore et al. (2000b) were used as the average density for open water and ice margin autumn estimates (Table 6-2).

By July, most ***bowhead whales*** are northeast of the Chukchi Sea, within or migrating toward their summer feeding grounds in the eastern Beaufort Sea resulting in low density estimates for the Chukchi Sea (Moore et al. 2006). The summer estimate in the Chukchi Sea was calculated by assuming there was one bowhead sightings during the 10,684 km of effort in the Chukchi Sea during the summer months reported in Moore et al. 2000b) although no bowheads were observed during those surveys. During the autumn, bowhead whales that summered in the Beaufort Sea and Amundsen Gulf are migrating west and south to their wintering grounds in the Bering Sea making it more likely that they will be encountered in the Chukchi Sea. However, many bowheads appear to travel through the northern Chukchi Sea to reach Russian waters north of the Chukotsk Peninsula (Quakenbush 2005). Thus, a correction factor of ×0.05 has been used to adjust the observed autumn densities from the Beaufort Sea (Richardson and Thomson 2002), for the following reasons (1) the migration corridor is narrower in the Beaufort Sea where available data have been obtained, (2) bowheads sometimes linger to feed for extended periods in the Beaufort but extended feeding has not been documented in the central and eastern Chukchi Sea in autumn and (3) most bowheads have passed through the proposed seismic survey before seismic activities are planned in 2008., to estimated densities in the Chukchi Sea, where the migration corridor becomes bifurcated and much broader.

Gray whale densities were also estimated from summer aerial surveys by Moore et al. (2000b). Moore et al. (2000b) found summer concentrations of gray whales off the Seward Peninsula, far to the south of planned seismic surveys. The distribution of gray whales in the proposed survey area was scattered and limited to nearshore areas where most whales were observed in water less than 35 m deep (Moore et al.

2000b). A density calculated from effort and sightings in Moore et al. (2000b) in water >35m in depth was used as the average estimate for the Chukchi Sea during the summer period. In the autumn, gray whales may be dispersed more widely through the northern Chukchi Sea (in the area of the survey), and densities are expected to be slightly higher. A density calculated from effort and sightings in water >35m deep during autumn in Moore (2000) was used as the average estimate for the Chukchi Sea during the fall period.

TABLE 6-1
Expected densities of cetaceans and seals in areas of the Chukchi Sea, Alaska, for the planned summer seismic period
Species listed under the U.S. ESA as endangered are in italics.

	Open Water[a]		Ice Margin[b]	
Species	**Average Density (# / km2)**	**Maximum Density (# / km2)**	**Average Density (# / km2)**	**Maximum Density (# / km2)**
Odontocetes				
Monodontidae				
Beluga	0.0008	0.0032	0.0008	0.0032
Delphinidae				
Killer whale	0.0001	0.0004	0.0001	0.0004
Phocoenidae				
Harbor porpoise	0.0056	0.0224	0.0056	0.0224
Mysticetes				
Bowhead whale	*0.0004*	*0.0016*	*0.0004*	*0.0016*
Fin whale	*0.0001*	*0.0004*	*0.0001*	*0.0004*
Gray whale	0.0108	0.0432	0.0108	0.0432
Humpback whale	*0.0001*	*0.0004*	*0.0001*	*0.0004*
Minke whale	0.0001	0.0004	0.0001	0.0004
Pinnipeds				
Bearded seal [c]	0.0180	0.0270	0.0180	0.0270
Ribbon seal	0.0001	0.0004	0.0001	0.0004
Ringed seal [c]	0.5200	0.8100	0.5200	0.8100
Spotted seal	0.0269	0.0419	0.0269	0.0419

[a] Open water regions for the Chukchi Sea are considered to be 90% of the seismic lines.
[b] Ice Margin regions for the Chukchi Sea are considered to be 10% of the seismic lines.
[c] Maximum density estimate available from the data source was used.

TABLE 6-2
Expected Densities of Cetaceans and Seals in Areas of the Chukchi Sea, Alaska, for the Fall Seismic Period
Species listed under the U.S. ESA as endangered are in italics.

	Open Water [a]		Ice Margin [b]	
Species	**Average Density (# / km2)**	**Maximum Density (# / km2)**	**Average Density (# / km2)**	**Maximum Density (# / km2)**
Odontocetes				
Monodontidae				
Beluga	0.0112	0.0448	0.0112	0.0448
Delphinidae				
Killer whale	0.0001	0.0004	0.0001	0.0004
Phocoenidae				
Harbor porpoise	0.0001	0.0004	0.0001	0.0004
Mysticetes				
Bowhead whale	*0.0011*	*0.0060*	*0.0011*	*0.0060*
Fin whale	*0.0001*	*0.0004*	*0.0001*	*0.0004*
Gray whale	0.0148	0.0592	0.0148	0.0592
Humpback whale	*0.0001*	*0.0004*	*0.0001*	*0.0004*
Minke whale	0.0001	0.0004	0.0001	0.0004
Pinnipeds				
Bearded seal [c]	0.0180	0.0270	0.0180	0.0270
Ribbon seal	0.0001	0.0004	0.0001	0.0004
Ringed seal [c]	0.3484	0.5427	0.3484	0.5427
Spotted seal	0.0183	0.0285	0.0183	0.0285

[a] Open water regions for the Chukchi Sea are considered to be 90% of the seismic lines.
[b] Ice Margin regions for the Chukchi Sea are considered to be 10% of the seismic lines.
[c] Maximum density estimate available from the data source was used.

Harbor Porpoise densities were estimated from Industry data collected during 2006 activities in the Chukchi Sea. Prior to 2006, no reliable estimates were available for the Chukchi Sea and harbor porpoise presence was expected to be very low and limited to nearshore regions. Observers on industry vessels in 2006, however, commonly recorded sightings throughout the Chukchi Sea during the summer and early autmn months. A density estimate from these data has been used for the summer period. No sightings were recorded during the majority of the fall period, so minimal values have been used for that time period.

The remaining four cetacean species that could be encountered in the Chukchi Sea during SOI's proposed seismic survey include the humpback whale, killer whale, minke whale, and fin whale. Although there is evidence of the occasional occurrence of these animals in the Chukchi Sea, it is unlikely that more than a few individuals will be encountered during the proposed survey. George et al. (1998) reported killer whales, Brueggeman et al. (1990) reported one minke whale, Suydam and George (1992) reported harbor porpoise near Pt. Barrow; and Gambell (1985) recorded the northern extent of fin whales to be in the Chukchi Sea. Small numbers of minke whales were observed during industry activities in 2006 and a few individual humpback whales were reported during 2007 operations.

Pinnipeds

Four species of pinnipeds are likely to be encountered in the Chukchi Sea portion of SOI's proposed seismic survey: ringed seal, bearded seal, spotted seal, and walrus. Each of these species, except for the spotted seal, is associated with both the ice margin and the nearshore area. The ice margin is considered preferred habitat (as compared to the nearshore areas) during most seasons. Spotted seals are often considered to be predominantly a coastal species except in the spring when they may be found in the southern margin of the retreating sea ice, before they move to shore. However, satellite tagging has shown that they sometimes undertake long excursions at sea during summer (Lowry et al. 1994, 1998). Ribbon seals have been reported in very small numbers within the Chukchi Sea by observers on industry vessels (Ireland et al. 2007 a and b, Patterson et al. 2007) so minimal values have been used for expected densities.

For ***ringed seal*** and ***bearded seals*** both "average" and "maximum" densities are available in Bengtson (2005) from spring surveys in the offshore pack ice zone of the northern Chukchi Sea (Tables A and B). The ringed seal density estimates are higher than the overall pinniped density (that was composed of mostly ringed seal sightings) calculated from data collected during 2006 industry operations (0.262 seals/km^2). The fall density of ringed seals in the Chukchi Sea has been estimated as 2/3 the summer densities because at that time of year ringed seals reoccupy nearshore fast ice areas as the fast ice forms.

Very little information on ***spotted seal*** densities in offshore areas of the Chukchi Sea is available. Spotted seal densities were estimated by summing the ringed seal and bearded seal densities and multiplying the result by 0.05. This was based on the assumption that about half of the Chukchi population of spotted seals is present in the Alaskan Chukchi Sea (i.e., ~16,000 based on Lowry et al. 1994) and that the combined population of bearded and ringed seals in the Alaskan Chukchi Sea is >300,000 animals (based on surveys by Bengston et al. 2005 and extrapolation of their pack-ice densities to unsurveyed areas).

Beaufort Sea

Cetaceans

The densities of beluga and bowhead whales present in the Beaufort Sea are expected to vary by season and location. During the early and mid-summer, most belugas and bowheads are found in the Canadian Beaufort Sea and Amundsen Gulf or adjacent areas. Low numbers are found in the eastern Alaskan Beaufort Sea, and few are found in the western Alaskan Beaufort Sea. Belugas begin to move across the northern Beaufort Sea in August, and bowheads do so toward the end of August. During fall, both species migrate through the Alaskan Beaufort Sea, sometimes interrupting their migration to feed.

Beluga density estimates are derived from data in Moore et al. (2000b). During the summer, beluga whales are most likely to be encountered in offshore waters of the eastern Beaufort Sea region. Very few beluga whales are expected to be encountered in the western Beaufort Sea in the summer period except among the pack ice if it is present. Therefore, 10% of the highest calculated beluga whale density from Moore et al. (2000b) for the eastern zone was used in the offshore region while 1% was used in nearshore and outer shelf zones (Table 6-3). The highest density of beluga whales is expected to occur in the offshore region during the fall where the density is expected to be roughly equal across the eastern and western regions. This density was calculated from Moore et al. (2000b; Table 6-4). Nearshore and outer shelf zones are expected to have beluga whale densities of about 10% of the offshore waters. "Takes by harassment" of beluga whales during this time period in the Beaufort Sea were not calculated in the same manner as described for bowhead whales because of the relatively lower expected densities of beluga whales in the nearshore area where a majority of the seismic survey will occur and the lack of detailed data on the likely timing and rate of migration through the area.

For ***bowhead whales***, both "average" and "maximum" densities are available in Chapter 9 of Richardson and Thomson (eds., 2002). During the summer period, bowhead whales are most likely to be encountered in the eastern Beaufort Sea region in offshore and possibly outer shelf waters. The expected offshore density in the eastern Alaskan Beaufort has been calculated from August surveys in Richardson and Thomson (2002; Table 6-3). Few bowhead whales are expected in waters of the nearshore or outer shelf zones in summer, so densities for those zones have been estimated as 10% of the density used for the offshore zone. Bowhead whale densities are expected to be low in the western region of the Beaufort Sea during the summer period, and densities equal to 10% of the eastern region densities have been assumed. Bowhead whales encountered during this time will likely not be migrating so these densities have been used in standard method (described below) of calculating "takes by harassment."

In most cases bowhead whales will be migrating past the seismic survey area during the fall period, so it is not accurate to assume that the same individuals would be present in the survey area from one day to the next. We have therefore developed an alternate method of calculating the number of individuals exposed to sounds >160 dB to the one used for non-migratory species. The method is founded on estimates of the proportion of the population that would pass within the >160 dB zone on a given day.

The total planned seismic activity for the Beaufort Sea during the fall migration could be completed in ~330 hrs of seismic activity or ~14 days. Approximately 2/3 of the population of bowhead whales is expected to pass by the fall seismic survey before 25 Sep. (Richardson and Thomson 2002, Appendix 9.1). During that time, it is assumed that seismic activity will not occur in order to avoid disturbing the subsistence hunt. The remainder of the population would be expected to pass while seismic activity was ongoing. If the bowhead population has continued to grow at an annual rate of 3.4%, the current population size would be ~13,326 individuals based on a 2001 population of 10,545 (Zeh and Punt 2005). Based on data in Richardson and Thomson (2002, Appendix 9.1) the number of whales expected to pass each day after 25 Sep. was estimated as a proportion of the population. Richardson and Thomson (2002) also calculated the proportion of animals within water depth bins (<20m, 20-40m, 40-200m, >200m). Using this information we multiplied the total number of whales expected to pass the seismic survey area each day by the proportion of whales that would be in each depth category to estimate how many individuals would be within each depth bin on a given day. The proportion of the total ≥160 dB zone within each depth bin was then multiplied by the number of whales within the respective bins to estimate the total number of individuals that would be exposed on each day. This was repeated for a total of 14 days and the results were summed to estimate the total number of Bowhead whales estimated to be exposed to ≥160 dB during the migration period in the Beaufort Sea.

For ***other cetacean*** species that may be encountered in the Beaufort Sea, densities are likely to vary somewhat by season, but differences are not expected to be great enough to estimate separate densities for the two seasons. Narwhals are not expected to be encountered within the proposed seismic survey area. However, there is a chance that a few individuals may be present in the eastern most portions of the Beaufort Sea near the ice margin and therefore an arbitrary low density has been applied to the ice margin region (Table 6-5). Harbor porpoises and gray whales are similarly not expected to be frequently encountered in the Beaufort Sea during the fall but small numbers may be encountered during the summer. They may be encountered during the summer. They are most likely to be encountered in nearshore waters. Arbitrarily assigned low densities have therefore been used in nearshore waters for those species (Table 6-5).

TABLE 6-3

Expected Summer Densities of Beluga and Bowhead Whales in the Alaskan Beaufort Sea from Camden Bay West to Point Barrow. Densities are Corrected for f(0) and g(0) biases.
Species listed under the U.S. ESA as endangered are in italics.

Species	Nearshore [a]		Outer Shelf [b]		Offshore [c]	
	Average Density (# / km2)	Maximum Density (# / km2)	Average Density (# / km2)	Maximum Density (# / km2)	Average Density (# / km2)	Maximum Density (# / km2)
Beluga	0.0003	0.0011	0.0003	0.0011	0.0027	0.0108
Bowhead whale	*0.0001*	*0.0003*	*0.0001*	*0.0003*	*0.0005*	*0.0033*

[a] Water between 0–50 m in depth.
[b] Water between 50–200 m in depth.
[c] Water >200 m in depth.

TABLE 6-4

Expected Autumn Densities of Beluga and Bowhead Whales in the Alaskan Beaufort Sea. Densities are Corrected for f(0) and g(0) Biases.
Species listed under the U.S. ESA as endangered are in italics.

Species	Nearshore [a]		Outer Shelf [b]		Offshore [c]	
	Average Density (# / km2)	Maximum Density (# / km2)	Average Density (# / km2)	Maximum Density (# / km2)	Average Density (# / km2)	Maximum Density (# / km2)
Beluga	0.0027	0.0108	0.0027	0.0108	0.0270	0.1080
Bowhead whale [d]	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*	*N/A*

[a] Water between 0–50 m in depth.
[b] Water between 50–200 m in depth.
[c] Water >200 m in depth.

TABLE 6-5

Expected Densities of Cetaceans and Seals in the Alaskan Beaufort Sea During both the Summer and Autumn Season

Species	Nearshore [a]		Open Water [b]		Ice Margin [c]	
	Average Density (# / km2)	Maximum Density (# / km2)	Average Density (# / km2)	Maximum Density (# / km2)	Average Density (# / km2)	Maximum Density (# / km2)
Odontocetes						
Monodontidae						
Narwhal	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
Phocoenidae						
Harbor porpoise	0.0001	0.0004	0.0000	0.0000	0.0000	0.0000
Mysticetes						
Gray whale	0.0001	0.0004	0.0000	0.0000	0.0000	0.0000
Pinnipeds						
Bearded seal	0.0181	0.0724	0.0015	0.0062	0.0128	0.0512
Ringed seal	0.3547	1.4188	0.0303	0.1211	0.2510	1.0040
Spotted seal	0.0037	0.0149	0.0001	0.0004	0.0001	0.0004
Walrus						
Carnivora						
Polar bear						

[a] Water between 0–200 m in depth.
[b] Water >200 m in depth but south of the ice margin.
[c] The northern 10% of planned tracklines.

Pinnipeds

Although densities are likely to vary within each of the three habitat zones by season, there is neither sufficient data nor are differences expected to be great enough to justify estimating separate densities of pinnipeds for the two seasons. Extensive surveys of ringed and bearded seals have been conducted in the Beaufort Sea, but most surveys have been conducted over the landfast ice, and few seal surveys have occurred in open water or in the pack ice. Kingsley (1986) conducted ***ringed seal*** surveys of the offshore pack ice in the central and eastern Beaufort Sea during late spring (late June). These surveys provide the most relevant information on densities of ringed seals in the ice margin zone of the Beaufort Sea survey area. The density estimate in Kingsley (1986) was used as the average density of ringed seals that may be encountered in the ice margin (Table 6-5). The average ringed seal density in the nearshore zone of the Alaskan Beaufort Sea was estimated from results of ship surveys at times without seismic operations (Moulton and Lawson 2002; Table 6-5).

Densities of ***bearded seals*** were estimated by multiplying the ringed seal densities by 0.051 based on the proportion of bearded seals to ringed seals reported in Stirling et al. (1982; Table 6-5). ***Spotted seal*** densities in the nearshore zone were estimated by summing the ringed seal and bearded seal densities and multiplying the result by 0.015 based on the proportion of spotted seals to ringed and bearded seals reported in Moulton and Lawson (2002; Table 6-5). Minimal values were assigned as densities in the open water and ice margin zones to accommodate any chance encounters (Table 6-5).

Potential Number of “Takes by Harassment”

Best and Maximum Estimates of the Number of Individuals that may be Exposed to ≥160 dB

The number of different individuals of each species potentially exposed to received levels ≥160 dB re 1 μPa (rms) within each survey region, time period, and habitat zone was estimated by multiplying

- the expected species density, by
- the anticipated area to be ensonified to that level (including operations with the full-airgun array and the mitigation gun) in the survey region, time period, and habitat zone to which that density applies.

The numbers of exposures were then summed for each species across the survey regions, seasons, and habitat zones. Some of the animals estimated to be exposed, particularly migrating bowhead whales, might show avoidance reactions before being exposed to ≥160 dB re 1 μPa (rms). Thus, these calculations actually estimate the number of individuals potentially exposed to ≥160 dB that would occur if there were no avoidance of the area ensonified to that level.

For the full-airgun array, the cross track distance is 2× the ≥160 dB radius which was measured in 2007 as 8100m in the Chukchi Sea and 13,405m in the Beaufort Sea. The mitigation gun ≥160 dB radius was measured at 1370m in the Chukchi Sea and 1370m in the Beaufort Sea. For shallow hazards surveys to be performed by the Henry C, the ≥160 dB radius measured in 2007 was equal to 621m. Using these distances, the area ensonified in the Chukchi Sea is estimated to be ~15,000 km^2 and ~10,100 km^2 In the Beaufort Sea.

Cetaceans

The estimates show that one endangered cetacean species (the bowhead whale) is expected to be exposed to such noise levels unless bowheads avoid the approaching survey vessel before the received levels reach 160 dB. Migrating bowheads are likely to do so, though many of the bowheads engaged in other activities, particularly feeding and socializing, probably will not. Our estimate of the number of bowhead whales potentially exposed to ≥160 dB is 1582 (Table 6-9). NMFS has asked that we include an estimate of the number of bowhead whales that may potentially be exposed to sounds ≥120 dB as bowhead whales may react behaviorally to sounds at received levels of ≥120 dB. The estimate of the number of bowheads that may be exposed at that level is 2968 individuals. Two other endangered cetacean species that may be encountered in the area (the fin whale and humpback whale) are unlikely to be exposed given their low "average" estimates of densities in the area.

Most of the cetaceans exposed to seismic sounds with received levels ≥160 dB would involve mysticetes (bowheads and gray whales), monodontids (belugas), and porpoise (harbor porpoise). Average and maximum estimates of the number of exposures of cetaceans other than bowheads, in descending order, are beluga (298 and 1192), gray whale (183 and 734), and harbor porpoise (58 and 234). The regional breakdown of these numbers is shown in Tables 6-6 to 6-8. Estimates for other species are lower (Table 6-9).

TABLE 6-6

Estimates of the Numbers of Marine Mammals in Areas Where Maximum Received Sound Levels in the Water Would be ≥160 dB During SOI's Proposed Seismic Program During the Summer (July – August, 2008) and Fall (October – November, 2008) Seasons in the Chukchi Sea, Alaska

	Number of Exposure to Sound Levels >160 dB															
	Summer						**Fall**									
	Open Water		**Ice Margin**		**Total**		**Open Water**		**Ice Margin**		**Total**		**Grand Total**			
	Avg.	**Max.**	**Avg.**	**Max.**	**Avg.**	**Max.**	**Avg.**	**Max.**	**Avg.**	**Max.**	**Avg.**	**Max.**	**Avg.**	**Max.**		
Monodontidae																
Beluga	7	29	1	3	8	32	50	200	6	22	55	222	63	254		
Delphinidae																
Killer whale	1	4	0	0	1	4	0	2	0	0	0	2	2	6		
Phocoenidae																
Harbor porpoise	51	203	6	23	56	225	0	2	0	0	0	2	57	227		
Mysticetes																
Bowhead whale	4	14	0	2	4	16	5	27	1	3	5	30	9	46		
Fin whale	1	4	0	0	1	4	0	2	0	0	0	2	2	6		
Gray whale	98	391	11	43	109	434	66	264	7	29	73	293	182	727		
Humpback Whale	1	4	0	0	1	4	0	2	0	0	0	2	2	6		
Minke whale	1	4	0	0	1	4	**0**	2	**0**	0	0	2	2	6		
Total Cetaceans	63	253	7	28	70	281	123	499	14	55	136	554				
Pinnipeds																
Bearded seal	163	244	18	27	181	271	80	120	9	13	89	134	270	405		
Ribbon seal	1	4	0	0	1	4	0	2	0	0	0	2	2	6		
Ringed seal	4703	7326	523	814	5226	8141	1552	2418	172	269	1725	2686	6951	10827		
Spotted seal	243	379	27	42	270	421	82	127	9	14	91	141	361	562		
Total Pinnipeds	5110	7953	568	884	5678	8836	1714	2667	190	296	1905	2963				

Open water regions for the Chukchi Sea are considered to be 90% of the seismic lines.

Ice Margin regions for the Chukchi Sea are considered to be 10% of the seismic lines.

TABLE 6-7

Estimates of the Numbers of Beluga and Bowhead Whales in Areas Where Maximum Received Sound Levels in the Water Would be ≥160 dB During SOI's Proposed Seismic Program in the Beaufort Sea, Alaska, August – October, 2008.

Not all marine mammals will change their behavior when exposed to these sound levels, although some might alter their behavior somewhat when levels are lower (see text).

	Number of Exposure to Sound Levels ≥160 dB													
	Summer (Western Beaufort)						Fall (Eastern Beaufort)							
	Nearshore [a]		Outer Shelf [b]		Offshore [c]		Nearshore [a]		Outer Shelf [b]		Offshore [c]		Total	
Species	**Avg.**	**Max.**	**Avg.**	**Max.**	**Avg.**	**Max.**	**Avg.**	**Max.**	**Avg.**	**Max.**	**Avg.**	**Max.**	**Avg.**	**Max.**
Beluga	2	8	1	2	3	11	19	76	19	76	191	764	234	938
Bowhead whale [d]	0	2	0	1	1	3	1249	1249	266	266	15	15	1531	1536

[a] Water between 0–50 m in depth.

[b] Water between 50–200 m in depth.

[c] Water >200 m in depth.

[d] See text for description of bowhead whale estimates for the Fall in the Beaufort Sea

TABLE 6-8

Estimates of the Numbers of Marine Mammals (Excluding Beluga and Bowhead Whales, Which are Shown in Table 6-7) in Areas Where Maximum Received Sound Levels in the Water Would be ≥160 dB During SOI's Proposed Seismic Program in the Beaufort Sea, Alaska, August – October, 2008

Not all marine mammals will change their behavior when exposed to these sound levels, although some might alter their behavior somewhat when levels are lower (see text).

	Number of Exposure to Sound Levels ≥160 dB							
	Nearshore [a]		Open Water [b]		Ice Margin [c]		Total	
Species	**Avg**	**Max**	**Avg**	**Max**	**Avg**	**Max**	**Avg**	**Max**
Odontocetes								
Monodontidae								
Narwhal	0	0	0	0	0	0	0	0
Phocoenidae								
Harbor porpoise	2	6	0	0	0	0	2	6
Mysticetes								
Gray whale	2	6	0	0	0	0	2	6
Pinnipeds								
Bearded seal	293	1170	3	12	26	104	322	1286
Ringed seal	5736	22946	61	245	507	2030	6305	25221
Spotted seal	60	241	0	1	0	1	61	243
Total Pinnipeds	6089	24357	65	258	534	2134	6687	26750

[a] Water between 0–200 m in depth.

[c] The northern 20 km of planned tracklines.

TABLE 6-9

Summary of the Number of Potential Exposures of Marine Mammals to Received Sound Levels in the Water of ≥160 dB During SOI's Proposed Seismic Program in the Chukchi Sea and Beaufort Sea, Alaska, July – November, 2008.
Not all marine mammals will change their behavior when exposed to these sound levels, although some might alter their behavior somewhat when levels are lower (see text).

	Number of Individuals Exposed to Sound Levels ≥160 dB						Requested Take Authorization
	Chukchi Sea		Beaufort Sea		Total		
Species	**Avg.**	**Max.**	**Avg.**	**Max.**	**Avg.**	**Max.**	
Odontocetes							
Monodontidae							
Beluga	63	254	234	938	298	1192	**1192**
Narwhal	0	0	0	0	0	0	**5**
Delphinidae							
Killer whale	2	6	0	0	2	6	**6**
Phocoenidae							
Harbor porpoise	57	227	2	6	58	234	**234**
Mysticetes							
Bowhead whale [a]	9	46	1531	1536	1540	1582	**1582**
Fin whale	2	6	0	0	2	6	**6**
Gray whale	182	727	2	6	183	734	**734**
Humpback whale	2	6	0	0	2	6	**6**
Minke whale	2	6	0	0	2	6	**6**
Total Cetaceans	70	281	1533	1543	1603	1824	
Pinnipeds							
Bearded seal	270	405	322	1286	592	1691	**1691**
Ribbon seal	2	6	0	0	2	6	**6**
Ringed seal	6951	10827	6305	25221	13256	36047	**36047**
Spotted seal	361	562	61	243	422	804	**804**
Total Pinnipeds	5678	8836	6687	26750	12366	35586	

[a] See text for description of bowhead whale estimate for the Beaufort Sea

The far right column in Table 6-9, "Requested Take Authorization", shows the numbers of animals for which "harassment take authorization" is requested. For the common species, the requested numbers are calculated as indicated above, based on the maximum densities calculated from the data reported in the different studies mentioned above.

Pinnipeds

As discussed above, there are few survey data that document pinniped distribution and densities within much of the proposed project area and almost no data that document their densities while they are in the water (but see Moulton and Lawson 2002). The most relevant surveys were conducted on ringed seals in the Beaufort Sea by Kingsley (1986). Data from those surveys and information on relative population sizes for other species have been used to estimate numbers of pinnipeds that might be affected by the seismic arrays.

Ringed Seals

The ringed seal is the most widespread and abundant pinniped in ice-covered arctic waters, and there is a great deal of annual variation in population size and distribution of these marine mammals. Ringed seals account for the vast majority of marine mammals expected to be encountered, and hence exposed to airgun sounds with received levels ≥160 dB re 1 µPa (rms) during the proposed seismic survey. The average (and maximum) estimate is that 13,256 (36,047) ringed seals might be exposed to seismic sounds with received levels ≥160 dB.

Other Pinniped Species

Two additional pinniped species (other than the Pacific walrus) are expected to be encountered. They are the bearded seal (592 and 1691, average and maximum estimates, respectively), and the spotted seal (422 and 804; Table 6-9). The harbor seal and ribbon seal are unlikely to be encountered, but their presence cannot be ruled out.

Conclusions

The proposed survey in the Chukchi and Beaufort seas will involve towing a 24-airgun array that will introduce pulsed sounds into the ocean. Routine vessel operations, other than the proposed operations by the airguns, are conventionally assumed not to affect marine mammals sufficiently to constitute “taking”.

Potential Bowhead Disturbance at Lower Received Levels

During autumn seismic surveys in the Beaufort Sea, migrating bowhead whales displayed avoidance at distances out to 20–30 km and received sound levels of ~130 dB (rms) (Miller et al. 1999; Richardson et al. 1999). Therefore, it is possible that a larger number of bowhead whales than estimated above may be disturbed to some extent if reactions occur at ≥130 dB (rms). However, ice permitting, SOI plans to survey in the western portion of the Alaskan Beaufort Sea during the summer period when many bowheads will be further to the east. If SOI reduces operations during the migration as was done in 2007, a large proportion of the bowhead population would migrate past the survey area without being exposed to sounds ≥160 dB (rms). Limiting operations during the fall bowhead whale migration is also meant to reduce any chance of conflicting with subsistence hunting and will continue at least until hunting quotas have been filled by the coastal communities.

Cetaceans

Strong avoidance reactions by several species of mysticetes to seismic vessels operating large arrays of airguns have been observed at ranges up to 6–8 km and avoidance may occur as far as 20–30 km from the source vessel. However, reactions at the longer distances appear to be atypical of most species and situations, particularly when feeding whales are involved (Miller et al. 2005). Most of the bowhead whales encountered during the summer will likely show overt disturbance (avoidance) only if they receive airgun sounds with levels ≥160 dB re 1 µPa (rms).

Odontocete reactions to seismic pulses are usually assumed to be limited to lesser distances from the airgun(s) than are those of mysticetes, probably in part because odontocete low-frequency hearing is less sensitive than that of mysticetes. However, at least when in the Canadian Beaufort Sea in summer, belugas appear to be fairly responsive to seismic surveys, with few being sighted within 10–20 km during aerial surveys (Miller et al. 2005).

Taking into account the mitigation measures that are planned, effects on cetaceans are generally expected to be restricted to avoidance of a limited area around the seismic operation and short-term changes in behavior, falling within the MMPA definition of “Level B harassment”. Furthermore, the estimated numbers of animals potentially exposed to sound levels sufficient to cause appreciable disturbance are relatively low percentages of the population sizes in the Bearing–Chukchi–Beaufort seas, as described below.

Based on the 160 dB criterion, the *best (average) estimates* of the numbers of cetacean *exposures* to sounds ≥160 dB re 1 μPa (rms) represent varying proportions of the populations of each species in the Chukchi and Beaufort seas and adjacent waters (*cf.* Table 2). For species listed as "Endangered" under the ESA, our estimates include ~6 fin whales, ~6 humpback whales and ~1582 bowheads. The latter is ~12% of the Bering-Chukchi-Beaufort population of >13,326 assuming 3.4% annual population growth from the 2001 estimate of >10,545 animals (Zeh and Punt 2005).

Some monodontids may be exposed to sounds produced by the airgun arrays during the proposed seismic study, and the numbers potentially affected are small relative to the population sizes (Table 6-9). Narwhals are rare in the U.S. Beaufort Sea and few, if any, are expected to be encountered during the survey. The best estimate of the number of belugas that might be exposed to ≥160 dB (298) represents <1% of their population.

Varying estimates of the numbers of marine mammals that might be exposed to sounds from the airgun arrays during the 2008 SOI seismic survey have been presented (average vs. maximum). The requested "take authorization" for each species is based on the estimated *maximum number of exposures* to ≥160 dB re 1 μPa (rms), i.e., the highest of the various estimates. The relatively short-term exposures that will occur are not expected to result in any long-term negative consequences for the individuals or their populations.

The many reported cases of apparent tolerance by cetaceans of seismic exploration, vessel traffic, and some other human activities show that co-existence is possible. Mitigation measures such as controlled speed, look outs, non-pursuit, shut downs or power downs when marine mammals are seen within defined ranges, and avoiding migration pathways when animals are likely most sensitive to noise will further reduce short-term reactions, and minimize any effects on hearing sensitivity. In all cases, the effects are expected to be short-term, with no lasting biological consequence. Subsistence issues are addressed below in § VIII.

Pinnipeds

A few pinniped species are likely to be encountered in the study area, but the ringed seal is by far the most abundant marine mammal that will be encountered. The best (average) estimates of the numbers of individuals exposed to airgun sounds at received levels ≥160 dB re 1 μPa (rms) during the seismic survey are as follows: ringed seals (36,047), bearded seals (1647), and spotted seals (802), (representing ~7%, <1%, and ~2.5%, respectively, of their Bearing–Chukchi–Beaufort populations). It is probable that only a small percentage of those would actually be disturbed.

As for cetaceans, the short-term exposures of pinnipeds to airgun sounds are not expected to result in any long-term negative consequences for the individuals or their populations.

7. The anticipated impact of the activity on the species or stock:

The only anticipated impacts to marine mammals associated with SOI activities in respect to noise propagation are from vessel movements, and seismic air gun operations. The impacts would be temporary and short-term displacement of seals and whales from within ensonified zones produced by such noise sources. Any impacts on the whale and seal populations of the Beaufort or Chukchi Seas activity areas are likely to be short-term and transitory arising from the temporary displacement of individuals or small groups from locations they may occupy at the times they are exposed to seismic sounds at the 160 to 190 decibel (dB) received levels. As noted in Section 6 above, it is highly unlikely that animals will be exposed to sounds of such intensity and duration as to physically damage their auditory mechanisms. In the case of bowhead whales that displacement might well take the form of a deflection of the swim paths of migrating bowheads away from (seaward of) received noise levels greater than 160 dB (Richardson et al. 1999). The cited and other studies conducted to test the hypothesis of the deflection response of bowheads have determined that bowheads return to the swim paths they were following at relatively short distances after their exposure to the received sounds. There is no evidence that bowheads so exposed have incurred injury to their auditory mechanisms. Additionally, there is no conclusive evidence that exposure to sounds exceeding 160 dB have displaced bowheads from feeding activity (Richardson, and Thomson 2002).

There is no evidence that seals are more than temporarily displaced from ensonified zones and no evidence that seals have experienced physical damage to their auditory mechanisms even within ensonified zones.

8. The anticipated impact of the activity on the availability of the species or stocks of marine mammals for subsistence uses:

There could be an adverse impact on the Inupiat bowhead subsistence hunt if the whales were deflected seaward (further from shore) in traditional hunting areas. The impact would be that whaling crews would have to travel greater distances to intercept westward migrating whales thereby creating a safety hazard for whaling crews and/or limiting chances of successfully striking and landing bowheads. This potential impact is mitigated by application of the procedures established in the POC, and if a CAA is successfully negotiated, between the seismic operators and the AEWC and the Whaling Captains' Associations of Kaktovik, Nuiqsut, Barrow, Pt. Hope and Wainwright. The times and locations of seismic and other noise producing sources are to be curtailed during times of active scouting and whaling within the traditional subsistence hunting areas of the potentially affected communities. (See Section 12, below). Survey activities will be scheduled to avoid the traditional subsistence beluga hunt which annually occurs in July in the community of Pt. Lay.

There should be no adverse impacts on the availability of the whale species for subsistence uses.

9. Anticipated impact on habitat:

The activities will not result in any permanent impact on habitats used by marine mammals, or to their prey sources. 3D seismic and site clearance and shallow hazard activities will occur during the time of year when bowhead whales are present (i.e., mid- to late July through September). Any effects would be temporary and of short duration at any one place. The primary potential impacts to marine mammals is associated with elevated sound levels from the proposed seismic (air guns) and site clearance (sonar) work discussed in detail earlier in Sections 6 and 7.

A broad discussion on the various types of potential effects of exposure to seismic on fish and invertebrates can be found in LGL (2005), and includes a summary of direct mortality (pathological/physiological) and indirect (behavioral) effects.

Mortality to fish, fish eggs and larvae from seismic energy sources would be expected within a few meters (0.5 to 3 m) from the seismic source. Direct mortality has been observed in cod and plaice within 48 hours that were subjected to seismic pulses 2 m from the source (Matishov 1992); however other studies did not report any fish kills from seismic source exposure (La Bella et al. 1996, IMG 2002, Hassel et al. 2003). To date, fish mortalities associated with normal seismic operations are thought to be slight. Saetre and Ona (1996) modeled a worst-case mathematical approach on the effects of seismic energy on fish eggs and larvae, and concluded that mortality rates caused by exposure to seismic are so low compared to natural mortality that issues relating to stock recruitment should be regarded as insignificant.

Limited studies on physiological effects on marine fish and invertebrates to acoustic stress have been conducted. No significant increases in physiological stress from seismic energy were detected for various fish, squid, and cuttlefish (McCauley et al. 2000) or in male snow crabs (Christian et al. 2003). Behavioral changes in fish associated with seismic exposures are expected to be minor at best. Because only a small portion of the available foraging habitat would be subjected to seismic pulses at a given time, fish would be expected to return to the area of disturbance anywhere from 15 to 30 minutes (McCauley et al. 2000) to several days (Engas et al. 1996).

Available data indicate that mortality and behavioral changes do occur within very close range to the seismic source; however, the proposed seismic acquisition activities in distinct areas in the Chukchi and Beaufort Seas is predicted to have a negligible effect to the prey resource of the various life stages of fish and invertebrates available to marine mammals occurring during the project's seismic activity.

10. Anticipated impact of habitat loss or modification:

The effects of the planned activities are expected to be negligible, as described in Section 9. It is estimated that only a small portion of the animals utilizing the areas of the proposed activities would be temporarily displaced.

During the period of seismic acquisition (mid-July through mid-November), most marine mammals would be dispersed throughout the area. The peak of the bowhead whale migration through the Chukchi and Beaufort Seas typically occurs in October, and efforts to reduce potential impacts during this time will be addressed with the actual start of the migration and with the whaling communities. The timing of seismic activities in the eastern Beaufort Sea will take place when the whales are not present, or in very low numbers. Starting in late August bowheads may travel in proximity to the aforementioned activity areas to hear sounds from vessel traffic and seismic activities, of which some might be displaced seaward by the planned activities. The numbers of cetaceans and pinnipeds subject to displacement of 0.6 to 1.2 km and 0.4 to 0.9 km (or more), respectively, are small in relation to abundance estimates for the mammals addressed under this IHA.

In addition, feeding does not appear to be an important activity by bowheads migrating through the eastern and central part of the Alaskan Chukchi and Beaufort Seas in most years. A few bowheads can be found in the Chukchi and Bering Seas during the summer and Rugh et al. (2003) suggests that this may be an expansion of the western Arctic stock although more research is needed. In the absence of important feeding areas, the potential diversion of a small number of bowheads is not expected to have any significant or long-term consequences for individual bowheads or their population. Bowheads, gray, or beluga whales are not predicted to be excluded from any habitat.

The proposed activities are not expected to have any habitat-related effects that would produce long-term affects to marine mammals or their habitat due to the limited extent of the acquisition areas and timing of the activities.

11. The availability and feasibility (economic and technological), methods, and manner of conducting such activity or means of effecting the least practicable impact upon affected species or stock, their habitat, and of their availability for subsistence uses, paying particular attention to rookeries, mating grounds, and areas of similar significance:

Five main mitigations regarding deep 3D seismic surveys and site clearance and shallow hazards seismic in the Chukchi and Beaufort Seas are proposed: (1) the timing and locations for active seismic acquisition work will be scheduled to curtail operations when whaling captains inform the operator that they are scouting or hunting within traditional hunting areas; (2) to configure air guns in a manner that directs energy primarily down to the seabed thus decreasing the range of horizontal spreading of seismic noise; (3) using a seismic energy source which is as small as possible while still accomplishing the geophysical objectives; (4) using the ramp-up and soft-start methods of initiating seismic operations which is intended to alert any marine mammals either within or approaching an operating air gun array so that they may swim away from the source; and (5) curtailing active seismic work when the marine mammal observers sight visually (from shipboard) or aerially the presence of marine mammals within identified ensonified zones. Details of the proposed mitigations are discussed further in the 4MP that is included as an Attachment B to this application.

12. Where the proposed activity would take place in or near a traditional Arctic subsistence hunting area and/or may affect the availability of a species or stock of marine mammal for Arctic subsistence uses, the applicant must submit a plan of cooperation or information that identifies what measures have been taken and/or will be taken to minimize any adverse effects on the availability of marine mammals for subsistence uses. A plan must include the following:

i. <u>A statement that the applicant has notified and provided the affected subsistence community with a draft plan of cooperation.</u>

SOI has summarized concerns received during 2006 and 2007 into the 2007 POC, which was submitted during June 2007 to federal agencies as well as to subsistence stakeholders, and updated again in July 2007. SOI is carrying this POC forward to proposed 2008 activities. SOI has developed the POC to mitigate and avoid any unreasonable interference by SOI's planned activities on North Slope subsistence uses and resources. The POC is the result of numerous meetings and consultations between SOI, affected subsistence communities and stakeholders, and federal agencies beginning in October 2006. The POC identifies and documents potential conflicts and associated measures that will be taken to minimize any adverse effects on the availability of marine mammals for subsistence use. To be effective, the POC must be a dynamic document which will expand to incorporate the communications and consultation that will continue to occur throughout 2007 and 2008. Outcomes of POC meetings are included in quarterly updates attached to the POC as addenda and distributed to federal, state, and local agencies as well as local stakeholder groups that either adjudicate or influence mitigation approaches for SOI's open water programs. The 2007 POC Addendum 1 was issued on July 11, 2007 and SOI will issue 2007 POC Addendum 2 in the last quarter of 2007 to capture concerns from affected subsistence users regarding SOI's 2007 open water program and planned upcoming 2008 open water activities.

SOI attended 22 POC meetings regarding SOI's 2007 programs (Table 1). Meetings for SOI's 2007 open water activities in the Beaufort Sea were held in Nuiqsut and Barrow on October 16 and 17, 2006, and on January 30, February 1, 2007, respectively and in Kaktovik on November 10, 11, and 28, 2006 and followed with meetings in 2007 on January 29 and March 14. SOI held POC meetings with the Chukchi Sea villages of Point Hope and Wainwright on February 21 and 22, 2007, respectively, and again on March 12 and 17, 2007. SOI also met with the village of Point Lay on June 11 and 21, 2007 and Shishmaref on August 30. Additional meetings were held with the Eskimo Walrus Commission, Alaska Beluga Committee, Ice Seal Committee, and the Nanuuq Commission in April and June 2007 (the Ice Seal Commission did not attend the April meeting). At these meetings, SOI presented its program and discussed local concerns regarding subsistence-related activities.

SOI plans to begin 2007/2008 POC meetings during the 4th quarter of 2007 with a application meeting for the 2008 open water seismic and marine survey program in the Beaufort and Chukchi Seas. Federal, state, and local agencies as well as North Slope subsistence stakeholder groups have been invited to attend this meeting.

TABLE 12-1
POC Meeting Dates and Locations

2006	Meeting Location
October 16	Nuiqsut
October 17	Barrow
November 8	Nuiqsut (MMS)
November 10	Kaktovik (MMS)
November 11	Kaktovik (MMS)
November 28	Kaktovik
2007	**Meeting Location**
January 29	Kaktovik
January 30	Nuiqsut
February 1	Barrow
February 21	Point Hope
February 22	Wainwright
March 12	Point Hope
March 13	Nuiqsut
March 14	Kaktovik
March 15	Nuiqsut
March 16	Barrow
March 17	Wainwright
April 25	Anchorage
June 7	Anchorage
June 11	Point Lay
June 21	Point Lay
August 30	Shishmaref

SOI intends to initiate negotiations with the AEWC to finalize a CAA between SOI, and the subsistence hunting communities of Barrow, Nuiqsut, Kaktovik, Pt. Hope and Wainwright for the 2008 activities. SOI anticipates multiple engagements with the Whaling Captains' Associations and AEWC. If successfully negotiated, and signed, a CAA would be a component of SOI's 2008-2009 POC and is anticipated it will cover the proposed Chukchi and Beaufort Sea deep 3D seismic and marine surveys.

ii A schedule for meeting with the affected subsistence communities to discuss proposed activities and to resolve potential conflicts regarding any aspects of either the operation or the plan of cooperation.

SOI will hold community meetings in Barrow, Nuiqsut, Kaktovik, Wainwright, Point Hope, Point Lay, regarding its Beaufort and Chukchi Seas 2008 open water seismic and marine surveys program, and an on-ice marine seismic program, beginning with Nuiqsut on November 1, 2007. During these meetings, SOI will focus on lessons learned from the 2007 open water program and begin dissecting the 2007 measures for avoiding potential conflicts outlined in the July 11, 2007 POC, complete with an adaptive management approach. SOI will also facilitate meetings with the above-mentioned marine mammal commissions that are focused on ice seals, walrus, polar bears, and beluga.

SOI will issue a third addenda to the 2007 POC which will document SOI's measures to continue to avoid any unreasonable interference to affected subsistence activities with all 2008 proposed programs.

iii A description of what measures the applicant has taken and/or will take to ensure that proposed activities will not interfere with subsistence whaling or sealing;

SOI and the AEWC signed a CAA agreement in July 2007 that was valid for the 2007 seismic season. SOI will work in good faith to negotiate, and hopefully sign an agreement for the 2008 season. This CAA would be a component of the SOI's overall POC. The POC, and the CAA as a component will incorporate all appropriate measures and procedures to mitigate possible adverse impacts on the subsistence hunts for bowhead whales, and seals. Regardless of whether a CAA is reached, SOI will then meet its regulatory requirements by implementing mitigation measures similar to those defined in the 2007 CAA, and what is assumed would be in a 2008 CAA. The following are the some of the key mitigations:

1. For the purposes of reducing or eliminating conflicts between subsistence whaling activities and SOI's seismic program, the Holder of this Authorization will establish and operate at least five Communication (Com), or Call, Centers to be staffed by Inupiat operators. The Com and Call Centers will be monitored 24 hours/day during the 2008 fall subsistence bowhead whale hunt in the area which each they are located.

2. Plan all vessel and aircraft routes to minimize any potential conflict with bowhead whale subsistence whaling activities. Coordinate with the whale hunters through the Com and Call Centers in order for all vessels to avoid areas of active or anticipated whaling activity.

3. During the bowhead whaling season, aircraft shall not operate below 1,000 ft unless approaching, landing or taking off, or unless engaged in providing assistance to a whaler or in poor weather (low ceilings) or other emergency situations. This does not apply to unmanned aerial vehicles (drones).

4. All geophysical activity in the Beaufort Sea and Chukchi Seas shall be restricted from conducting seismic as set forth below:

   (1) *Kaktovik.* No geophysical activity from the Canadian border to the Canning River (-146 deg. 4 min. W) from August 25 to the end of the fall bowhead whale hunt

   (2) *Nuiqsut:* No geophysical activity from the Canning River (-146 deg. 4 min. W) to Point Storkersen (– 148 deg. 45 min. W) from August 25 to the end of the fall bowhead whale hunt in Nuiqsut;

(3) *Barrow:* No geophysical activity from Pitt Point on the east side of Smith Bay (- 152 deg 15 min. W) to a location about half way between Barrow and Peard Bay (-157 deg. 20 min. W) from September 10 to the end of the fall bowhead whale hunt in Barrow

5. Seismic vessel transits in the Chukchi Sea spring lead system must not occur prior to July 1, 2008.

6. Upon notification by Com or Call Center operator of an at-sea emergency, the Holder of this Authorization shall provide such assistance as necessary to prevent the loss of life.

7. Upon request for emergency assistance made by a subsistence whale hunting organization, or by a member of such an organization in order to prevent the loss of a whale, the Holder of this Authorization shall assist towing of a whale taken in a traditional subsistence whale hunt if possible.

8. Post-Season Review: No later than 90 days following the end of the fall 2007 bowhead subsistence hunt, SOI will host a joint meeting with all whaling captains of the Villages of Nuiqsut, Kaktovik and Barrow, the Inupiat Communicator(s) and with the Chairman and Executive Director of the AEWC at a mutually agreed upon place on the North Slope to review the results of the 2007 fall season (unless it is agreed by all designated individuals or their representatives that such a meeting should be held at a different location, should be postponed, or is not necessary).

9. No later than 90 days following completion of geophysical operations in the Chukchi Sea, SOI will host a meeting in each of the following villages: Wainwright, Point Hope, and Barrow (or a joint meeting of the whaling captain from all these villages if the whaling captains agree to a joint meeting) to review the results of operations and to discuss any concerns residents of those villages might have regarding the operations.

iv What plans the applicant has to continue to meet with the affected communities, both prior to and while conducting activity, to resolve conflicts and to notify the communities of any changes in the operation.

SOI's approach will be to conduct an application overview meeting with federal, state, and local agencies as well as non-governmental agencies in an application meeting to introduce the proposed 2008 open water seismic and marine survey programs in the 4^{th} quarter of 2007 at a location to be determined. This meeting will serve to facilitate early identification of key issues. The agencies and stakeholder attendees can assist SOI in conducting constructive discussion of the success for the 2007 POC mitigation measures and assist SOI and affected subsistence communities in continuing a communicative relationship for conflict avoidance during the 2008 program. The agencies and stakeholders may also assist SOI in developing an appropriate schedule for conducting POC meetings in the communities in the fall of 2007 and continuing through 2008.

Further POC meetings will be held in winter/spring 2008 in the affected communities. In addition, the applicant can meet with North Slope officials and community leaders on an as-requested basis before the open water season in order to discuss the proposed activities.

13. The suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species, the level of taking or impacts on the population of marine mammals that are expected to be present while conducting activities and suggested means of minimizing burdens by coordinating such reporting requirements with other schemes already applicable to persons conducting such activity. Monitoring plans should include a description of the survey techniques that would be used to determine the movement and activity of marine mammals near the activity site(s) including migration and other habitat uses, such as feeding:

The proposed Marine Mammal Monitoring and Mitigation Plan for the deep 3D seismic surveys in the Chukchi and Beaufort Seas, and marine surveys, also in both seas, is included as Attachment B of this application.

14. Suggested means of learning of, encouraging, and coordinating research opportunities, plans, and activities relating to reducing such incidental taking and evaluating its effects:

Various agencies and programs may undertake marine mammal studies in the Beaufort Sea during the course of the 2008 and 2009 open water season. It is unclear if these studies might be relevant to SOI's proposed activities. SOI is prepared to share information obtained during implementation of our marine mammal monitoring program with a variety of groups who may find the data useful in their research. A suggested list of recipients includes:

- The North Slope Borough Department of Wildlife Management (T. Hepa)
- The USFWS Office of Marine Mammal Management (C. Perham and J. Garlic-Miller)
- The MMS's Bowhead Whale Aerial Survey Program (C. Monnett)
- The Kuukpik Subsistence Oversight Panel (KSOP)
- Alaska Eskimo Whaling Commission (H. Brower - Barrow)
- Beluga Whale Committee (W. Goodwin - Kotzebue)
- Inupiat Community of the Arctic Slope (Arnold Brower -Barrow)
- MMS – Resource Evaluation (R. Wall)
- North Slope Science Initiative (J. Payne)
- Alaska Department of Natural Resources (D. Perrin)

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Attachment A –
Overview/Description of Vessels

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Table of Contents

Seismic 3-D Surveys

Purpose

Marine three-dimensional (3-D) seismic surveys are the current industry standard method of gathering subsurface information in the offshore environment. They provide a detailed image of geological structures such as bedding layers and faults. This information is essential for exploration and production of hydrocarbons. The improved information from 3-D seismic relative to older two-dimensional seismic allows exploration wells to be drilled with a higher likelihood of success as well as reducing the number of development wells required.

Overview of Marine 3-D Seismic Acquisition

In the seismic method, reflected sound energy produces graphic images of seafloor and sub-seafloor features. The seismic system consists of sources and detectors, the positions of which must be accurately measured at all times. The sound signal comes from arrays of towed energy sources. These energy sources store compressed air which is released on command from the towing vessel. The released air forms a bubble which expands and contracts in a predictable fashion, emitting sound waves as it does so. Individual sources are configured into arrays. These arrays have an output signal which is more desirable than that of a single bubble and also serves to focus the sound output primarily in the downward direction which is useful for the seismic method. This array effect also minimizes the sound emitted in the horizontal direction.

The downward propagating sound travels to the seafloor and into the geologic strata below the seafloor. Changes in the acoustic properties between the various rock layers result in a portion of the sound being reflected back toward the surface at each layer. This reflected energy is received by detectors called hydrophones, which are housed within submerged streamer cables which are towed behind the seismic vessel. Data from these hydrophones are recorded to produce seismic records or profiles. Seismic profiles often resemble geologic cross-sections along the course traveled by the survey vessel.

During the seismic acquisition the vessel to be used, the M/V Gilavar, is operated by WesternGeco. Specifications for the Gilavar are included in Appendix 1. The Gilavar will tow two source arrays, comprising three identical subarrays each, which will be fired alternately as the ship sails downline in the survey area. The Gilavar will tow up to six streamer cables up to 5,400 meters (m) long. With this configuration each pass of the Gilavar can record 12 subsurface lines scanning a swath of up to 360 m.

The Gilavar will be accompanied by a support vessel, M/V Gulf Provider (or similar vessel) which is owned and operated by Northern Transport Company limited (NTCL). The Gulf Provider will act as a support vessel and will be used to re-supply and refuel the Gilavar.

Operational Plan

The M/V Gilavar will be in the Chukchi Sea in mid to late July to begin deploying the acquisition equipment. Seismic acquisition is planned to begin on or about July 20, 2007. The approximate area of operations are shown in Figure 1. Acquisition will continue in the Chukchi Sea until ice conditions permit a transit into the Beaufort Sea around mid-September. Seismic acquisition is planned to continue in the Beaufort Sea until early October depending on ice conditions. For the 3-D areas, the Gilavar will traverse the area multiple times until data over the area of interest has been recorded. At the conclusion of seismic acquisition in the Beaufort Sea, the Gilavar will transit back through the Chukchi Sea.

APPENDIX 1 – VESSEL SPECIFICATIONS
M/V GILAVAR

WesternGeco reserves the right to alter specifications without prior notice.

Maritime Specifications / Particulars

Main Particulars

Ships Name	**"GILAVAR"**
Call sign	4JKW
International Maritime Org. (IMO) No.	8008539
Owner	Caspian Geophysical Ltd. Baku, Azerbaijan.
Previous Name	"Geco Gamma"
Flag state & port of registry	Azerbaijan, Baku
Azerbaijan Official No.	12885
Date of Build	February 1981
Hull No. and type of vessel	132 / Seismic Research Vessel. / "Trosvik-Class"
Yard built	Trosvik, Norway
Date converted / power upgraded	April 1994 / April 1998 / August 2003
Yard converted	Motorwerken, Bremerhaven, Germany. Navy dock Yard, Baku by Transmarine
Classification Society and Class	RMRS / DNV+1A1 - EO - Ice C - Helideck.
DNV Class ID No.	12885
Main Class renewal	04/2004. Valid to year 2009
Classification Machinery System	Planned Maintenance System (PMS) Year 1997
Class approved maintenance system	1 x Electronic plan / rec. TM-Master 1.76. Build 76. Replaced RAST OM 3.81 in 03.02.
International Safety Management, (ISM) code compliance	RMRS June 02, 2002. Renewal next due: June 05.
Safe Manning certificate (minimum)	12 Maritime crewmembers. (Galley dep. not incl.)

Principal Particulars

Gross tonnage (GRT)	3953 metric ton
GRT national & international	3953 / 3953 metric ton
Gross tonnage (GRT) Suez canal	N/A
Net registered tonnage (NRT) Panama Canal	N/A
NRT National & International	1186
NRT Suez canal	N/A
Lightship displacement	2773 metric ton
Deadweight	1359 metric ton
Length over all (LOA)	84.90 m
Length between perpendiculars	75.80 m
Breadth (moulded)	18,4
Breadth (extreme)	19.1 m Helideck (NB! Hinged flap on stb side)
Depth (moulded)	8.60 m
Summer draft (max)	5.3 m
Draft (mean)	
Air draft (to highest antenna)	28.1 m at design draft: 5.30 m
Helicopter Deck rating	Bell 214 / Super Puma / Year 1994
Helicopter Deck diameter (D-value)	19.10m
Helicopter Deck markings standard	Azal Helicopter Company / CAA UK

Capacities And Endurance's

HP air source, standard m³ / hour	2 x 2700, 1 x 1224. Total 6624 m³ at 4.8 knots
Engine Room HP air compressors	2 x Sperre
Pulling power, dynamic at full ahead	27 ton at 4.5 knots water speed
Fresh water capacity	4 tanks. Total x 208 metric tons
Fresh water maker production	1 x Evaporator 6 - 16 m³/day, dependent on engine load 1 x Reverse Osmosis, 12 m³ / day.
Potable water system	1 x Common potable & wash water system
Fuel capacity, all tanks topped	14 x tanks. Total x 810 m³
Fuel, useful for 100 % consumption	730 m³ (3 days safety margin in addition)
Fuel type	Marine Gas Oil (MGO) Grade DMA Distillate. Standard: ISO 8217,1996. Grade ISO 8216,1985
Fuel tank heating	None
Lube oil, engine oil (m³)	2 x tanks. Total x 22 m³ Shell Gadina 40
Cylinder oil, HP compressors (m³)	2 x tanks. Total x 6.75 m³ Mobil Rarus 827
Cable oil, kerosene (clean/separated/dirty)	3 x tanks. Total x 21.1 m³, Isopar M
Ballast, sea water (m³)	6 x tanks. Total x 316 m³
Speed, transit, max in calm sea	14 knots (336 nautical miles/24 hours)
Speed, transit economy, ditto	11 knots (264 nautical miles/24 hours)
Consumption x fuel, full speed	18.6 m³ / 24 hours
Consumption x fuel, economy speed	12 m³ / 24 hours (only 2 generators in service)
Operational endurance	39 days at full speed / 60 days at economy speed
Endurance x fuel during survey	45 - 23 days, dependent on configuration x gear.
Consumption x fuel during survey	Minimum 16 m³, maximum 32 m³ per 24 hours at full thrust. Azimuth Thruster and 3 HP compressors
Consumption x fuel in port	3 m³ / 24 hours
Safety equipment certificate	Maximum 50 persons allowed onboard when at sea

Bridge Navigation Equipment

Radar no 1	1 x Krupp Atlas 9600, ARPA X-band, Y 1996
Radar no 2	1 x Krupp Atlas 8600, ARPA S-band, Y 1986
Radar no 3	None
ECDIS	None
Gyro compass	1 x Robertson RGC 11
Auto-Pilot	1 x Robertson AP 9 MK II with Robnav
AIS	SAAB R4 AIS Class A Transponder System
GPS receiver (for AIS)	Furuno GP-90
GPS receiver	1 x Raystar 390 GPS
Speed log	1 x JRC: JLR-203 Doppler log
Echo Sounder	1 x Simrad EN-200 Bridge. 1 x EA-500 in I-room
Radios, VHF, GMDSS*, type 1	1 x Shipmate RS8100
Radios, VHF, GMDSS*, type 2	3 x Sailor 2048, 2 with DSC
Radios, VHF, GMDSS*, type 3	None
Radios, UHF	6 x Motorola GP300
Radio direction finder	1 x Furuno VHF Direction finder FD 525
Weather facsimile	1 x Furuno WFR Fax 108
NAVTEX receiver	1 x JRC, NRC 300 A
UPS, power supply to all GMDSS radio's	1 x Metric M-2000, Year 1994

Communication Equipment, Compliant With GMDSS Requirements

Radio Station license No.	00547 Azerbaijan (23776-B Panama)
Class / corr. category	33a CP H8
Ship / Aircraft radio	1 x (type unknown), 1 x Portable, ICOM
Helicopter Beacon	1 x RS110 + Automatic keying device 6ANG
Transmitter / receiver, main (MF)	1 x Sailor C2140 Simplex
Transmitter / receiver, reserve (MF)	1 x Skanti 8000, Year 1994
Transmitter / receiver, main (VHF)	4 x Sailor RT 2048
Transmitter / receiver, main (DSC)	1 x GMDSS, VHF DSC RM 2042
Radio, portable, UHF	6 x Motorola GP 300
Booster unit for portable radio (UHF)	1 x base repeater, TP Radio 6725 B
Emergency radio beacon (EPIRB)	1 x Tron 30S MK II
Radar transponder	2 x Tron Sart 9
Radio, Liferaft, VHF	4 x Sailor 3110

Satellite Communications

Inmarsat type B	1 x Nera Saturn B Mk2
Inmarsat type C	1 x Sailor H2095B
Inmarsat telephone No./ Fax No./HSD (64kb)	+873-342309010 / +873-342309012 / +873-391015139
V-Sat	Spacetrack 4000 SESAT
V-Sat online Tele-link to Aberdeen, 24 hrs	(+44) 2075 766865 - (+1) 713 296 5365
Telefax machine	1 x Canon T-301 (Sat), 1 x Panafax UF450 (Mob)
TV-Satellite receiver	1 x Skipper DMC. 4 channels internally distributed
Internal E-mail & PC-network	12 x Work areas and Senior staff cabins
E-mail address to vessel	Department head title before @ i.e. Party_Chief or Captain@gilavar.vessel.caspian.slb.com

Safety Equipment Crew

Liferaft davits	2 - One either side x Bridge Deck
Liferafts type / capacity	6 Viking 25DKF (25 persons), 1 MOB raft, Viking 6DKR (6 persons)
Number x life rafts	6 (MOB raft excluded)
Lifejackets no.	43 x Seamaster 83, 38 x Seamaster 69, 20 x T-vest 87. **Total No. Onboard: 101**
Survival suits, Thermo Insulated	44 x Helly Hansen E 305-7, E 305, E353. 6 x Helly Hansen E 351, E 305, D 602. **Total No. Onboard: 50**
Work suits, Thermo Insulated	9 x Helly Hansen E 300-2
Man overboard boat (MOB) type	1 x Springer MP-741. Year 1996
Engine, MOB and speed x boat	1 x Cummings 6B TA5. 9M2, 30 knots / 2400 rpm
Waterjet and gear drive, mob	Hamilton 273 with Borg Warner 72 C
Work boat	Norpower 25 feet. Year 1999
Engine, work boat and speed x boat	Cummings Diesel 220 hp. 15 knots

Fixed Fire Extinguisher System

Engine room	7 x Halon 1301. Year 1981
Separator room	1 x Halon 1301 (combined with tape store)
Tape store	1 x Halon 1301 (combined with sep. room)
Incinerator room / Galley ducting	None
Cable store	1 x Sprinkler system, foam AFFF. Year 1994
Steamer Winch Room	1 x Sprinkler system, AFFF, plus full coverage x CO2
Helicopter deck	1 x Foam monitor, AFFF
Paint store	1 x Seawater sprinkler system. Year 1994
Chemical store	1 x Sprinkler system, foam AFFF. Year 1994
Main foam pump, AFFF foam mixture	1 x 110 m^3/h 8 bar (Engine Room starboard)
Main fire pump	2 x 32 m^3/hr 8 bar. (Engine room stbd.fwd and port aft)
Emergency fire pump	1 x 32 m^3/hr 8 bar. (El. driven, B/T room)
Fire detection monitoring system	1 x 12 loops, Servoteknik AS, entire vessel, Y -96

Hull Outfitting

Anchor	2 Stockless - Hall type
Windlass	2 x Norwinch Type: 1A33/38-36 "Split", Y -81
Mooring winches	2 x Capstan on end x each windlass.
Capstan no 1	1 x Br. Bauer-Nilsen, 5 ton (stbd. shelter deck) Y -96
Capstan no 2	1 x Br. Bauer-Nilsen, 5 ton (port shelter deck) Y -81
Deck crane 1, capacity/reach/location	1 x Hydralift 5,5 ton/ 16,5 m / stbd side, Y 1999
Decks crane 2, capacity/reach/location	1 x Has 30h, 3 ton/ 10 m. / port side, Y 1981
Stores / personnel elevator	1 x Fortuna – load 500 kg
Anti rolling damping system	1 x Flume tank (passive) under Heli-deck. Y-94
Heeling tanks, volume and fuel/FW/SW	2 x 30 ton fuel each, active system, bridge operated
Bunker connections, locations	2 on shelter deck, each side. 1 on bow
Bunker connections, type(s)	Flange ND100/220 mm
Bunker hose length and dimension (loose)	Yes / 3 x 6", 10 m length, total 30 m. Year 1995
Crew accommodation, no x bunks	50
Single berth cabins	30. Each cabin with toilet and shower
Double berth cabins	10 x Each cabin w/toilet and shower
Client cabins, single berth	1 x All facilities incl. Live TV and video. Y 1998
Business conference and training room	1 x 12 persons. TV / video / 2 x computers
Sauna and fitness room	1 x sauna, 1 x well equipped fitness room. Y 1996

International Oil Pollution Prevention (IOPP) Equipment

Incinerator, sludge and waste oil	1 x Fredrikstad 2.1 L. Year 1981
Bilge / oily water separator	1 x ROW. SKIT S 2.5 (ton/h) Year 1997 Compliance MARPOL 73/78. IMO Res. A 393 (x)
Oily water / sludge tanks cap.	4 x Total 102 m^3
Oil spill absorbent / damage control	2 x Absorbent kits + 200 l. chem. Seacare O.S.D
Sewage treatment plant	ORCA IIA-70 / Marine Sanitation Device. 9,46 m3
Sewage/grey water holding tank capacity	170m3 / 20 days
Waste compactor	1 For tins and sheet metal recycling

Machinery Equipment

Air capacity, each and total (cfm)	2 x 2700, 1 x 1224. Total 6624 m^3/hr.
HP compressor drive motors, large	2 x ASEA 60 Hz 600V, Y 825A MF 560L 660 kW
HP compressor drive motors, small	1x ABB 60 Hz 600V, Y 410A M2BA 355/360 kW
Main engine or electric prop. motors	4 x Asea LAB-450 LN 600kW, tot. 2400 bkW. Y-98
Redundancy propulsion, Azimuth thruster	1 x Brunvoll AR-LNC-1650 / 736 bkW. Year 1994
Vessels total brake hp / kw for prop.	1 x 2400 kW and 1 x 736 kW = 3136 bkW/4265 bhp
Main engines, power supply	4 x SCR (rectifiers) convert DC power to M/E. Y-81
Auxiliary engines (generator drive)	4 x Bergen Diesel KRGB-9 x 2065 bhp Tot. 8260 bhp
Aux. Engine manufacturer nos. 1 to 4	Nos. 2865, 2863, 2864, 2915. Year 1998
Aux. eng. turbochargers	1 x Brown Boveri ser. No. HT-344738, Type: VTR250, Specification ZB8C19.8 IVMH 110AW3P/A2
Propeller type, main propulsion	1 x 4 blade, Hjelseth, CPP / bronze / Nozzle. Y -94
Propeller, noise & pitch control	1 x Step-less adjustment x pitch/rpm (10-240 rpm)
Propeller blade, spare	1 x Ulstein / bronze. Stored in cable store. Y 1994
Generators / Alternators	4 x ABB/AMG 560 S8, 1900kva / 1445 kW. Y -98
Electric power, useful, out from main switchboard	4 x 1400 kW, 600V 60 Hz each. Tot. X 5600 kW
UPS power to instrument room	1 x Merlin Gerin 80 KVA. 15 min. back up. Y -98
Power supply instrument room back-up	1 x Watt AS Rotating conv. SGB 434/4KR. Y -81
Emergency & Harbour generator engine	1 x Cummings Diesel, NTA-855-G. Year 1980/-99
Emergency & Harbour generator	1 x Stamford MC534C. 440V / 250 kW. Y 1980
Fuel back-up system for aux. eng.	1 x Automatic changeover if main system fails. Year 1995
Cooling system for aux. engines	2 x Segregated systems. 2 x eng. on each. Y -98
Bow thruster	1 x Brunvoll SPT VP 600 / 450 kW. Year 1981
Azimuth thruster	1 x Brunvoll AR-LNC-1650 / 736 bkW
Stern thruster	None
Fresh water generator (FWG)	1 x Alfa Laval Nirex 10-11. Year 1994 1 x Atlas Reverse Osmosis 12m3 per day
Boiler, exhaust gas & oil fired	1 x Pyro A800-1500 Hot water boiler, 85º C. Y -94
Steering gear	1 x Porsgrunn 260-12. Dual type, 2 pumps. Y -81

Seismic Specifications

Main Particulars

Streamers	8 (Max spread 6 x 6km limited by propulsion power x 27 tons)
Tow Points	8
Sub Arrays	6 x Sub Array Y1998 Y (Max 8)

Energy Systems

Gun Controller (Type & Manufacturer)	WesternGeco TRISOR 1.5
Guns (Manufacturer, Type & Capacities)	Bolt - Long Life Airgun, 1500 & 1900 – $30m^3$ to $290m^3$
Nominal Source Pressure	2000 psi
Pressure Release	Solenoid
Sensor Return	Piezoelectric
Timing Resolution	0.1 ms
Source	Combinations x variable sub arrays, up to 6 strings
Total Compressor Capacity	3900 CFM
Compressors (Manufacturer & Capacity)	2 x Burchardt B5S 1.55.1 – 1590 CFM 1 x LMF 200HD – 720 CFM
Near Field Phone (Manufacturer & Type)	WesternGeco, HD-1TC (Typically one NFP per ultrabox)
Far Field Phone (Manufacturer & Type)	None
Depth Indicators	TSED Fjørd – Pt # P20004931

Streamer Systems

Streamer (Manufacturer & Type)	TMS Solid Streamer Sentry/Guardian 150m
Streamer Deflector Type	Doors 300%
Section Breaking Strength (Typical)	>60 kN
Typical Towed-Streamer Stress	1000 - 2500 kg
Streamer Capacity (Max)	24000m
Nap-4	None
Streamers Vs. Length (Max)	1 x 8000m to 4 x 6000m
Nap-4	None
Streamer Spread (Max Spread Configuration)	300m using 300% doors
Streamer Control Device (Manufacturer & Type)	DigiCourse, 5011
Recording System (Manufacturer & Type)	Serce, Syntrak 960-24

Navigation Systems

Instrument Room Gyrocompass (Manufacturer & Type)	SG Brown SGB 1000
Source Positioning System (Manufacturer & Type)	Navia Maritime A/S, Seatrack 330
Global Positioning System (GPS) Receivers (Manufacturer & Type)	2 x Novatel, Millennium dual frequency 1 x leica, MX9400 single frequency
DGPS Qc System (Manufacturer & Type)	PDN Norway, TRINAV rGPS
Integrated Navigation System (Manufacturer & Type)	PDN Norway, TRINAV RT 2.6.0
3-D Quality Control System (Manufacturer & Type)	PDN Norway, TRINAV QC
Tailbuoy (Manufacturer & Type)	PDN Norway, TAG 3
Tailbuoy Navigation (Manufacturer & Type)	Navia Maritime A/S, Seatrack 220
Onboard Tailbuoy Positioning (Manufacturer & Type)	PDN Norway, TRINAV rGPS
Ultra-Short Baseline (USBL) Acoustic Positioning System (Manufacturer & Type)	None
Acoustic Positioning System (Manufacturer & Type)	Sonardyne, SIPSI & HGPS
Current Profiler (Manufacturer, Type & Frequency)	RDI, ADCP, 600kHz
Temperature/Salinity Dip Profiler (Manufacturer & Type)	12 x Sippicans 1 x Valeport, Mk600
Echo Sounder (Manufacturer & Type)	1 x Simrad EA-500
Transducer Frequency & Theoretical Range	1 x 38 kHz to 3400m 1 x 18 kHz to 9000m 1 x 200 kHz to 200m
Transducer Draft	-5.75m
Recording System	
Format	P1/90, P2/94, SPS, SEG-D for acquisition tapes
Media	IBM 3590 tape
Device	IBM 3590

Other Systems

Single & Multi-Trace Plotter (Manufacturer & Type)	OYO, GS 622

Onboard Seismic Qc

System	Omega QC
Software	Omega
Hardware	SUN Enterprise 6000

Onboard Seismic Processing

System	TRIPRO
Software	Omega (Latest Version)
Hardware	SUN enterprise 6000

Note:

Additional system, equipment, hardware and, software information may be available. Please refer to the appropriate specification sheets and/or manuals for more information.

Appendix 2 – WesternGeco’s 3,147 in^3 Bolt Gun Array for 3-D Operations

WesternGeco’s source arrays are composed of identically tuned Bolt gun sub-arrays operating at 2,000 psi, air pressure. In general, the signature produced by an array composed of multiple sub-arrays has the same shape as that produced by a single sub-array while the overall acoustic output of the array is determined by the number of sub-arrays employed. In this manner WesternGeco can offer a consistent source signature across our fleet of survey vessels.

The gun arrangement for the 1,049 in^3 sub-array is detailed below.

Standard 1,049 in^3 sub-array - 3 subarrays comprise each 3,147 in^3 Source

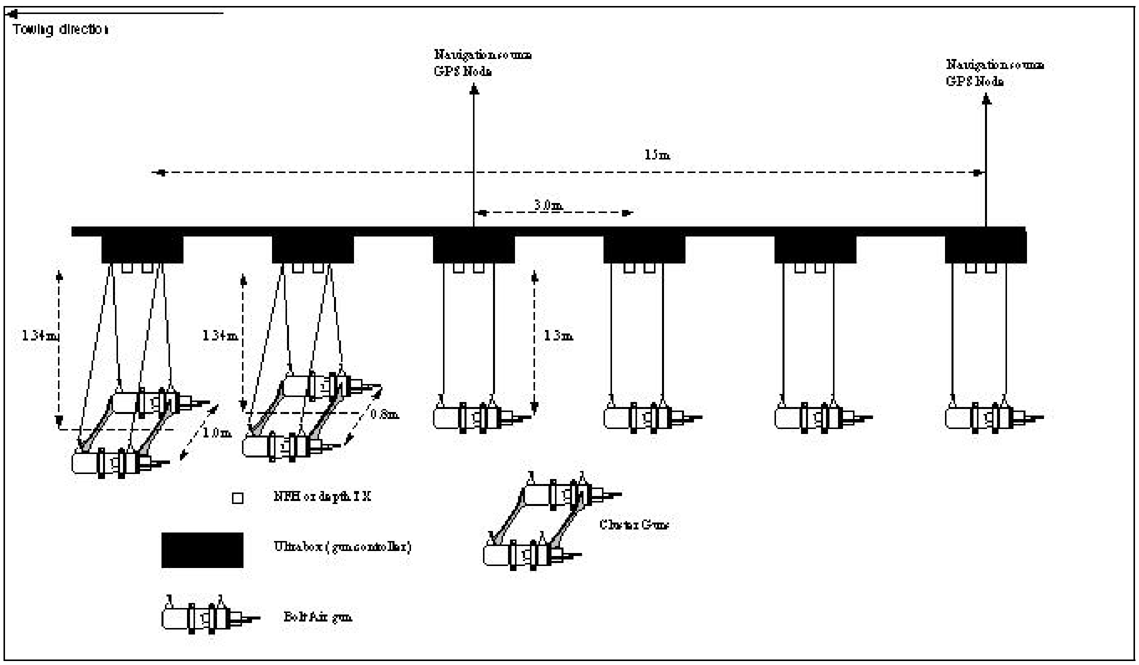


Figure 1 - Standard 1,049 in^3 sub-array

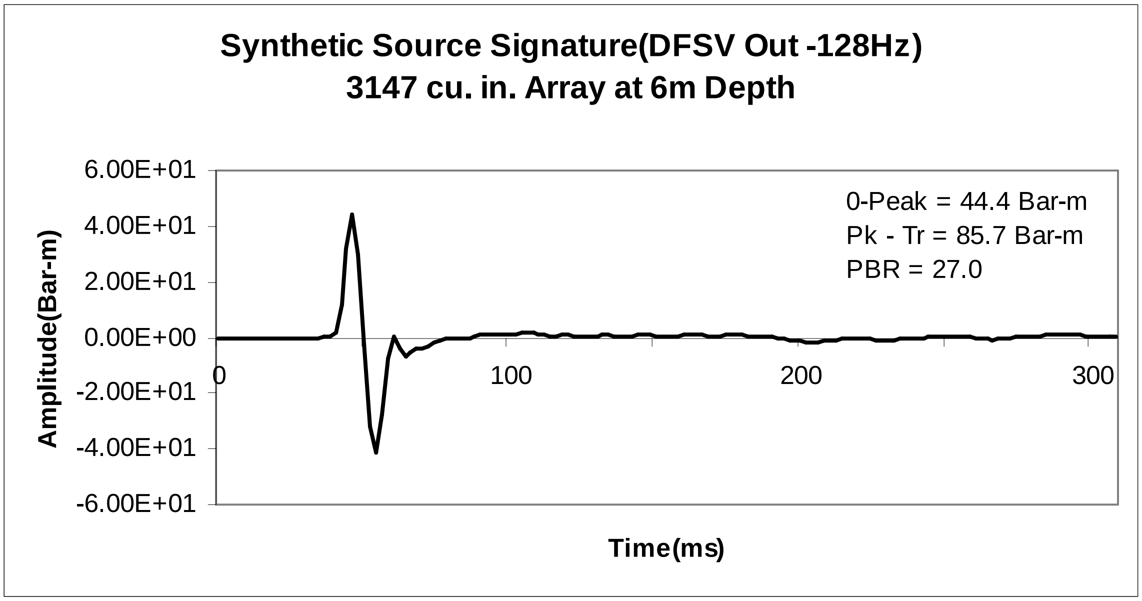
As indicated in the diagram, the sub-array is composed of six tuning elements; two 2-gun clusters and four single guns. The clusters have their component guns arranged in a fixed side-by-side fashion with the distance between the gun ports set to maximise the bubble suppression effects of clustered guns. A near-field hydrophone is mounted about 1 m above each gun station (one phone is used per cluster), one depth transducer per position is mounted on the gun’s ultrabox, and a high pressure transducer is mounted at the aft end of the subarray to monitor high pressure air supply. All the data from these sensors are transmitted to the vessel for input into the onboard systems and recording to tape.

The standard configuration of a source array for 3D surveys consists of one or more 1049 in^3 sub-arrays. When more than one sub-array is used the strings are lined up parallel to each other with either 8 m or 10 m cross-line separation between them. This separation had been chosen so as to minimise the areal dimensions of the array in order to approximate point source radiation characteristics for frequencies in the nominal seismic processing band. For the 3,147 in^3 array the overall dimensions of the array are 15 m long by 16 m wide.

3,147 in³ Array Signature and Acoustic Radiation Patterns

The following pages show the time series and amplitude spectrum for the far-field signature and the computed acoustic emission pattern for the vertical inline and crossline planes for the 3,147 in³ array with guns at a depth of 6 m.

The signature for this array was computed using GSAP, WesternGeco's in house signature modelling software. The following table lists the gun parameters used as input to the model.



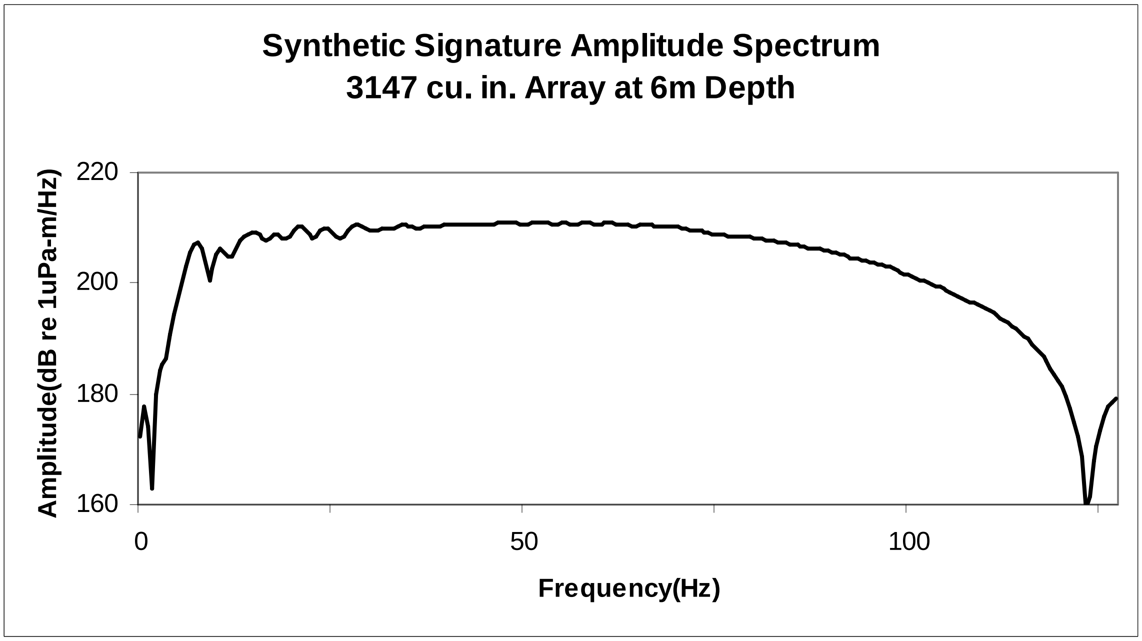


Figure - 2 3,147 in³ Array Far Field Signature and Spectrum

3,147 cu. in. Array Far Field Pressure Distribution

The following figures demonstrate modeled pressure around the array in:

- 0 degree azimuth vertical plane
- 90 degree azimuth vertical plane
- horizontal plane at 20 m depth

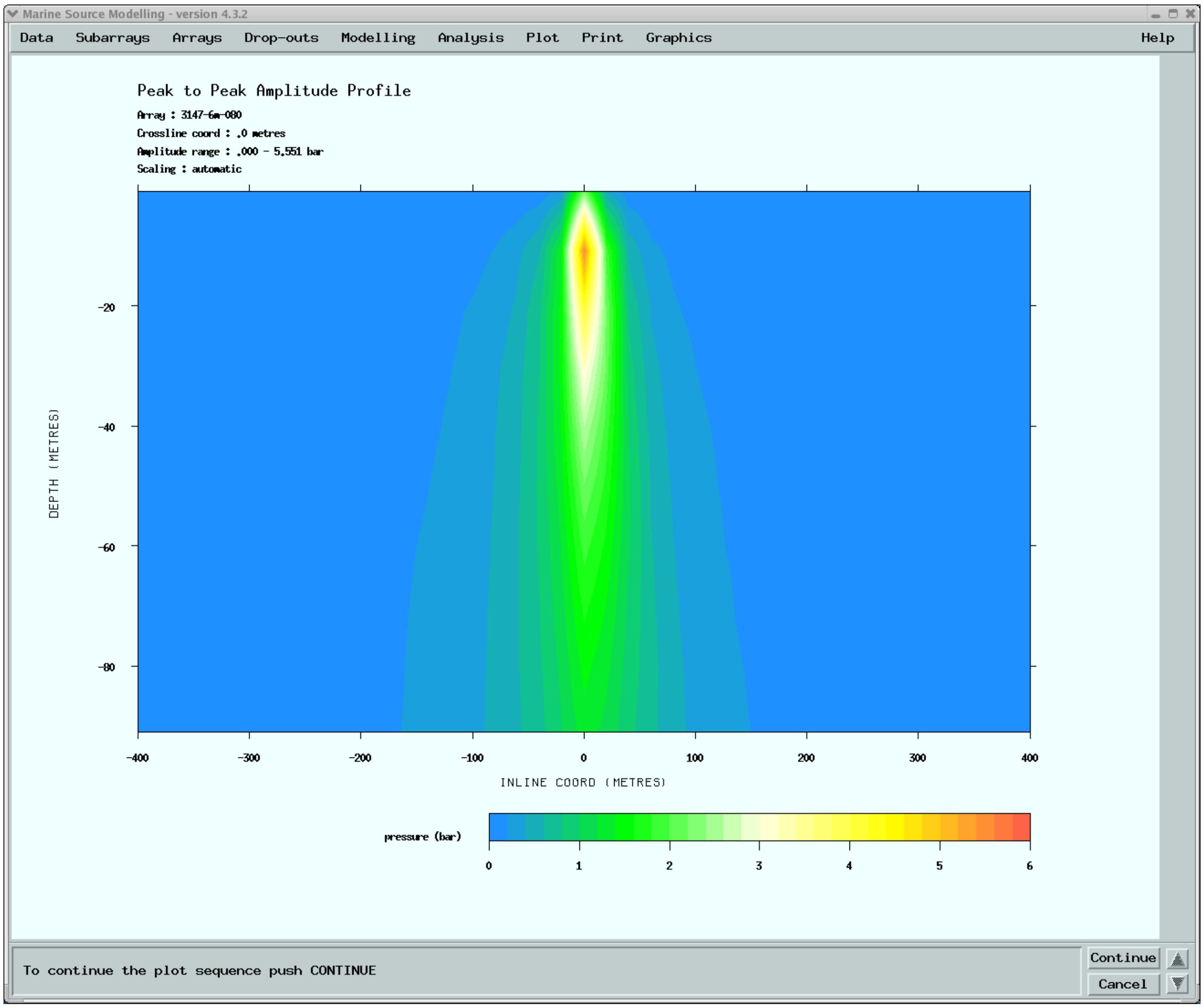


Figure 3 - Azimuth = 0 deg. pressure field. Peak to Peak amplitude

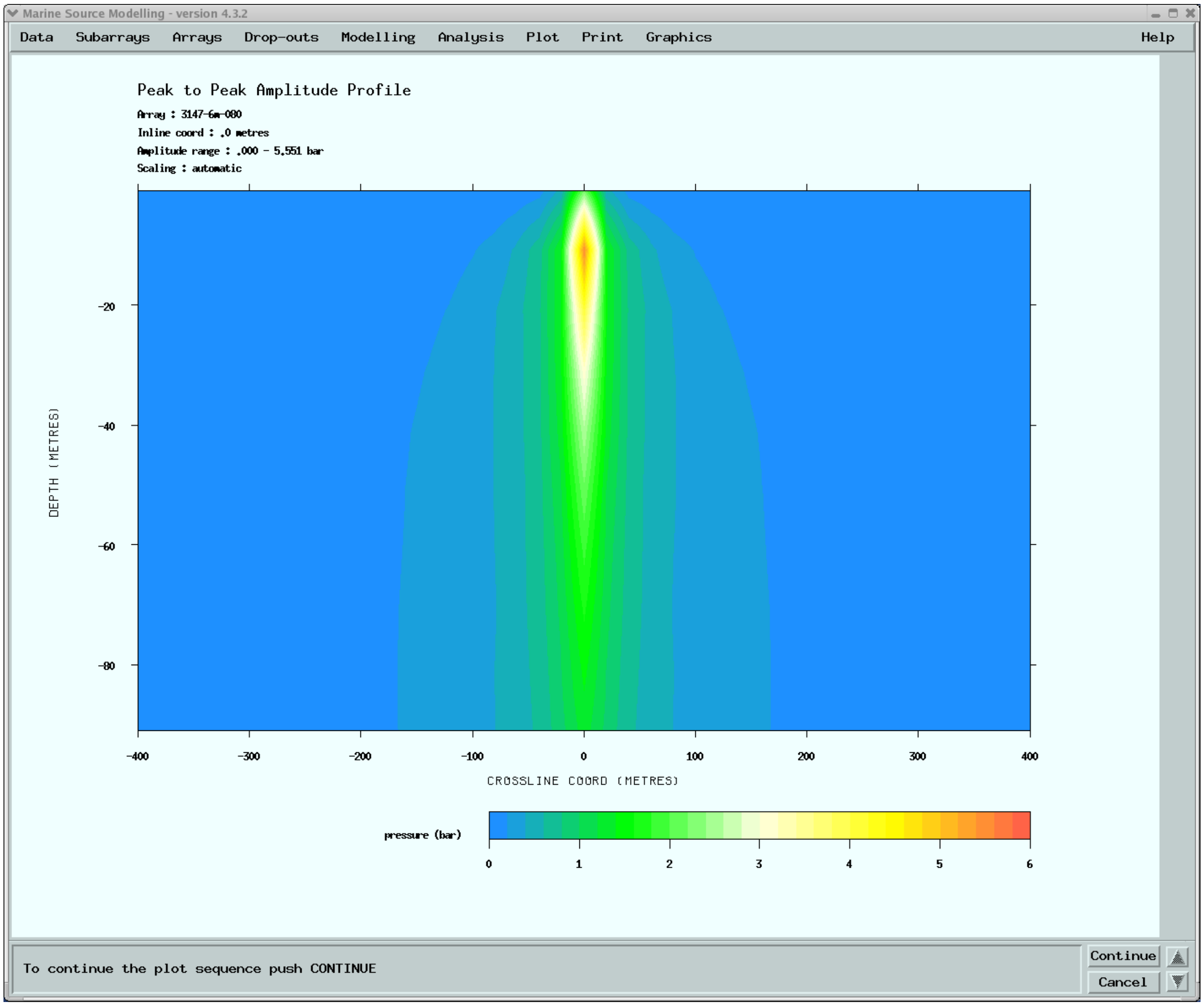


Figure 4 - Azimuth = 90 deg. pressure field. Peak to Peak amplitude

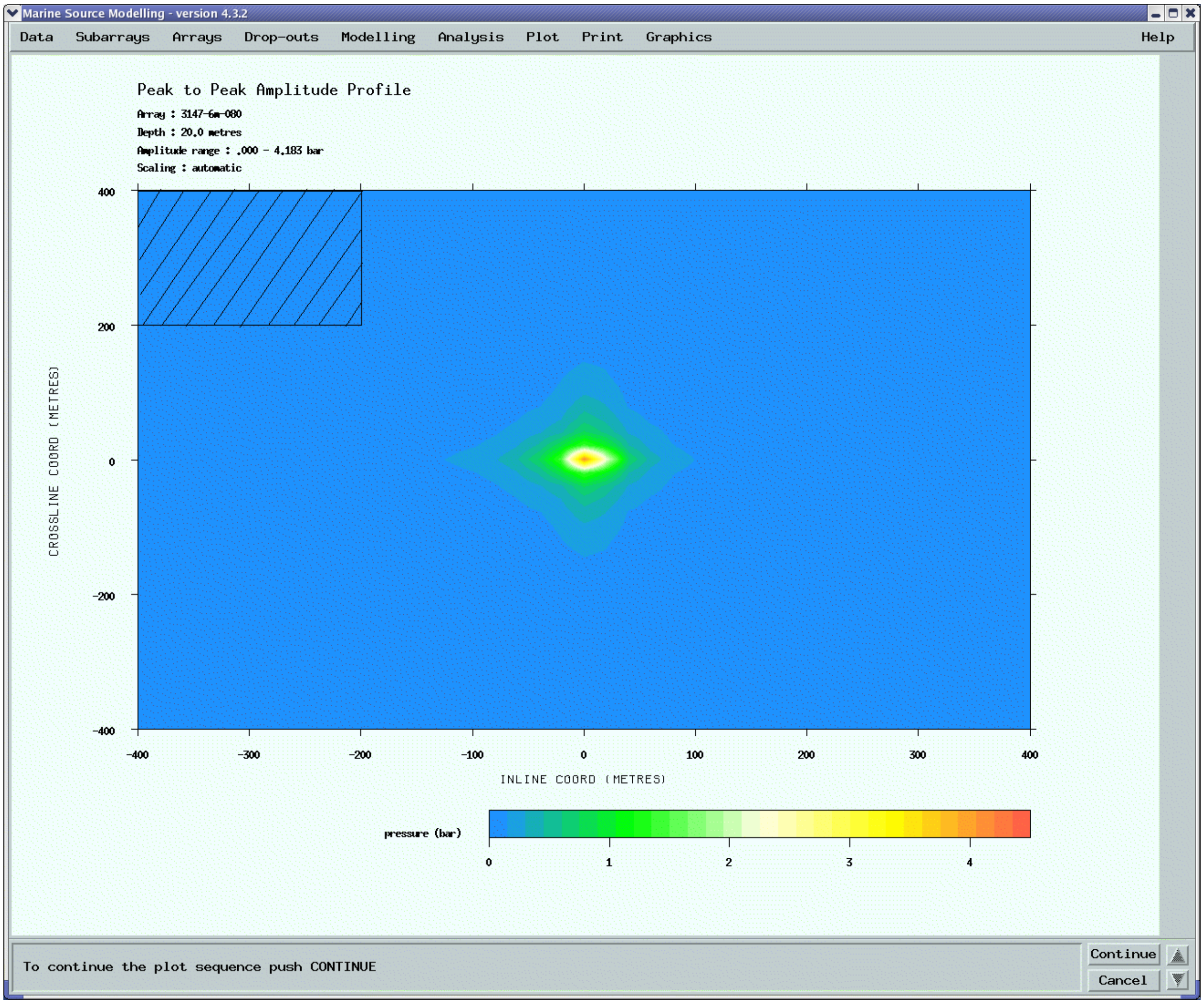


Figure 5 - Horizontal plane at 20 m depth pressure field. Area of -400 to +400 m centered on the array. Peak to Peak amplitude. Hatched area enlarged below to show farthest 200m to 400m.

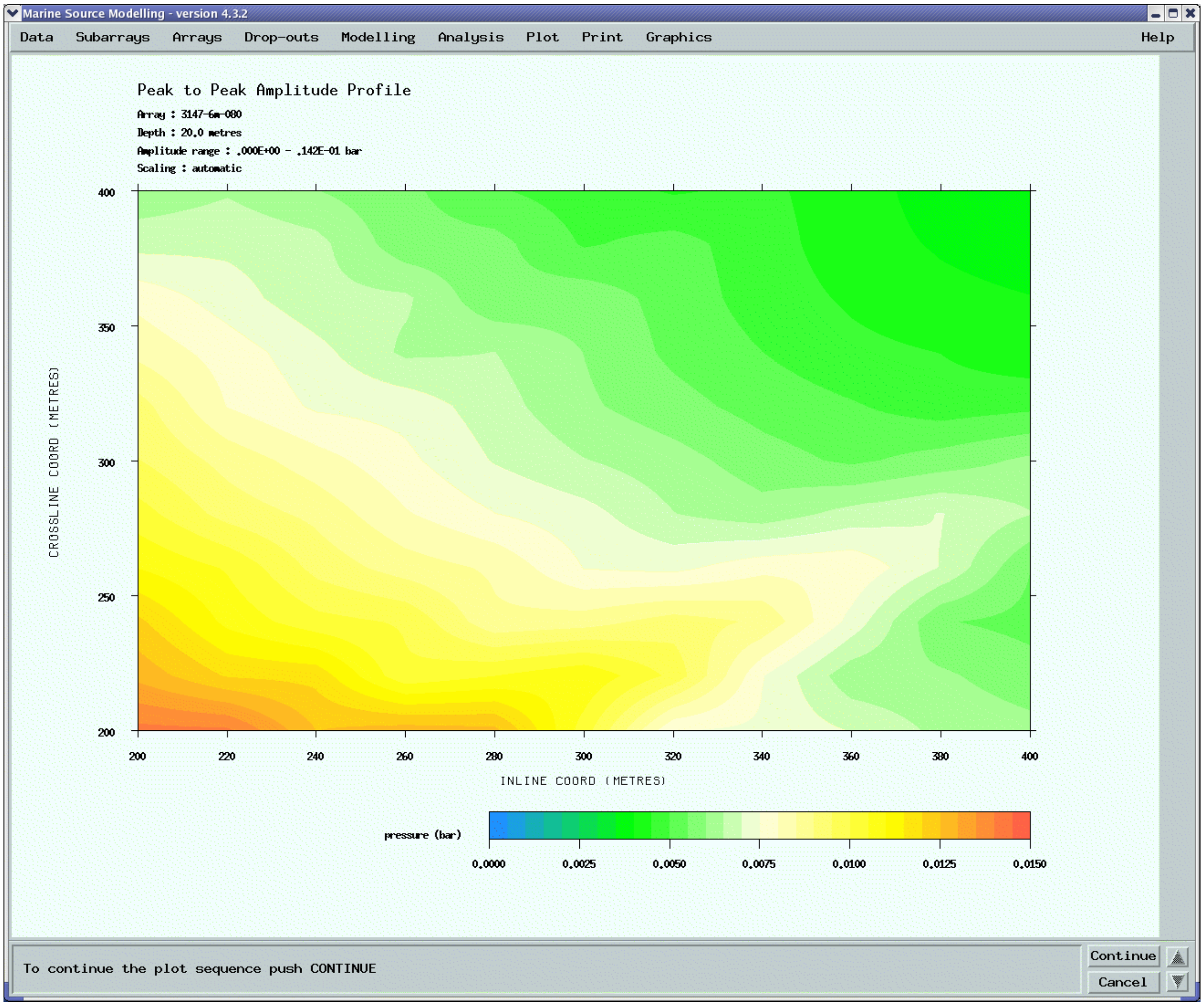


Figure 6 - Hatched area of previous figure. Horizontal plane at 20 m depth pressure field. Peak to Peak amplitude.

Attachment B –
Marine Mammal Monitoring and Mitigation Plan

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Marine Mammal Monitoring and Mitigation Plan

for

Seismic Exploration in
the Alaskan Chukchi and Beaufort Seas, 2008

Shell Offshore Incorporated

Prepared by

Alaska Research Associates, Inc.

JASCO RESEARCH

Marine Mammal Monitoring and Mitigation Plan

for

Seismic Exploration in
the Alaskan Chukchi and Beaufort Seas, 2008

Prepared by

LGL Alaska Research Associates, Inc.
JASCO Research
Greeneridge Sciences, Inc.

Prepared for

Shell Offshore Incorporated

October 2008

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INTRODUCTION

Shell Offshore Incorporated (SOI) has contracted LGL Alaska Research Associates, Inc. (LGL) to design and conduct a Marine Mammal Monitoring and Mitigation Program (4MP) for their open-water seismic activities in the Chukchi and Beaufort seas in 2008. The goal of the 4MP 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 2008. 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.

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 4MP 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 4MP 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 2007 will also be required in the Chukchi and the Beaufort seas in 2008. 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 2008 as was done in 2006 and 2007. If required by conditions of an IHA, SOI will utilize planned aerial overflights to monitor the 120 dB zone in the Beaufort Sea. Mitigation and monitoring methods are discussed in the sections below.

Duing the 2006 and 2007 seismic programs in the Chukchi Sea, SOI utilized a combination of pre-season modeling and early season sound source verification to establish safety zones for the above sound level criteria. As the equipment being utilized in 2008 is the same as that used in 2006 and 2007, and the majority of locations where seismic is to be acquired were modeled prior to the 2006 and 2007 seasons, SOI will initially utilize the derived (i.e. measured) sound criterion distances from 2006. Any locations not modeled previously will be modeled prior to 2008 initiation and mitigation distances and safety zones adjusted up, if necessary following sound measurements at the new locations. Modeling of the sound propagation is based on the size and configuration of the airgun array and on available oceanographic data. 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. If seismic support vessels utilized are the same or significantly similar to the support vessels utilized during 2007, the sound characteristics of these vessels will not be independently measured. Rather cumulative sound generated by the seismic operation will be measured by remotely deployed arrays of sonobuoys.

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. The actual time period 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 based on previous measurements of the .

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 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 five to 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 2008 will be individuals with experience as observers during one or more of the 1996-2007 seismic monitoring projects for Shell, 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).

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 2008 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 2008 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 2008 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 20 x 50 image stabilized binoculars, and 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 previous seismic programs 1998-2007 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 and 2007, 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, 20 x 50 image stabilized 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 2008, 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 three 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 2008 using MMOs onboard the chase vessel. The 160 dB radius in the Chukchi Sea in 2007 was determined by JASCO (2007) to extend ~8.1 km from the airgun source on the *Gilavar* (the seismic vessel). In the Beaufort Sea, the 160 dB radius was measured at ~13.45 km (JASCO 2007). This area around the seismic vessel was monitored by MMOs onboard the *Gulf Provider* (the chase boat used in 2007 operations). As in 2007 during monitoring of the 160 dB zone the *Gulf Provider (the chase boat to be used in 2008)* will travel ~8 km ahead and to the side of the *Gilavar*. MMOs onboard the *Gulf Provider* will search the area ahead of the *Gilavar* within the 160 dB zone for marine mammals. Every ~8 km the Gulf Provider will move to the other side of the Gilivar continuing in a stair-step type pattern. The distance at which the Gulf Provider (or other equivalent vessel) travels ahead of the Gilavar will be determined by the measured 160 dB radius. Mitigation (i.e., power down or shut down of the airgun array) will 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. Depending upon the size of the measured 160 dB zone around the airgun array Shell may decide to use a vessel equipped with a Passive Acoustic Monitoring (PAM) system or may use a second chase boat to ensure effective monitoring of the area.

In 2007 the measured distance to the 180 dB isopleth ranged from ~2.45 km in the Chukchi Sea to ~2.2 km in the Beaufort Sea near the Sivulliq prospect. SOI decided to use an additional vessel to monitor this zone given its importance in protecting marine mammals from potential injury associated with exposure to seismic pulses. Depending upon the measured radius for the 180 dB zone in 2008 Shell may elect to use a PAM system to help monitor this area around the *Gilavar* as well.

Reporting

The results of the 2008 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 2008. 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 provide mitigation monitoring (120 dB zones) as may be required under the conditions of the IHA,
- 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

The same aerial survey design will be implemented during the summer (August) and fall (late August–October) periods, but during the summer, the survey grid will be flown twice a week, and during the fall, flights will be conducted daily. During the early summer, few cetaceans are expected to be encountered in the nearshore Alaskan Beaufort Sea where seismic surveys will be conducted (see Fig. 3 in Moore et al. 1989b but also see Moore and Clarke 1989, 1991; Moore 1992; Moore et al. 1989a, 1993, 2000; Moore and Reeves 1993; Moore and DeMaster 1997; Miller et al. 1998, 1999, 2002). Those cetaceans that are encountered are expected to be either along the coast (gray whales: Maher 1960; Rugh and Fraker 1981; Miller et al. 1999; Treacy 2000) or seaward of the continental shelf among the pack ice (bowheads: Moore et al. 1989b; Miller et al. 2002; and belugas: Moore et al. 1993; Clark et al. 1993; Miller et al. 1999) 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 (Clarke et al. 1993; Moore et al. 1993; Miller et al. 2002). 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 (Ljungblad et al. 1986a; Lowry 1993; Landino et al. 1994; Wüsig et al. 2002; Lowry et al. 2004) and their stop-overs vary in duration from a few hours to a few weeks (Koski et al. 2002). A commonly used feeding area is 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 2008 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 (Ljungblad et al.1986b; Miller et al. 1999, 2002; Monnett and Treacy 2005). 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 digital recorders 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 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 mitigation measures, as mandated by definition in the IHA (e.g. power down or shut down the airgun array) will be implemented, 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 sizes of the survey grids planned for late August–October 2008 are comparable in total length to grids flown during earlier industry surveys. The planned surveys will require up to 10 or more 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 (late August–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, a three-person survey crew will be used. Inupiat observers were trained as observers during our 2006 and 2007 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 2008 (Dr. C. Monnett, MMS, pers. comm.). In 2008 the surveys may be contracted to the National Marine Mammal Laboratory in Seattle. These surveys include the Beaufort Sea part of the SOI study area. SOI will co-ordinate with MMS/NMML to obtain access to their data, both during the field season and for use in analyses and reports.

SOI will also consult with MMS/NMML 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 2008 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/NMML 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 July/Oct. 2008. 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 Alaskan Beaufort Sea during summer (see above). Few bowhead whales are expected to be found in the shallow-water areas of the Alaskan 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 Alaskan Beaufort Sea during summer in the 1980s were generally found among the pack ice in deep offshore waters of the central Beaufort Sea (see fig. 3 in Moore and Clarke 1989) which is seaward of the continental shelf (Moore and DeMaster 1997) where seismic programs will be conducted. 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 be the same as the grid flown later in the year, but it will be flown twice a week instead of daily (Fig. 1). 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.

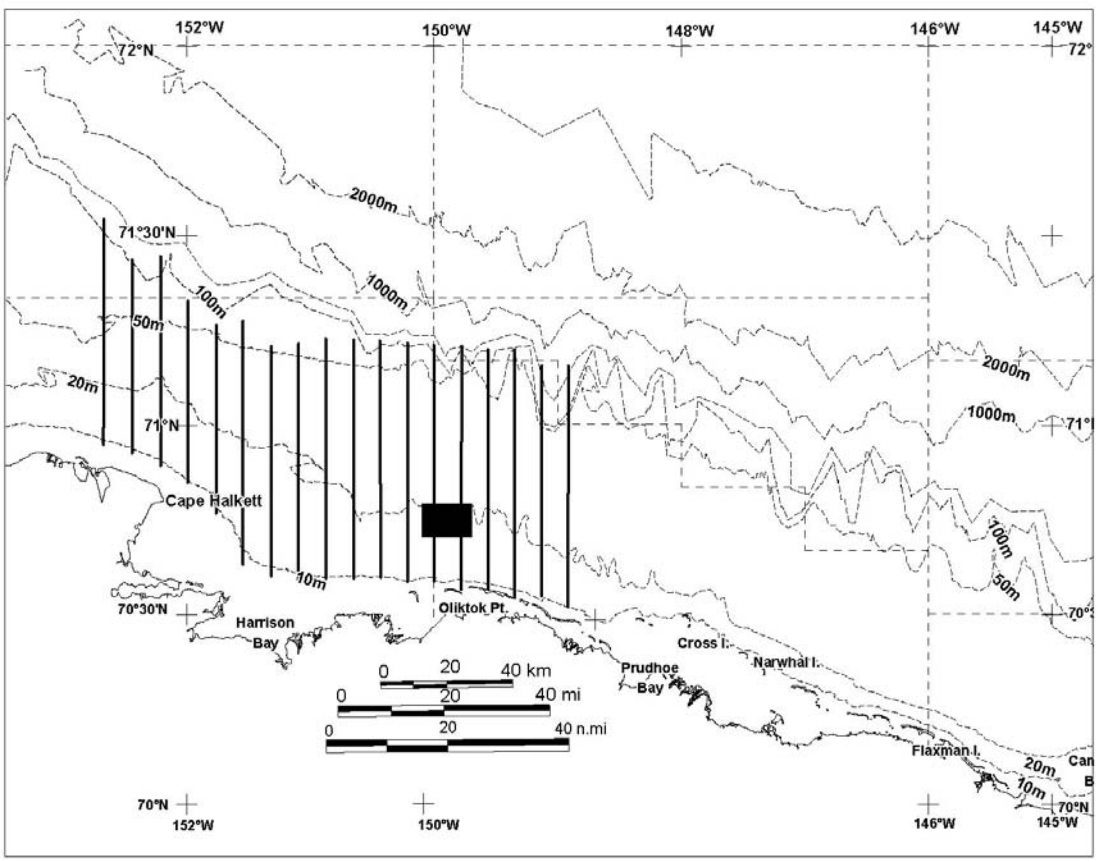

FIGURE 1. Central Alaskan Beaufort Sea showing aerial survey lines that will be flown 2 days a week during summer if seismic surveys were centered on the middle of the grid. Survey grids will be moved east or west depending on the location of the seismic surveys. See also fig. 2.

Survey Design in Beaufort Sea in Fall

Aerial surveys during the late August-October period will be designed to provide mitigation monitoring as required by the IHA. If, as in 2006 and 2007, mitigation monitoring is required 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, priority will be given to mitigation monitoring to the east of the seismic operation as shown in Figure 2. If permitted by the IHA, we are prepared to conduct some surveys of the transects shown in Figures 1 to collect data on the extent of westward deflection while still monitoring the 120 dB radius east of the seismic operation. The Figure 2 grid 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. The Figure 1 grid would obtain the same data for an area about 100 km to the west of the primary seismic vessel and about 20 km east of it and again about 65 km offshore. This site-specific survey coverage will complement the simultaneous MMS/NMML/BWASP survey coverage of the broader Beaufort Sea area.

The proposed survey grids 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 grids were developed consistent with 2006 and 2007 mitigation monitoring requirements and surveying only the Figure 2 grid would not provide information to assess the point of return from deflection. If these mitigation monitoring requirements are changed in 2008, priority will be given to assessing the area west of the seismic operations using the grid shown in Figure 1.

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 over the areas shown in Figures 1 and 2, 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 or from 100 km west to 20 km east of the seismic activities, depending on the survey grid approved as part of the IHA.

If the grid in Figure 1 is surveyed, data from the easternmost transects of the proposed grid will be too close to the seismic operation to document the main bowhead whale migration corridor east of the seismic exploration area. That information will be obtained from the surveys conducted east of the drillship or from the DSAR-Bs east of the seismic operation.

We do not propose to fly a smaller "intensive" survey grid in 2008. 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 west of the seismic activity.

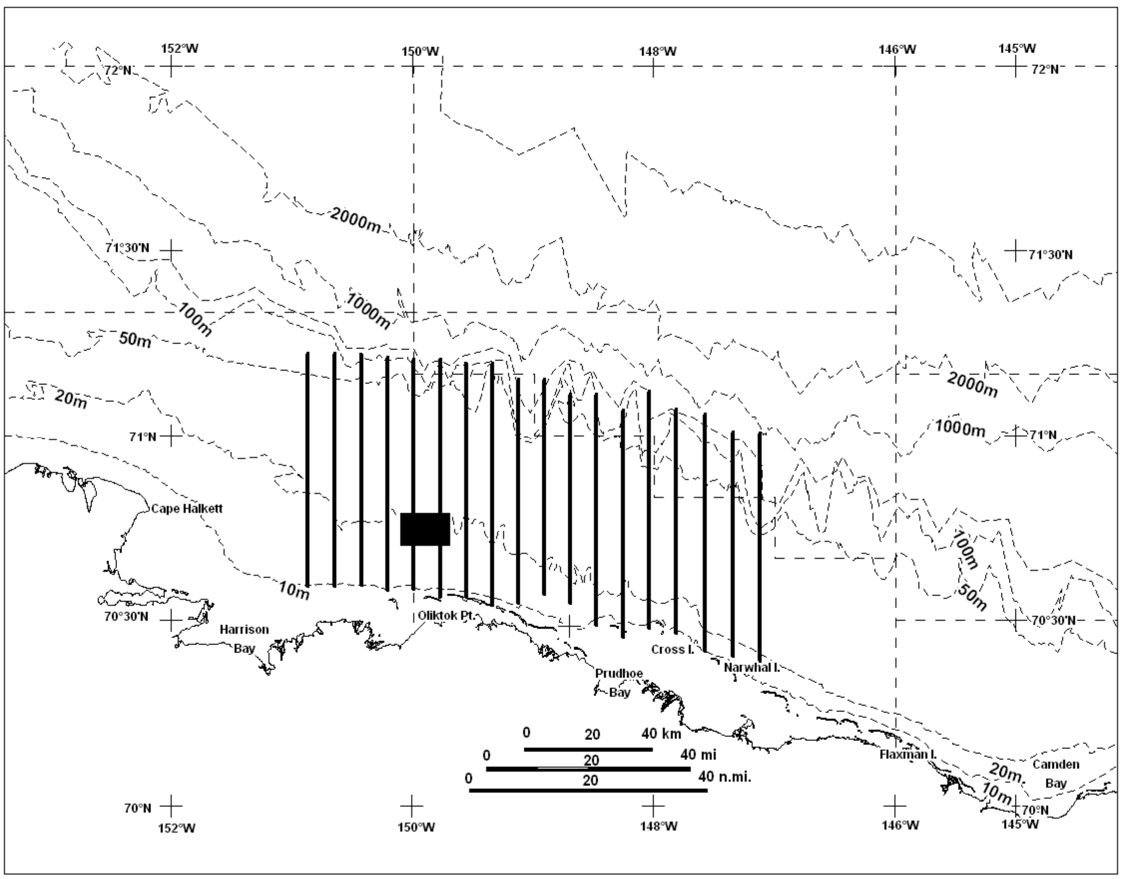

FIGURE 2. Central Alaskan Beaufort Sea showing aerial survey lines during fall if seismic surveys were conducted in the area of the back square (seismic survey area). Survey grids will be moved east or west depending on the location of the seismic surveys.

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

The same aerial survey grid is proposed for surveys being conducted during summer (July to late August) and fall (late August–October). The proposed survey grid consists of up to 18 north-south lines spaced 8 km apart and will extend to 100 km east (or west if allowed by the IHA) 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. These pre- and post-seismic surveys will provide information on the migration corridor in the absence of seismic activities. If 120 dB monitoring is required by the IHA, 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 (or easterly, depending on IHA requirements) lines will not be surveyed. This will mean that the survey lines will only extend as far west as the seismic operation or start as far east as the seismic operations. 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).

The survey 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), the number of refueling/rest stops, and the fuel capacity of the survey aircraft. The twin otters that will likely be used in 2008 can not fly as far without refueling as the Aerocommander that was used at the start of the 2006 surveys. During the early summer period, the grid would be flown over a two-day period, because a single pilot and marine mammal observer crew could not complete the survey in one day.

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 if the grid in Figure 2 is surveyed, and the grid will be flown west to east if the grid in Figure 1 is surveyed. Although the protocol for the Figure 2 grid increases difficulties associated with double counting of whales that are (predominantly) migrating westward, the main purpose of surveying that grid 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 2008 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 2008 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 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 would have done so if they had not been displaced farther offshore, will be estimate*d. If the 2008 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. 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 2008 will be determined by examining data from periods with no seismic 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 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 2008 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 2008 is a year when weather conditions were poorer than average, which would limit the periods when surveys could be conducted. The 2008 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.

ACOUSTIC MONITORING PLAN

Seismic Sound Source Verification Measurements

Background

As part of the IHA application process for similar seismic acquisition in 2006 and 2007, SOI contracted JASCO Research Ltd. to use an acoustic model to predict the distances from WesternGeco's airgun array on the SOI source vessel, the MV *Gilavar*, to broadband received levels of 190, 180, 170, 160, and 120 dB_{rms} re 1 μPa. The model accounted for airgun array characteristics and geoacoustic properties at several sites in the Chukchi to estimate 1/3-octave band and broadband sound levels in various directions from the array. The radii predicted by the model were as temporary safety radii until sound source verification measurements of the actual airgun array sound were available. The measurements were made at the beginning of the field season and the measured radii were used for the remainder of the survey period. Measured radii were found to exceed the corresponding radii predicted by the model. Later analysis showed that the reason for the difference was that the model predictions were made for a receptor at 10m depth, and the measurements were made by recorders placed on the seabed at over 40m depth. Post-season modeling, with the receptor placed at the seabed agreed well with measurements. This analysis pointed out an important characteristic of the sound field produced by seismic operations in the Chukchi: namely that the field is depth-dependent with higher levels between mid-water depth and bottom. Measurements will be performed at bottom depth in 2008 to ensure the highest levels are captured.

In 2008 SOI plans to again use the *Gilavar* as its seismic source vessel. SOI intends to make new sound source verification measurements at the start both its 2008 Chukchi Sea and Beaufort Sea surveys even though the airgun array planned for 2008 surveying operations is identical to the one used in 2006 and 2007 (WesternGeco's 3147 in^3 Bolt-Gun Array). Verification measurements will be performed on or as close as possible to the actual survey locations, with ice conditions being the limiting factor. Measurements to approximately 100 km distance in both endfire and broadside directions will be made to define the zone ensonified above 120 dB_{rms} re 1 μPa.

Objectives

The objectives of the sound source verification measurements planned for 2008 in the Chukchi and Beaufort Seas will be (1) to measure the distances in the broadside and endfire directions at which broadband received levels reach 190, 180, 170, 160, and 120 dB_{rms} re 1 μPa for the airgun array combinations that may be used during the seismic acquisition process. The configurations will include at least the full array operating and the operation of a single airgun that will be used during power downs, and (2) to measure the source levels of support vessels. The measurements of airgun array sounds will be made at the beginning of the survey and the distances to the various radii will be reported within as soon as possible after recovery of the equipment 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, nominal distances to other sound isopleths down to 120 dB_{rms} will be reported in increments of 10 dB.

Technical Approach

The seismic source verification measurement program will be designed to capture high resolution recordings of sound pressure waveforms as a function of distance and direction from the array. Measurements will be made by qualified acousticians using an array of up to six ocean bottom hydrophone (OBH) systems (Fig. 3). These systems are pop-up style recorders that are deployed on the seabed using acoustic release systems.

Figure 3. Ocean Bottom Hydrophone (OBH) system to be used for seismic sound source verification program, and for Chukchi Net Array program.

An array of six OBHs will be deployed according to the configuration shown in Figure 4, with two units placed along a survey track ahead of the vessel and four units placed at various distances to the side of the track. This arrangement is designed to capture simultaneously broadside (at right angles to tow direction) and endfire (in line with tow direction) sound levels as the survey vessel approaches, passes over, and departs from the recording locations. The OBH systems will also be used to measure noise from the seismic vessel and support (chase) vessels. Those measurements will be made by sailing the respective vessel past an OBH system while tracking the vessel location so its position relative to the OBH can be accurately determined.

In 2007, SOI measured vessel sounds from each ship used in its operations. In 2008, SOI plans to measure only the ship sounds of the Gilavar and sound source equipment. To the extent that support vessels are the same or significantly similar to those used during 2007, they will not undergo individual sound level measurement Cumulative sound input from other support vessels used in the operations in 2008 will be measured using hydrophone arrays deployed as part of the Joint Industry Studies Program in both the Chukchi and Beaufort seas. Measurements in 2007 indicated that it is possible to visually monitor the 160 dB zone around all of these vessels. SOI has used MMOs on all of the vessels in their operations since 2006 and plans to continue this in 2008. The hydrophone arrays will provide an integrated sound measurement for the entire operation which is a more important predictor of potential impacts to marine mammals from industrial noise associated with the operations than are sound measurements from individual vessels which are unlikely to change greatly from year to year.

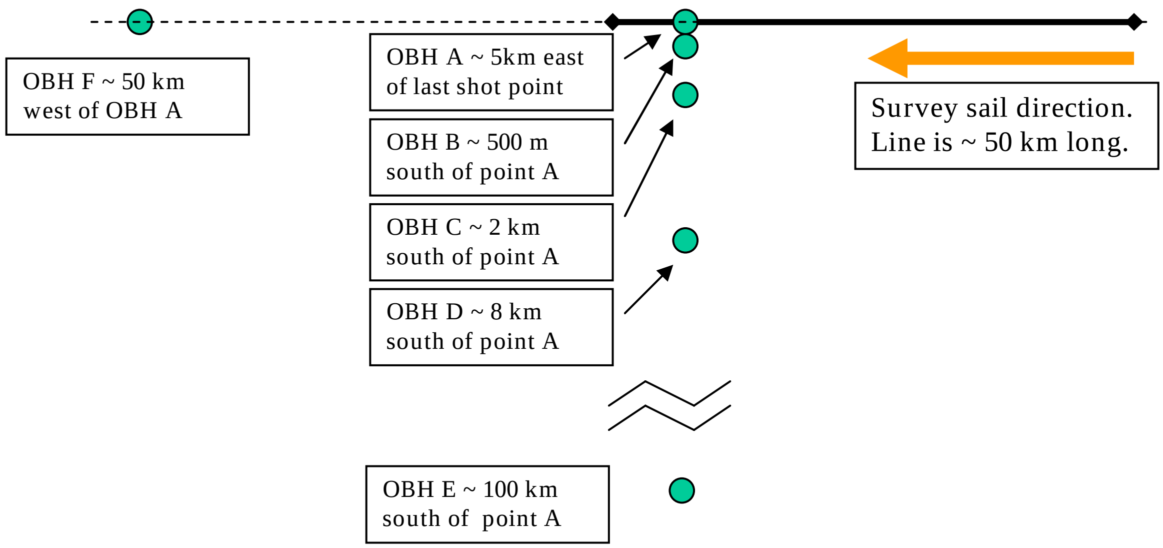

Figure 4. Airgun Array sound source verification measurement study design. Circles show Ocean Bottom Hydrophone (OBH) deployment positions. The survey vessel with operating airguns will sail west along the survey line (dashed). Airgun shooting will occur along the solid line. OBHs will be deployed south of the survey line (as shown) in the Chukchi Sea. They will be moved north of the survey line for measurements performed in the Beaufort Sea.

The OBH systems that will be used for these measurements are ideal for the water depths present over the entire survey regions. They incorporate 24-bit digital recorders using two channels with different hydrophone sensitivities to provide fully 150 dB of dynamic range (65 dB re µPa to 215 dB re µPa). Sample rate will be 48 kHz. Similar systems provided high resolution measurements during SOI's airgun array sound verification measurements at the beginning of its 2007 field season. The OBH systems are also capable of recording very low infrasonic sound frequencies associated with the seismic sounds. Those frequencies may be of importance to bowhead whales. Figure 5 shows the spectrogram of a seismic shot recorded by an OBH in the Chukchi in 2006. The spectral characteristics were captured to frequencies well below 10 Hz.

Field analysis and reporting:

Data will be previewed in the field immediately after download from the OBH instruments. An initial sound source analysis will be supplied to NMFS and the seismic operators within 120 hours of completion of the measurements, if possible. The report will indicate the distances to sound levels between 190 dB_{rms} re 1 µPa and 120 dB_{rms} re 1 µPa based on a fits of empirical transmission loss formulae to data in the endfire and broadside directions. The 120 hour report findings will be based on analysis of measurements from at least three of the OBH systems. A more detailed report including analysis of data from all OBH systems will be issued to NMFS as part of the 90 day report following completion of the seismic program.

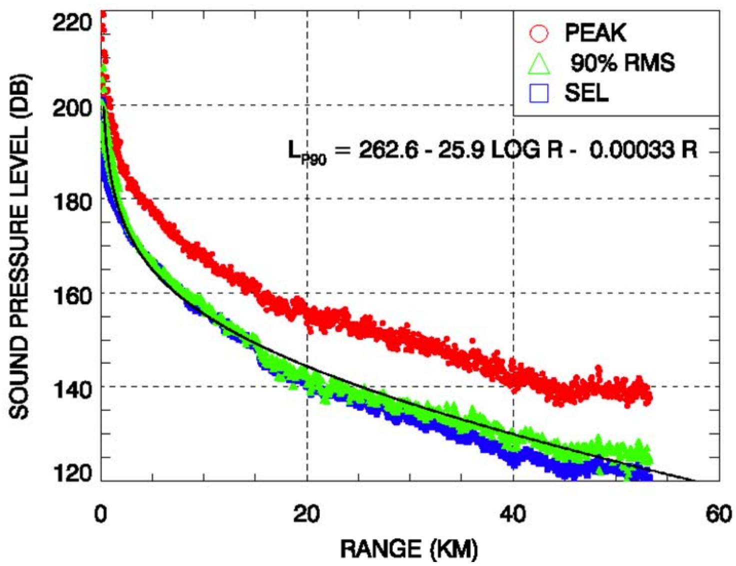

Figure 5. Airgun Array sound level measurement results including Peak, RMS and SEL metrics and empirical fit to RMS levels.

Airgun pressure waveform data from the OBH systems will be analyzed using JASCO's suite of custom signal processing software that implements the following data processing steps:

- Airgun pulses in the OBH recordings are identified using an automated detection algorithm. The algorithm also chooses the 90% energy time window for rms sound level computations.
- Waveform data is converted to units of microPascals (μPa) using the calibrated acoustic response of the OBH system. Gains for frequency-dependent hydrophone sensitivity, amplifier and digitizer are applied in this step.
- For each pulse, the distance to the airgun array is computed from GPS deployment positions of the OBH systems and the time referenced DGPS navigation logs of the survey vessel.
- The waveform data are processed to determine flat-weighted peak sound pressure level (PSPL), rms sound pressure level (SPL) and sound exposure level (SEL).
- Each airgun pulse is Fast Fourier Transformed (FFT) to obtain 1-Hz spectral power levels in 1 second steps.
- The spectral power levels are integrated in standard 1/3-octave bands to obtain band sound pressure levels (BSPL) for bands from 10 Hz to 20 kHz. M-

weighted SPL's for each airgun pulse may be computed in this step for species of interest.

The output of the above data processing steps includes listings and graphs of airgun array narrow band and broadband sound levels versus range, and spectrograms of shot waveforms at specified ranges. Of particular importance are the graphs of level versus range, that are used to compute representative radii to specific sound level thresholds.

JOINT INDUSTRY STUDIES PROGRAM

This section describes studies that were undertaken in 2006 and 2007 in the Chukchi Sea that will be continued during seismic operations in 2008. SOI plans to conduct aerial surveys consistent with the 2006 and 2007 programs along the Chukchi Sea coast. Additionally, the acoustic net array similar to the one deployed in 2007 will be used to monitor industry sounds and marine mammals along the Chukchi Sea coast. 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 2008 that will also be similar to the one used 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 and 2007 in support of SOI's summer seismic exploration. These surveys provided data on the distribution and abundance of marine mammals in nearshore waters of the Chukchi Sea. 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 plans to conduct an aerial survey program in the Chukchi Sea in 2008 that will be similar to the 2006 and 2007 programs.

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 2008. 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 to mid July and will continue until mid-November or 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 2008 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. 7). 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.

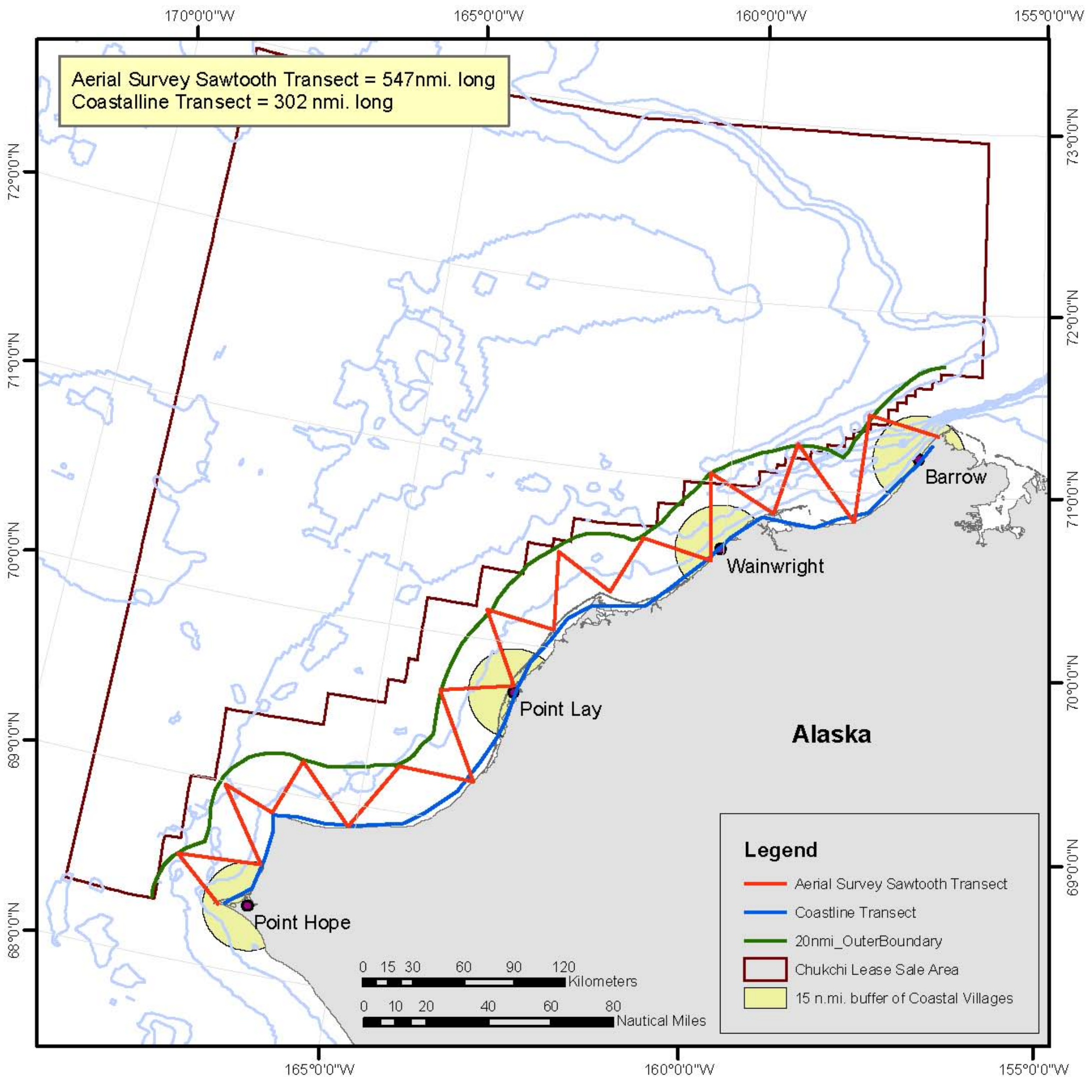

Figure 7. Aerial survey transects location and general pattern for the eastern Chukchi Sea, summer 2008. Specific transect start-/end-points will be altered randomly from survey to survey, and hunting areas will be avoided when hunting is occurring.

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 1,000 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 1,000 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. Additionally, if large groups of other marine mammals are encountered on the surveys, such as the large aggregations of walruses seen in 2007, we will attempt to photograph the animals and provide location information to interested stakeholders.

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 2008 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 in Chukchi Sea

Background and Objectives

The acoustic "net" array used during the 2007 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 to record received levels of sounds from seismic survey activities further offshore in the Chukchi Sea.

Technical Approach

The net array configuration used in 2007 is again proposed for 2008. The basic components of this effort consist of 30 OBH systems. Two separate deployments with different configurations are planned. The first deployment will occur in mid-July immediately following the beluga hunt. The deployment schedule will be adjusted to avoid any interference with the beluga hunt. The initial net array configuration will include and extend the 2006 configuration; 24 OBHs will be distributed as 6 systems at each of the four primary locations: Cape Lizborne, Point Hope, Wainwright and Barrow. The 6 OBHs will be placed at 5, 10, 15, 20, 35 and 50 nmi from shore at each location. The remaining 6 OBHs will be distributed further offshore in the central Chukchi as shown in Figure 8. These offshore systems will capture seismic exploration sounds over large distances to help characterize the sound transmission properties of larger areas of the Chukchi. The specific deployment locations along the coast may be slightly modified to attempt to answer specific questions about the movement of belugas following the July hunt. Ice conditions may also preclude deployments at all locations, in which case we will attempt to deploy as closely as possible to the planned locations.

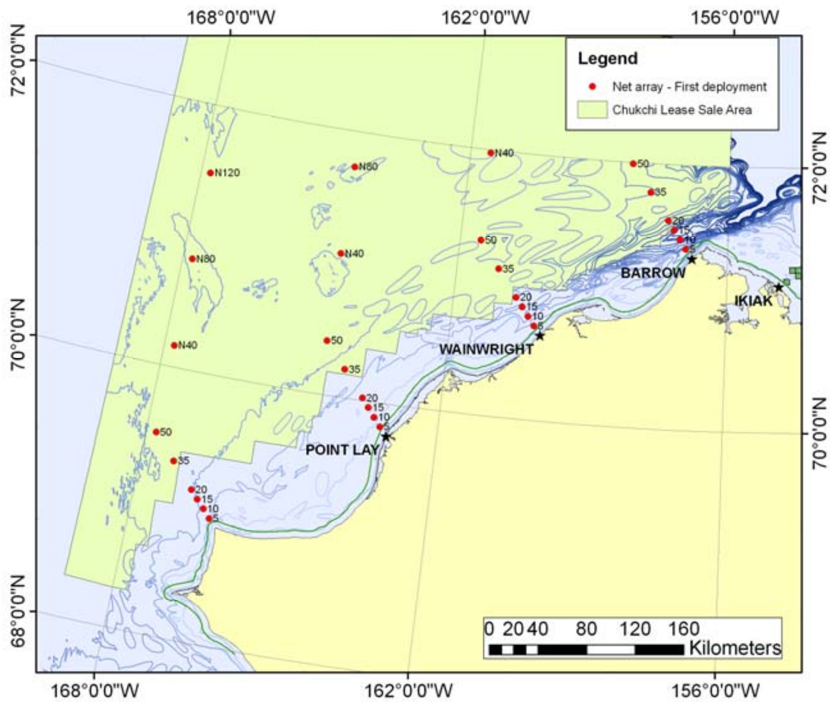

Figure 8. First deployment locations of OBHs in acoustic net array along the coast of the eastern Chukchi Sea, Alaska 2008.

The second deployment will occur in late August at the same time that all presently deployed systems are recovered for battery replacement and data extraction. Servicing will be performed at sea so that redeployments can be done as quickly as possible. The second deployment configuration is shown in Figure 9. This configuration emphasizes the offshore coverage out to 72 degrees North, which is approximately 80 nmi north of Wainwright, 150 nmi North of Point Lay, and 180 nmi north of Cape Lizborne. The primary goal of extending the arrays further offshore later in the season is to obtain greater coverage of the central Chukchi Sea to detect vocalizations from migrating bowheads starting in September. The planned configuration has offshore OBH's nominally separated by 20 nmi which should permit some vocalizations to be detected simultaneously on two or three OBHs. Localization of these calls by analysis of arrival time differences between OBHs will be attempted if calls can be simultaneously detected. Rough localizations can be performed even without simultaneous detections. These localizations will be based on amplitude of vocalizations and their frequency dispersion characteristics.

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. Timing of deployment and final positions will be subject to weather and ice conditions, and based on consultation with local villages. The program will be carried out to minimize any interference with subsistence hunting or fishing activities.

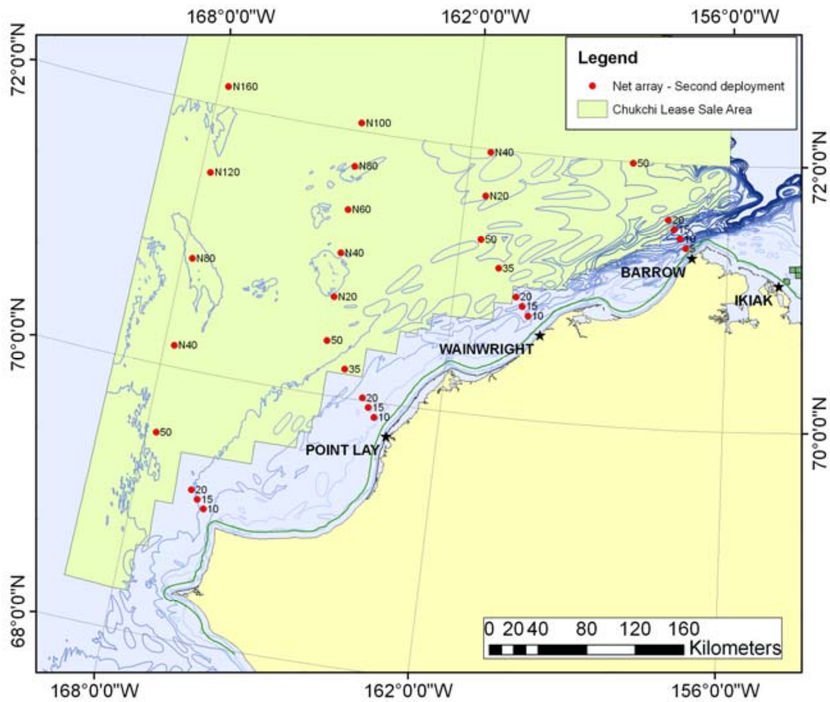

Figure 9. Second deployment locations of OBHs in acoustic net array along the coast of the eastern Chukchi Sea, Alaska 2008.

Additionally, a set of 4 to 6 OBH systems will be deployed near the end of the season to collect data throughout the winter. The precise locations of these recorders will be determined in consultation with stakeholders, but will be positioned to provide data on the use of areas by marine mammals in and around the SOI prospects in the Chukchi Sea. Recorders will be set to collect data intermittently. The duty cycle will be established to collect as much data as possible as often as possible for the prescribed time period (approximately mid-October 2008 through early to mid July 2009).

Field analysis and reporting:

The Chukchi Net Arrays of 30 OBH recorders, deployed for up to 3 months, will produce an extremely large dataset comprising several Terabytes of acoustic data. The analyses of these data require identification of marine mammal vocalizations. Because of the very large amount of data to be processed, the analyses methods will incorporate the automated vocalization detection algorithms developed at Scripps Institute of Oceanography. Scripps personnel have been assigned to assist in application of these algorithms for this analysis. While the OBHs used in the net array are not directional, and therefore not capable of accurate localization of detections, the number of vocalizations detected on each of the sensors will provide good measurement of the relative spatial density distribution of various marine mammals. These results will therefore provide information such as timing of migrations and routes of migration for belugas and bowheads. There is possibility that simultaneous vocalization detections on multiple OBHs can be used to more accurately localize these calls. This possibility will be investigated using the 2008 acoustic measurement results.

A second purpose of the Chukchi net array is to monitor the amplitude of seismic survey sounds reaching the near-shore region from seismic surveys performed further offshore. It is expected that sounds from seismic surveys performed in most parts of the Chukchi will be detectable on all OBH systems when ambient noise conditions are low. The seismic sound levels at OBH locations will be quantified and reported.

Acoustic Study of Bowhead Deflections in Beaufort Sea

In addition to the continuation of the acoustic net array program in the Chukchi Sea in 2008, SOI will also continue a program that deployed directional acoustic recording systems in the Beaufort Sea that uses. The purpose of the array is to further understand, define, and document sound characteristics and propagation resulting from offshore seismic and other industry 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 supplementary methods 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. The combined use of acoustic and aerial survey methods will provide information about these issues.

Objective

The objective of this study element is to provide information on bowhead migration paths along the Alaskan coast, particularly with respect to industrial operations and whether and to what extent there is deflection due to industrial sound levels. Using passive acoustics with directional autonomous recorders, the locations of calling whales will be observed for a six- to ten-week continuous monitoring period at five coastal sites (subject to favorable ice and weather conditions). Essential to achieving this objective is the continuous record of the positions of the 3-D seismic survey vessel during whale migration.

An example of the whale call locations measured from a pair of DASARs about 25 km (15 mi)NNE of Cross Island in 2006 is presented in Figure 10 (Greene et al. 2007). The element spacing was 5 km oriented east-west and the water depth was 37 m (122 ft).

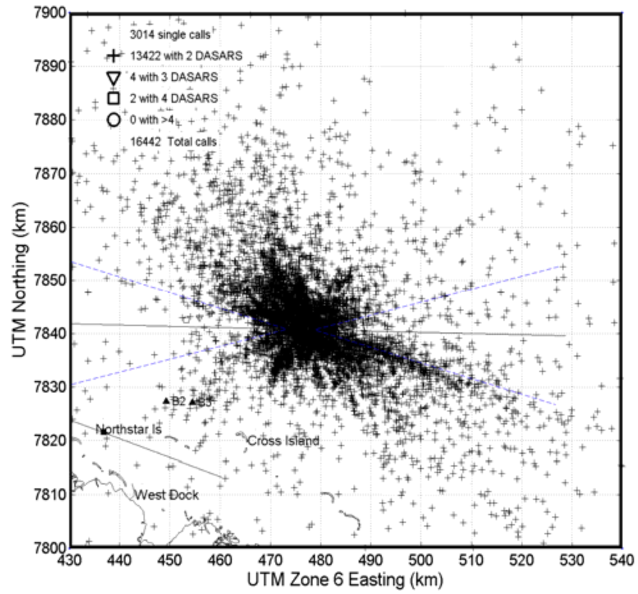

Figure 10. Bowhead whale call locations determined from the received bearings at a pair of DASARs 25 km NNE of Cross Island. The pair spacing was 5 km. There were 13,422 locations determined for the period from 12 September to 1 October.

Monitoring Plan

Greeneridge plans to conduct the whale migration monitoring using the passive acoustics techniques developed and used successfully since 2001 for monitoring the migration past BP's Northstar production island northwest of Prudhoe Bay. Those techniques involve using directional autonomous seafloor acoustic recorders (DASARs) to measure the arrival angles of bowhead calls at known locations, then triangulating to locate the calling whale. Thousands, in some years tens of thousands, of whale calls have been located each year since 2001. The 2008 study will use a new model of the DASAR similar to those deployed in 2007.

In attempting to assess the responses of bowhead whales to the planned industrial operations, it will be essential to monitor whale locations at sites both near and far from industry. Shell plans to monitor at five sites along the Alaskan Beaufort Sea coast as shown in Figure 11. The eastern-most site (#5 in fig.11) will be just east of Kaktovik and the western-most site (#1) will be in the vicinity of Harrison Bay. Site 4 will be 15 km (9.3 mi) east of the Sivulliq drilling area and site 3 will be 20 km (12.4 mi) west of Sivulliq. These five sites should provide information on possible migration deflection well in advance of whales encountering an industry operation and on "recovery" after passing such operations.

The proposed geometry of DASARs at each site is to use seven DASARs oriented in a north-south pattern so that five equilateral triangles with 7-km element spacing is achieved. This geometry is illustrated in Figure 11. Five kilometer spacing has been used successfully in the migration studies at Northstar, but whale calls are received reliably at greater spacing and the 7 km spacing will result in greater coverage of whales along the north-south dimension, important in studying possible offshore deflection.

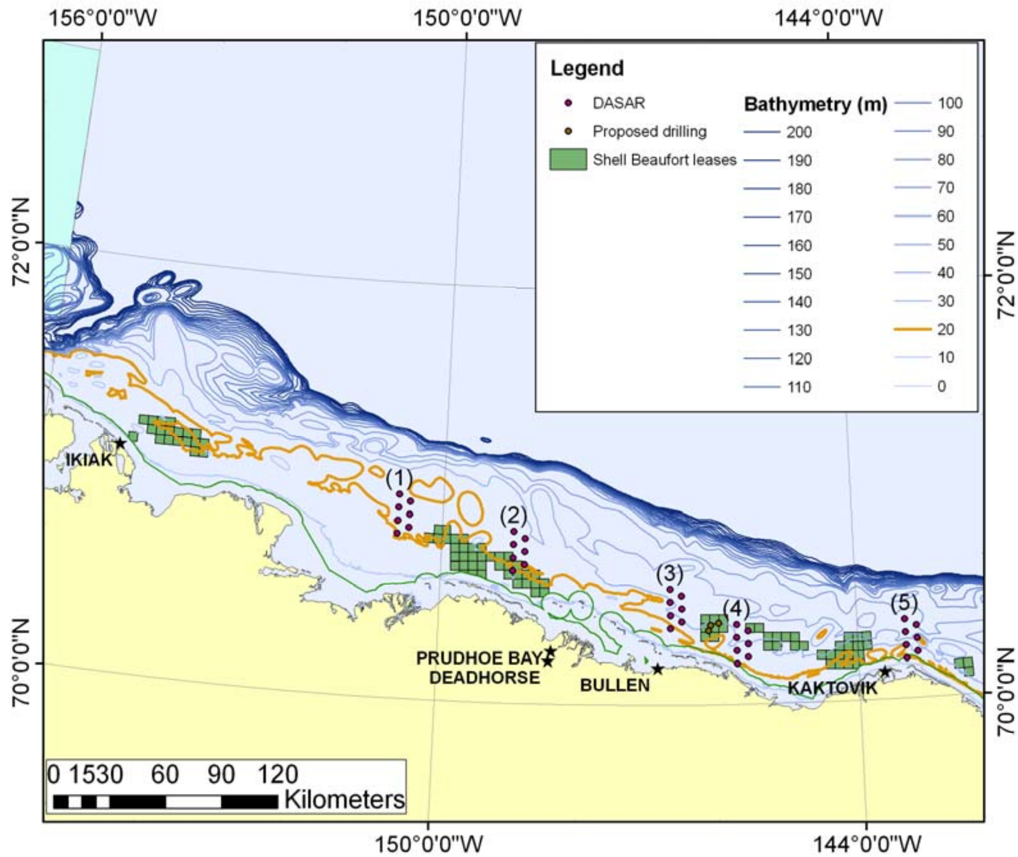

Figure 11: The Alaskan Beaufort Sea coast showing DASAR site locations for whale call location studies. The DASAR array locations at the five sites are shown to scale, with seven DASARs forming five equilateral triangles with a unit spacing of 7 km and a north-south extent of 21 km to aid being able to observe possible offshore deflection.

DASARs are installed at locations marked by GPS. However, each DASAR's orientation is unknown and must be determined to know how to reference the call angles measured to the whales. That is, where is true north relative to the DASAR orientation? Also, the internal clocks used to sample the acoustic data drifts slightly but linearly by an amount that can amount to a few seconds after six weeks of autonomous operation. Knowing the time differences within a second or two between DASARs is essential for identifying calls common on different DASARs. Solving these two problems is accomplished by transmitting known sounds at known times from known locations (by GPS) at six points around each DASAR at the beginning and at the end of the operational period. (We also propose a mid-season calibration.) Because of the equilateral triangular geometry, it requires 25 transmission stations for each site. Each set of transmissions requires less than half a minute. For the 5-km spacing, experience has been that it requires an hour to do 4 calibration transmissions, including transit. For our planned 7-km spacing, we estimate three calibration transmissions per hour. With 25 to do at each site, calibration of a site will require 8.3 hours.

These transmissions are made using a model J-9 sound projector. The J-9 is a small projector easily deployed and retrieved by a single person on deck. Maximum source level is only 150 dB re 1µPa at 1 m. The received level at distance 100 m will be on the order of 110 dB, a level less than any known to cause disturbance to marine life.

The DASAR installation configuration includes a small (5 lb) Danforth anchor and 5 ft of chain attached to a stretched-out 100-m tag line attached to the DASAR. GPS locations are marked for the anchor and the DASAR. For retrieval, two grapnel anchors attached by a 20-ft chain with a heavy shackle (~40 lbs for weight, to assure the grapnel anchors will be on the bottom) are deployed at one side of the tag line, then dragged over the line to snag it for retrieval. This scheme has worked reliably with all the DASARs installed at Northstar since 2000 without loss, as well as with the four DASARs installed for Shell in 2006 and for the full complement of arrays installed in 2007 .

Bowhead migration begins in late August with the whales moving westward from their feeding sites in the Canadian Beaufort Sea. It continues through September and well into October. However, because of the drilling schedule, we will attempt to install the 21 DASARs at three sites (3, 4 and 5 in Figure 11) in early August. The remaining 14 DASARs will be installed at sites 1 and 2 in late August. Thus, we propose to be monitoring for whale calls from before 15 August until sometime before the 15th of October, after which date few whales typically remain and ice formation becomes a threat to marine operations.

At the end of the season the 4th DASAR in each array will be refurbished, recalibrated, and redeployed to collect data through the winter. The other DASARs in the arrays will be recovered. The redeployed DASARs will be programmed to record 35 minutes every three hours with a disk capacity of 10 months at that recording rate. This should be ample space to allow over-wintering from ~mid-October 2008 through mid-July 2009.

Whale call analysis for the Northstar DASARs has been a manual process in which analysts observe acoustic spectrograms in one-minute periods, looking for patterns caused by a whale call. Listening to the sound, the analyst verifies that a sound is or is not a whale call, and when it is, the bearing is calculated and stored for localization if the same call is present at one or more other DASARs in an array. In the proposed 2008 project, machine-aided call detection software will be used to simplify and accelerate the call analysis. Such software was developed with Shell's sponsorship in 2006 and is described by A. Thode in Greene et al. (2007).

When the call locations have been assessed for accuracy, the locations must be analyzed for evidence of migration deflection. However, one must assess what might be "normal" migration, known to vary from year to year as a consequence of factors that are difficult to quantify. Array pairs east and west of industrial activities will be used to compare offshore distances prior to and after whales pass through areas exposed to varying levels of anthropogenic sound. All DASAR arrays, and potentially those deployed for other studies (i.e., those supporting BP's studies of migration past its Northstar development), could be used to quantify density contours of the bowhead whale migration corridor. This estimation of the migration corridor would amount to an unprecedented quantification of the whale migration corridor in terms of the extent of the coastline covered and the amount of data included.

Many interesting analyses will be available from the data collected by our five array sites. We discuss only two that assess whether whales are being displaced farther offshore during periods of high industrial sound production.

One analysis will estimate the location of the migration corridor across the extent of our study area. The migration corridor will be estimated by contours for the distribution of whale locations along the coast from array #1 to array #5. Density contours will be estimated using kernel density estimation (Silverman 1998). To be included in this analysis, call precision must be high, or alternatively, calls will be inversely weighted according to the size of their error ellipse. Because we anticipate that calls occurring between arrays will have very low precision, the variance of density estimates in these areas will be high. If the migration corridor is generally close to shore at arrays #5 and #4, but far offshore at the locations of array #3, #2, and #1, we might infer an offshore displacement of the corridor near the proposed drilling activity. Likewise, if the migration corridor appears to follow the coastline from the locations of array #2 through #5, but deviates offshore at #1, we might infer an offshore displacement of the corridor near the proposed seismic activity. We plan to use block bootstrapping (Lahiri 2003) of raw data to assess variation in contours when appropriate. Block bootstrapping accounts for potential autocorrelation among locations collected during short time intervals. We note that this analysis does not depend on quantification of underwater industrial sounds emanating from seismic or drilling operations.

A second analysis we will use to assess deflection will relate changes in offshore distribution to changes in industrial sound levels. These analyses are predicated on the assumption that industrial sound levels will vary from below background to substantially above background throughout the season, and that reliable measurements of industrial sound at the source are available. Assuming source levels vary substantially throughout the season, this analysis will use periods of low industrial sound as "reference" periods, and relate shifts in the offshore distribution to increased levels of sound using regression or quantile regression analysis (Koenker and Park 1996; Koenker and Geling 2001; Koenker and Xiao 2002).

To illustrate our second analysis, consider DASAR sites #4 and #3 in Figure 11. Over a standard reporting period, for example 6 hours, we will collect calls located by these two arrays, as well as other environmental covariates such as water depth, ambient sound levels, time of day, etc. From these data, we will calculate summary statistics for offshore distribution, and all covariates of interest. For example, we may calculate the 25th percentile of offshore distance, and the average water depth of all call locations in the 6 hour reporting period. Differences in offshore summary statistics between arrays will then be calculated and used in a regression or quantile regression analysis. For example, the difference in 25th percentile of offshore distance between array #4 and array #3 could be related to the average industrial sound level output by the source. Assuming displacement occurs somewhere between arrays #4 and #3, we would expect a constant difference in the 25th percentile of offshore distance when sound levels are low, and larger differences in offshore distance when industrial sound levels increase. A significant slope of the regression relating offshore distance difference to sound levels will indicate significant displacement between the arrays in question. This type of analysis can be run using any pair of DASAR arrays (e.g., between #5 and #3 or between #4 and #1, etc.).

Analysis assumptions:

- We assume that changes in the offshore distribution of call locations reflect either changes in whale locations or changes in calling behavior.
- We assume that industrial sound levels will vary substantially throughout the season. "Substantial" means by a level that is both detectable and important to bowhead whales. In other words, extended periods of both low and high sound production need to be present.
- Industrial sound levels surrounding the seismic and drilling sources need to be accurately quantified at varying distances in such a way that we can temporally match industrial sound levels and whale locations. We assume that an accurate propagation model for industrial sounds can be constructed from the collected data.
- A large number of whales will swim through the areas where our arrays can reliably locate their calls.

Tasks

The bowhead migration path study includes the following tasks:

1. Test and prepare the DASARs for deployment.
2. Sail to two early-deployment sites and install seven DASARs and project calibration sounds.
3. Repeat step 2 in late August for 14 DASARs at sites 1 and 2.
4. Mid-season, around 1-20 September, conduct another set of calibration transmissions at each of the first three sites (3, 4, and 5).
5. Retrieve the 21 DASARs from sites 3, 4, and 5, replace batteries in the 21 DASARs, install new data-storage disks, re-install, and conduct calibration transmissions for those three sites.
6. As soon a good operating weather is available on or after 1 October, conduct final calibration transmissions and retrieve all 35 installed DASARs.
7. Redeploy and calibrate one DASAR (th 4th one in each line) in each line for over-wintering.
8. Convert raw DASAR data into multi-channel WAV format for automated analysis.
9. Obtain sound level histories for the drillsites and the seismic and shallow hazard survey vessel location histories for use in conducting the deflection analyses.
10. Analyze all calibration transmission data to determine clock correction functions and DASAR reference axis directions.

11. Analyze the omnidirectional hydrophone data from each DASAR to determine percentile distributions for narrowband and one-third octave band level statistics.
12. Analyze whale calls for directions, call type, and source location.
13. Conduct the statistical deflection analyses.
14. Prepare preliminary technical (90-day) report.
15. Prepare deflection analysis section (acoustics study) for comprehensive report.

Description of Directional Autonomous Seafloor Acoustic Recorder (DASAR)

The key requirements for Greeneridge's new DASAR design were for a low profile to resist motion in water currents and a new directional sensor. The housing is 9" high and 18" in diameter with the sensor suspended elastically about 5" above. A latex "sock" stretched over a tubular frame protects the sensor from water currents. The housing is secured to a weighted square frame 30" on a side. The in-air weight is 115 lb and the in-water weight is 40 lb.

The concept for the new sensor is to use three-axis geophone elements for the directional sensors and a flexural pressure transducer for the omni-directional sensor (necessary to resolve the directional ambiguities from the geophone response patterns). Using a geophone element with a 28-Hz resonant frequency, critical damping, and spurious frequency response behavior at frequencies >500 Hz resulted in a frequency response essentially flat from about 20 Hz to 500 Hz, the range within which most bowhead calls occur. The vector sensor so constructed is ideally suited for this application where low-power consumption is imperative.

DASARs are designed to be installed on the bottom with no surface expression, important to avoid entanglement with ice floes. A small Danforth anchor and chain is attached to a 100 m "tag line" of ground rope that is stretched out during deployment and attached to a corner of the frame. By noting the GPS coordinates of the Danforth anchor and the DASAR, it is straightforward to retrieve everything by using grapnel anchors and chain dragged over the center of the tag line. With an average of 11 DASARs deployed every year 2000-2004 and seven deployed during the two years 2005-2006 (almost 80 units) in BP's Northstar project, every unit has been retrieved. (Water depths range from 20 to 25 m, but similar retrievals have been effective in water 50 m deep.)

The four data channels in each sensor (two horizontal, one vertical, and one omni) are sampled at 1000 samples/sec, 16-bits/sample. That sample rate supports a data bandwidth of 450 Hz, allowing for anti-aliasing. The samples are buffered, then written to an internal hard drive. A 40 GB hard drive will store the data from 60 days' continuous operation.

Figure 12 illustrates the DASAR assembly configuration. Figure 13 is a top-view photograph of a DASAR on the deck of *M.V. Henry Cristoffersen* after retrieval. One of the grapnel anchors with chain is in the picture. Figure 14 is the calibrated pattern of the two directional sensors in the new DASAR.

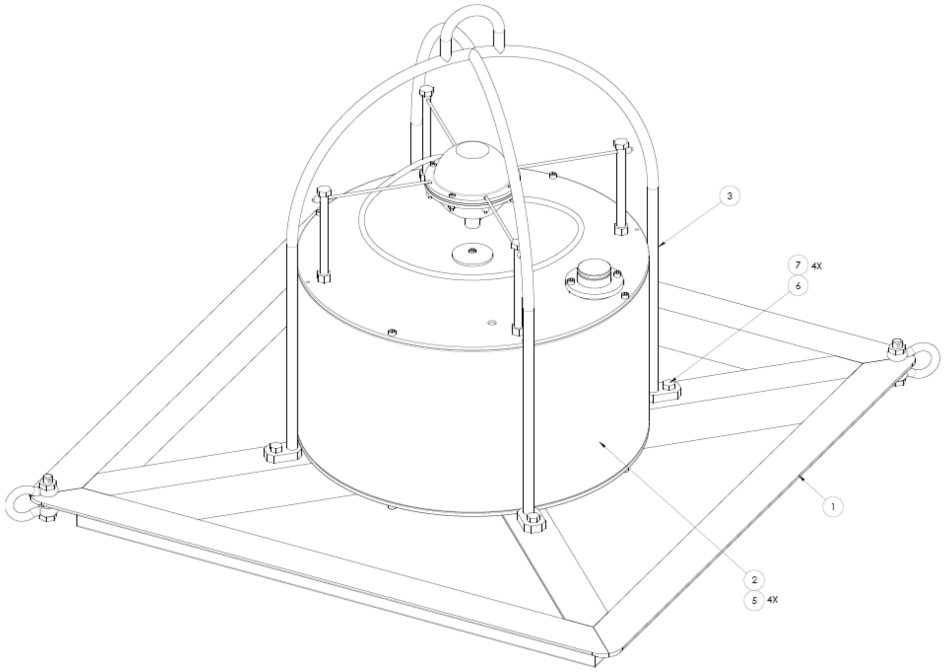

Figure 12: The assembly drawing for the DASARb. The small loop at the top is for the lowering line. The sensor is directly beneath the small loop and over the housing. The loop coming from the back-left of the sensor and disappearing beyond the sensor on the housing top is the tube with the electrical signal wires. The sensor is attached by four elastic strings to four vertical posts. The "knob" drawn on the right side of the housing holds the transponder transducer. A shackle on the left or right side of the frame is for attaching the tag line.

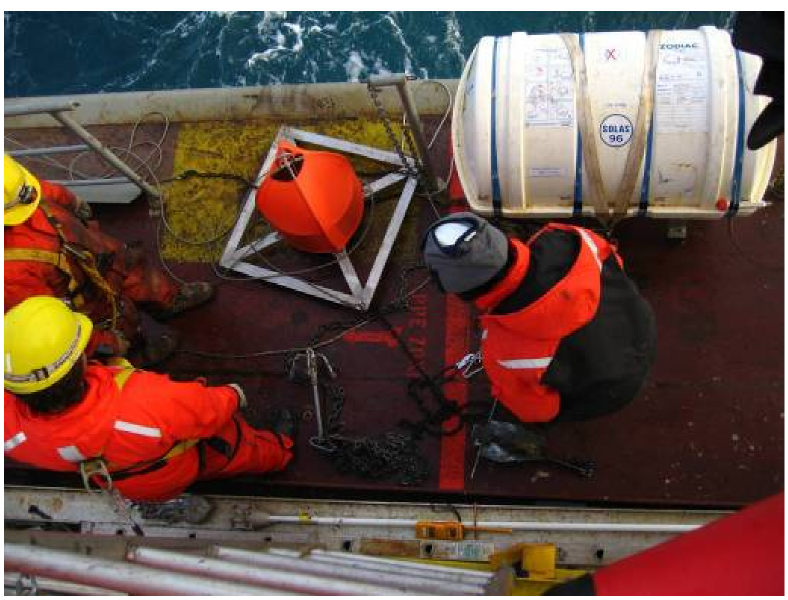

Figure 13: Photograph of a DASARb on deck after retrieval. Note the latex sock over the frame and a grapnel anchor and chain on the deck.

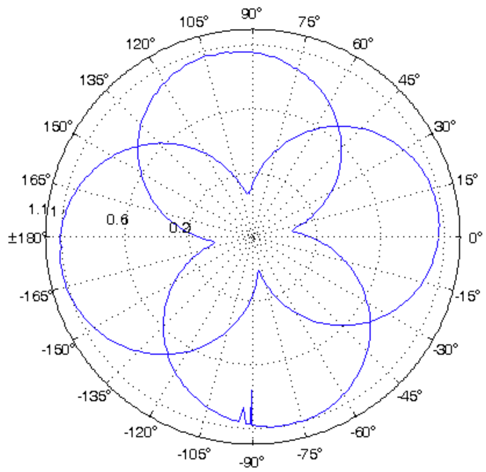

Figure 14: Azimuthal calibration responses of the two horizontal directional sensors. Note that the calibration setup was not aligned with the sensors' main response axes and that averaging filled in the response nulls. The notch near -90° is from the calibration facility instrumentation.

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

Following the 2008 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 and Beaufort Seas during 2008. The report will help to establish long term data sets that can assist with the evaluation of changes in the Chukchi and Beaufort sea ecosystems. The report 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 and allow integration of the data sets over a period years. Data protocols for the seismic operations will be similar to those used in 2006 and 2007 to facilitate this integration.

Cumulative effects of SOIs activities will be evaluated to the extent possible, but 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 and Beaufort Seas. Data will be presented and discussed at a workshop on cumulative effects associated with offshore activities if a workshop can be organized. 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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