MARINE MAMMAL MONITORING AND MITIGATION PLAN

for

Marine Seismic Surveys in the Arctic Ocean, 2012

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February 2012

Revised June 2012

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Introduction

Ion Geophysical (Ion) plans to conduct a geophysical (seismic reflection/refraction) survey and related vessel operations in the Alaskan Beaufort and Chukchi seas from October–December 2012. The primary survey area extends from the U.S.–Canadian border in the east to Point Barrow in the west. Two survey lines extend west of Point Barrow into the northern Chukchi Sea and three short tie lines are proposed near the U.S.–Russian border (Fig. 1). The bathymetry of the proposed survey area ranges from shallow (~20 m) to relatively deep (>3500 m) water over the continental shelf, the continental slope, and the abyssal plain.

The survey will be conducted from the seismic vessel *Geo Arctic* escorted by the *Polar Prince*, a medium class (100A) icebreaker. The survey grid consists of ~7175 km of transect line, not including transits when the airguns are not operating. There may be small amounts of additional seismic operations associated with airgun testing, start up, and repeat coverage of any areas where initial data quality is sub-standard. The seismic source towed by the *Geo Arctic* will be an airgun array consisting of 26 active Sercel G-gun airguns with a total volume of 4450 in^3. A single hydrophone streamer 4.5–9 km in length, depending on ice conditions, will be towed by the *Geo Arctic* to record the returning seismic signals.

The survey vessels will access the survey area from Canadian waters in late September to begin data collection on or after 1 October. After completion of the survey, or when ice and weather conditions dictate, the vessels will exit to the south transiting through the Chukchi and Bering seas. The *Polar Prince* may be used to perform an at-sea refueling (bunkering) operation to supply as much as 500 metric tons of Arctic diesel to the *Geo Arctic*. The *Polar Prince* will carry that fuel onboard at the start of the operation and it would be transferred to the *Geo Arctic* if/when necessary. Depending on its own fuel consumption, the *Polar Prince* may then transit to Tuktoyuktuk, Canada to take on additional fuel for itself. Once the *Polar Prince* returns to the Geo Arctic the survey would continue. The entire refueling operation would therefore involve one fuel transfer and *potentially* one transit to and from Tuktoyuktuk. The refueling operation would likely take place in late October, at which time the *Geo Arctic* would likely be in the eastern or east-central Alaskan Beaufort Sea.

Ion's geophysical survey has been designed and scheduled to minimize potential effects to marine mammals, particularly bowhead whales. For mitigation and operational reasons the survey area has been bisected by a line that runs from 70.5° N, 150.5° W to 73° N, 148° W (Fig. 1). Weather and ice permitting, Ion plans to begin survey operations east of the line described above (eastern survey area; Fig. 1) in offshore waters (>1000 m) where bowheads are expected to be least abundant in early October. This operational plan is based on the fact that only ~2% of bowhead whales observed by MMS aerial surveys 1979–2007 occurred in areas of water depth >1000 m (MMS 2010), and on average ~97% of bowheads have passed through the eastern U.S. Beaufort Sea by 15 Oct (Miller et al 2002). The survey will then progress to shallower waters in the eastern survey area before moving to the west survey area (Fig. 1) in late October or early November.

The Marine Mammal Monitoring and Mitigation Program (4MP) developed for Ion's geophysical survey is designed to protect the marine mammal resources in the area, fulfill reporting obligations to the National Marine Fisheries Service (NMFS), the U.S. Fish and Wildlife Service (USFWS), and the Bureau of Ocean Energy Management (BOEM), and establish a means for gathering additional data on marine mammals for future operations planning.

Ion's 4MP is a combination of active monitoring of the area of operations and the implementation of mitigation measures designed to minimize project impacts to marine resources. If marine mammals are observed within or about to enter specific safety radii around the proposed survey activities, mitigation

will be initiated by vessel-based marine mammal observers (MMOs). The size of the 180 and 190 dB re 1 µPa (rms) safety radii were modeled and are described below in the section *Mitigation Measures during Survey Activities.* These radii will be used to initiate any necessary mitigation during initial survey activities at which time an acoustics contractor will measure underwater sound propagation from the airguns to empirically determine the size of the safety radii. These measured radii will be used for mitigation purposes as soon as they become available. An initial sound source analysis will be supplied to NMFS, USFWS, and the seismic survey operators within 120 hours of completion of the measurements. A more detailed report describing the sounds produced by the airguns will be provided to NMFS and USFWS as part of the 90-day report following the end of the survey. In the event that ice and/or weather conditions do not permit sound source measurements to be conducted, results of a sound speed profile measurement will be used to update sound propagation modeling of the source array.

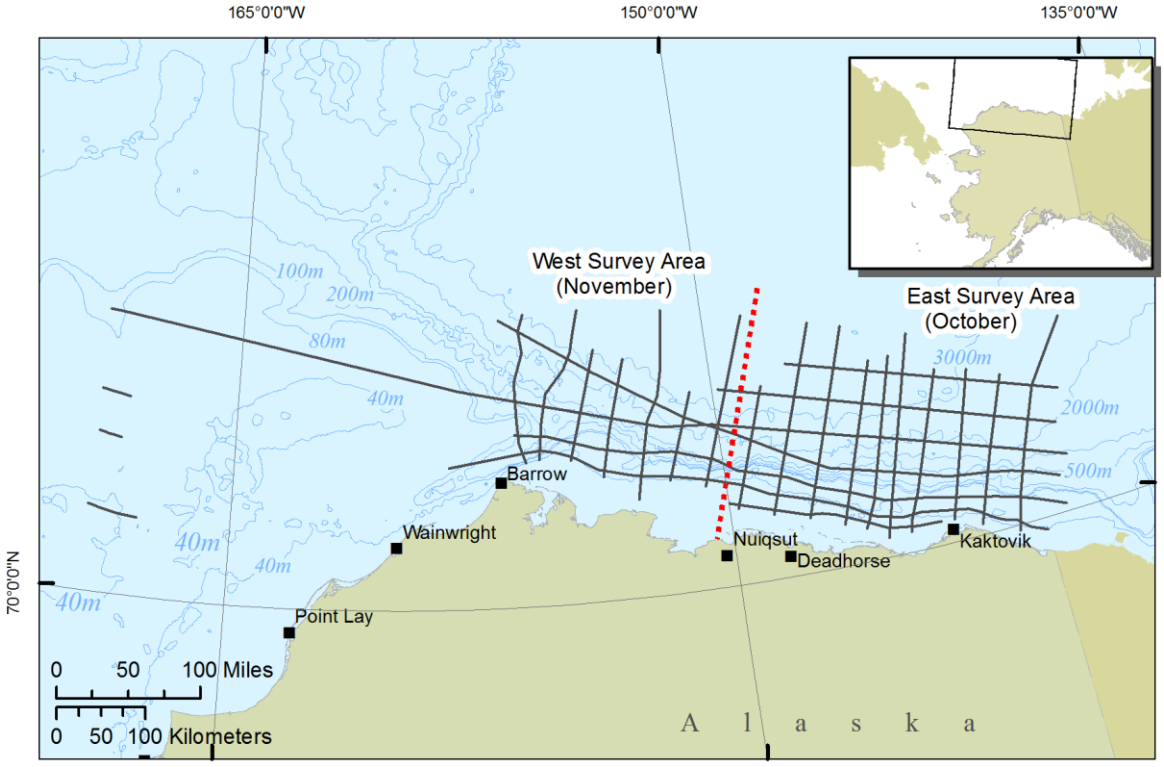

Figure 1. Proposed seismic survey lines for Ion 2D seismic survey, Oct–Dec 2012. The red dashed line indicates the division between the "east survey area" and the "west survey area".

Visual monitoring by MMOs during airgun activity and periods when airguns are not active will provide information on the numbers of marine mammals potentially affected by the survey activities and facilitate real time mitigation to prevent impacts to marine mammals by industrial sounds or activities. Vessel-based MMOs onboard the survey vessel and icebreaker will record the numbers and species of marine mammals observed in the area and any observable reaction of marine mammals to the survey activities.

Vessel-Based Marine Mammal Monitoring Program

Introduction

The vessel-based operations of Ion's 4MP are designed to meet the requirements of Incidental Harassment Authorization (IHA) and Letter of Authorization (LOA) permits issued by NMFS and USFWS, respectively, and to meet any other stipulation agreements between Ion and other agencies or groups. The objectives of the program will be:

- to ensure that disturbance to marine mammals and subsistence hunts is minimized and all permit stipulations are followed,
- to document the effects of the proposed survey activities on marine mammals, and
- to collect baseline data on the occurrence and distribution of marine mammals in the study area.

The 4MP will be implemented by a team of experienced MMOs. MMOs will be stationed aboard the survey vessel and icebreaker through the duration of the seismic survey. Reporting of the results of the vessel-based monitoring program will include the estimation of the number of "takes" as stipulated in the IHA and LOA.

The vessel-based portion of Ion's 4MP will be required to support the survey activities in the Beaufort Sea. The survey dates and specific operating areas will depend upon ice and weather conditions, along with Ion's arrangements with agencies and stakeholders. Survey activities are expected to occur from October through December, 2012.

The vessel-based observations will provide:

- the basis for real-time mitigation, if necessary, as required by the various permits that Ion receives,
- information needed to estimate the number of "takes" 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 survey program is conducted,
- information to compare the distances, distributions, behavior, and movements of marine mammals relative to the survey vessel at times with and without airgun activity, and
- a communication channel to coastal communities including Inupiat whalers.

The 4MP will be implemented consistent with other monitoring programs conducted during seismic surveys in the Arctic and with any alternative requirements that may be specified in the NMFS IHA and USFWS LOA for this project. Any other agreements between Ion and agencies or groups such as BOEM, the North Slope Borough (NSB), or the Alaska Eskimo Whaling Commission (AEWC) will also be fully incorporated. All MMOs will be provided training prior to deployment, as described below.

Mitigation Measures during Survey Activities

Ion's planned seismic survey program incorporates both design features and operational procedures for minimizing potential impacts on marine mammals and on subsistence hunts. The design features and operational procedures have been described in the IHA and LOA applications submitted to NMFS and USFWS, respectively and are summarized below. Survey design features include:

- scheduling the survey to occur in October–December in order to avoid periods of higher abundance of marine mammal species and most of the subsistence hunting activities that occur during the open-water season;
- planning the survey to proceed from east to west across the Beaufort and Chukchi seas to avoid, as much as possible, any remaining migratory animals and associated subsistence activities;
- completing the survey prior the time when ringed seals would establish and enter lairs for reproductive purposes and;

The potential disturbance of marine mammals during survey operations will be minimized further through the implementation of several ship-based mitigation measures when necessary. These include ramping up the airguns at the beginning of operations, and implementing power downs or shut downs when marine mammals are detected within specified distances from the sound source. These distances have been determined using models of sound propagation from the planned airgun source described below.

The mitigation and monitoring measures described herein represent a combination of the procedures required by past IHAs for Arctic projects, plus additional measures that address the unique challenges associated with the early winter timing of the proposed survey. The following subsections provide more detailed information about the mitigation measures that are an integral part of the planned activity.

Safety and Disturbance Zones

Under current NMFS and USFWS guidelines (e.g., NMFS 2000, 50CFR18.118), "safety radii" for marine mammals around industrial sound sources are customarily defined as the distances within which received sound levels are ≥180 dB re 1 μPa (rms) for cetaceans and Pacific walruses and ≥190 dB re 1 μPa (rms) for pinnipeds (excluding walruses) and polar bears. These safety criteria are based on an assumption that sound energy at lower received levels will not injure these animals or impair their hearing abilities, but that higher received levels might have some such effects. Disturbance or behavioral effects to marine mammals from underwater sound may occur after exposure to sound at distances greater than the safety radii (Richardson et al. 1995).

Received sound levels were modeled for the full 26 airgun, 4450 in^3 array in relation to distance and direction from the source (Zykov et al. 2010). Based on the model results, Table 1 shows the distances from the airguns where Ion predicts that received sound levels will drop below 190, 180, and 160 dB re 1 μPa (rms). A single 70 in^3 airgun will be used as a mitigation gun during turns or if a power down of the full array is necessary due to the presence of a marine mammal within or about to enter the applicable safety radius of the full airgun array. Underwater sound propagation of a 30-in^3 airgun was measured in <100 m of water near Harrison Bay in 2007 and results were reported in Funk et al. (2008). The constant term of the resulting equation was increased by 2.45 dB based on the difference between the volume of the two airguns [2.45 = 20Log(70/30)^(1/3)]. The 190 and 180 dB (rms) distances from the adjusted equation, 19 m and 86 m respectively, will be used as the safety zones around the single 70 in^3 airgun in all water depths until results from field measurements are available.

Table 1. Distances to which sound is estimated to propagate by water depth and received sound level.

Received Sound Level (dB re 1µPa rms)	Water Depth (m)		
	<100	100-1000	>1000
190	600	180	180
180	2,850	660	580
160	27,800	42,200	31,600

An acoustics contractor will perform the direct measurements of the received levels of underwater sound versus distance and direction from the energy source 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 field report will be made available to NMFS, USFWS, and the MMOs within 120 hrs of completing the measurements (see the *Acoustic Monitoring Plan* section below for more details). The mitigation measures to be implemented at the 190 and 180 dB (rms) sound levels will include power downs and shut downs as described below.

Speed or Course Alteration

If a marine mammal (in water) is detected outside the safety radius and, based on its position and the relative motion, is likely to enter the safety radius, the vessel's speed and/or direct course may, when practical and safe, be changed in a manner that also minimizes the effect on the planned objectives. The marine mammal activities and movements relative to the seismic vessel will be closely monitored to ensure that the marine mammal does not approach within the safety radius. If the mammal appears likely to enter the safety radius, further mitigative actions will be taken, i.e., either further course alterations or power down or shut down of the airgun(s).

Ramp Ups

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 is to "warn" marine mammals 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 survey program, the seismic operator will ramp up the airgun arrays slowly. Full ramp ups (i.e., from a cold start after a shut down or when no airguns have been firing) will begin by firing a single airgun in the array. The minimum duration of a shut-down period, i.e., without airguns firing, which must be followed by a ramp up is typically the amount of time it would take the source vessel to cover the 180 dB (rms) safety radius. The actual time period depends on ship speed and the size of the 180 dB (rms) safety radius. We estimate that period to be about 5 minutes in intermediate (100-1000 m) and deep (>1000 m) waters, and ~23 minutes in shallow waters (<100 m) based on the airgun array modeling results (Zykov et al. 2010) and a survey speed of 4 kts.

A full ramp up, after a shut down, will not begin until there has been a minimum of 30 minutes of observation of the safety zone by MMOs 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, pinnipeds (excluding walruses), and polar bears or 30 minutes for mysticetes, large odontocetes, and walruses.

During turns and transit between seismic transects, the 70 in^3 mitigation gun will remain operational. The ramp up procedure will still be followed when increasing the source levels from one airgun to the full array. However, keeping one airgun firing will allow a ramp up to the full array during darkness or other periods of poor visibility on the assumption that marine mammals will be alerted by the sounds from the single airgun and can move away in response. 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 minute periods prior to full ramp ups. Daylight will occur for ~11 hours/day at the start of the survey in early October diminishing to ~3 hours/day in mid-November. The seismic operator and MMOs will maintain records of the times when ramp ups start, and when the airgun arrays reach full power.

Power Down Procedures

A power down involves decreasing the number of airguns in use such that the radii of the 190 and 180 dB (rms) zones are decreased to the extent that observed marine mammals are not in the applicable safety zone. A power down may also occur when the vessel is moving from one seismic line to another. During a power down, one airgun is operated. The continued operation of one airgun is intended to (a) alert marine mammals to the presence of the seismic vessel in the area, and (b) retain the option of initiating a ramp up to full array under poor visibility conditions. In contrast, a shut down is when all airgun activity is suspended (see next section).

If a marine mammal is detected outside the safety radius but is likely to enter the safety radius, and if the vessel's speed and/or course cannot be changed to avoid having the mammal enter the safety radius, the airguns may (as an alternative to a complete shut down) be powered down before the mammal is within the safety radius. Likewise, if a mammal is already within the safety zone when first detected, the airguns will be powered down immediately if this is a reasonable alternative to a complete shut down. During a power down of the array, the number of guns operating will be reduced to a single 70 in^3 airgun. The pre-season estimates of the 190 dB (rms) and 180 dB (rms) safety radii around the power down source are 19 m and 86 m, respectively. The 70 in^3 airgun power down source will be measured during acoustic sound source measurements conducted at the start of seismic operations. If a marine mammal is detected within or near the applicable safety radius around the single 70 in^3 airgun, it too will be deactivated resulting in a complete shut down (see next subsection).

Marine mammals hauled out on ice may enter the water when approached closely by a vessel. If a marine mammal on ice is detected by MMOs within the safety zones it will be watched carefully in case it enters the water. In the event the animal does enter the water and is within an applicable safety zone of the airguns during seismic operations, a power down or other necessary mitigation measures will immediately be implemented. If the animal does not enter the water, it will not be exposed to sounds at received levels for which mitigation is required and therefore no mitigation measures will be taken.

Following a power down, operation of the full airgun array will not resume until the marine mammal has cleared the safety zone. The animal will be considered to have cleared the safety zone if it

- is visually observed to have left the safety zone, or
- has not been seen within the zone for 15 min in the case of pinnipeds (excluding walruses) or small odontocetes, or

- has not been seen within the zone for 30 min in the case of Pacific walrus and mysticetes (large odontocetes do not occur within the study area).

Shut Down Procedures

The operating airgun(s) will be shut down completely if a marine mammal approaches or enters the then-applicable safety radius and a power down is not practical or adequate to reduce exposure to less than 190 or 180 dB (rms), as appropriate. The operating airgun(s) will also be shut down completely if a marine mammal approaches or enters the estimated safety radius around the reduced source (one 70 in^3 airgun) that will be used during a power down.

Airgun activity will not resume until the marine mammal has cleared the safety radius. The animal will be considered to have cleared the safety radius if it is visually observed to have left the safety radius, or if it has not been seen within the radius for 15 min (pinnipeds, excluding walruses) or 30 min (mysticetes and Pacific walruses). Ramp up procedures will be followed during resumption of full seismic operations after a shut down of the airgun array.

Marine Mammal Observers

Vessel-based monitoring for marine mammals will be performed by trained MMOs throughout the period of survey activities, supplemented by the officers on duty, to comply with expected provisions in the IHA and LOA that Ion receives. The observers will monitor the occurrence and behavior of marine mammals near the survey vessels during all daylight periods. MMO duties will include watching for and identifying marine mammals; recording their numbers, distances, and reactions to the survey operations; and documenting "take by harassment" as defined by NMFS and USFWS.

Number of Observers

A sufficient number of MMOs will be required onboard the survey vessel to meet the following criteria:

- 100% monitoring coverage during all periods of survey operations in daylight;
- maximum of 4 consecutive hours on watch per MMO;
- maximum of ~12 hours of watch time per day per MMO.

An experienced field crew leader will supervise the MMO team onboard the survey vessels. Ion's proposed survey will occur in October–December when the number of hours of daylight is significantly reduced, and thus will require fewer MMOs to be aboard the survey vessel than required for surveys conducted during the open water season with nearly 24 hrs of daylight. MMOs aboard the icebreaker operating 0.5–1 km ahead of the survey vessel will provide early detection of marine mammals along the survey track. Three MMOs will be stationed aboard the icebreaker *Polar Prince* to take advantage of this forward operating platform and provide advanced notice of marine mammals to the MMO on the survey vessel. Three MMOs will be stationed aboard the survey vessel *Geo Arctic* to monitor the safety zones centered on the airguns and to request mitigation actions when necessary.

Observer Qualifications and Training

Crew leaders and most other biologists serving as observers will be individuals with recent experience as observers during one or more seismic monitoring projects in Alaska, the Canadian Beaufort, or other offshore areas.

Biologist-observers will have previous marine mammal observation experience, and field crew leaders will be highly experienced with previous vessel-based marine mammal monitoring and mitigation

projects. Résumés for all individuals will be provided to NMFS and USFWS for review and acceptance of their qualifications. Inupiat observers will be experienced in the region, familiar with the marine mammals of the area, and complete an approved observer training course designed to familiarize individuals with monitoring and data collection procedures. A marine mammal observers' handbook, adapted for the specifics of the planned survey program, will be prepared and distributed beforehand to all MMOs (see summary below).

Biologist observers and Inupiat observers will also complete a two or three-day training and refresher session together on marine mammal monitoring, to be conducted shortly before the anticipated start of the seismic survey. When possible, experienced observers will be paired with inexperienced observers. The training session(s) will be conducted by qualified 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 IHA or LOA, by BOEM, or by other agreements in which Ion may elect to participate;
- review of marine mammal sighting, identification, and distance estimation methods using visual aids
- 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 marine mammal sightings, 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 specific tasks of the Inupiat Communicator.
- exam to ensure all observers can correctly identify marine mammals and record sightings;

MMO Handbook

A Marine Mammal Observers' Handbook will be prepared for Ions' monitoring program. Handbooks contain maps, illustrations, and photographs, as well as text, and are 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 Ion project:

- summary overview descriptions of the project, marine mammals and underwater noise, the marine mammal monitoring program (vessel-based, aerial, acoustic measurements), the NMFS IHA and USFWS LOA and other regulations/permits/agencies, the Marine Mammal Protection Act;
- monitoring and mitigation objectives and procedures, initial safety radii;
- responsibilities of staff and crew regarding the marine mammal monitoring plan;
- 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, field data sheet;
- list of species that might be encountered: identification cues, natural history information;
- use of specialized field equipment (reticle binoculars, NVDs, FLIR system);
- reticle binocular distance scale;
- table of wind speed, Beaufort wind force, and sea state codes;

- data storage and backup procedures;
- 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;
- communication availability and procedures;
- list of field gear that will be provided;
- suggested list of personal items to pack;
- suggested literature, or literature cited; and
- copies of the NMFS IHA and USFWS LOA when available.

Monitoring Methodology

The observer(s) will watch for marine mammals from the best available vantage point on the survey vessels, typically the bridge. The observer(s) will scan systematically with the unaided eye and 7×50 reticle binoculars, supplemented during good visibility conditions with 20×60 image-stabilized Zeiss Binoculars or Fujinon 25×150 "Big-eye" binoculars, a thermal imaging (FLIR) camera, and night-vision equipment when needed (see below). Personnel on the bridge will assist the marine mammal observer(s) in watching for marine mammals.

Information to be recorded by marine mammal observers will include the same types of information that were recorded during recent monitoring programs associated with Industry activity in the Arctic (e.g., Ireland et al. 2009). 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 determinable), bearing and distance from observer, apparent reaction to activities (e.g., none, avoidance, approach, etc.), closest point of approach, and pace;
- additional details for any unidentified marine mammal or unknown observed
- time, location, speed, and activity of the vessel, sea state, ice cover, visibility, and sun glare; and
- the positions of other vessel(s) in the vicinity of the observer location.

The ship's position, speed of the vessel, water depth, sea state, ice cover, visibility, airgun status (ramp up, mitigation gun, or full array), and sun glare will also be recorded at the start and end of each observation watch, every 30 minutes during a watch, and whenever there is a change in any of those variables.

Distances to nearby marine mammals will be estimated with binoculars containing a reticle to measure the vertical angle of the line of sight to the animal relative to the horizon. Observers may use a laser rangefinder to test and improve their abilities for visually estimating distances to objects in the water. However, previous experience has shown that a Class 1 eye-safe device was not able to measure distances to seals more than about 70 m (230 ft) away. The device 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. 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 required by the IHA and LOA can be implemented. It is expected that the airgun array 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/if needed. Past experience with night-vision devices (NVDs) in the Beaufort Sea and elsewhere has indicated that NVDs are not nearly as effective as visual observation during daylight hours (e.g., Harris et al. 1997, 1998; Moulton and Lawson 2002). A forward looking thermal imaging (FLIR) camera system mounted on a high point near the bow of the icebreaker will also be available to assist with detecting the presence of seals and polar bears on ice and, perhaps also in the water, ahead of the airgun array. The FLIR system detects thermal contrasts and its ability to sense these differences is not dependent on daylight.

Additional details regarding the monitoring protocol during NVD and FLIR system use has been developed in order to collect data in a standardized manner such that the effectiveness of the two devices can be analyzed and compared. Details of the protocol are included below in the section *FLIR and NVD Monitoring Protocol*.

Specialized Field Equipment

Ion will provide or arrange for the following specialized field equipment for use by the onboard MMOs: 7×50 reticle binoculars, Big-eye binoculars or high power image-stabilized binoculars, GPS unit, laptop computers, night vision binoculars, digital still and possibly digital video cameras in addition to the above mentioned FLIR camera system.

Field Data-Recording, Verification, Handling, and Security

The observers 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 regularly onto CDs and/or USB disks, 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 Anchorage office during crew rotations.

In addition to routine MMO duties, observers will use Traditional Knowledge and Natural History datasheets to record observations that are not captured by the sighting or effort data. Copies of these records will be available to 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 survey program, the observers will prepare a report each day or at such other interval as the IHA, LOA, or Ion may require summarizing the recent results of the monitoring program. The reports will summarize the species and numbers of marine mammals sighted. These reports will be provided to NMFS, USFWS, and to the survey operators.

Reporting

Results of the 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 in the IHA and USFWS in the LOA.

The technical report(s) will include:

- summaries of monitoring effort: total hours, total distances, and distribution of marine mammals through the study period accounting for sea state and other factors affecting visibility and detectability of marine mammals;
- methods, results, and interpretation pertaining to all acoustic characterization work and vessel-based monitoring;
- analyses of the effects of various factors influencing detectability of marine mammals including 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 survey operations:
  - sighting rates of marine mammals during periods with and without airgun activities (and other variables that could affect detectability);
  - initial sighting distances versus airgun activity state;
  - closest point of approach versus airgun activity state;
  - observed behaviors and types of movements versus airgun activity state;
  - numbers of sightings/individuals seen versus airgun activity state;
  - distribution around the survey vessel versus airgun activity state;
  - estimates of "take by harassment".

FLIR and NVD Monitoring

The infrared system is able to detect differences in the surface temperature of objects making it potentially useful during both daylight and darkness periods. Night vision devices, or light intensifiers, amplify low levels of ambient light from moonlight or sky glow light in order to provide an image to the user. Both technologies have the potential to improve monitoring and mitigation efforts in darkness. However, they remain relatively unproven in regards to their effectiveness under the conditions and it the manner of use planned for this survey. The protocols for FLIR and NVD use and data collection described below are intended to collect the necessary data in order to evaluate the ability of these technologies to aid in the detection of marine mammals from a vessel.

- All MMOs will monitor for marine mammals according to the procedures outlined in the Marine Mammal Observer handbook.

- One MMO will be responsible for monitoring the FLIR system (IR-MMO) during most darkness and twilight periods. The on-duty IR-MMO will monitor the IR display and alternate between the two search methods described below. If a second MMO is on watch, they will scan the same area as the FLIR using the NVDs for comparison. The two MMOs will coordinate what area is currently being scanned.
- The IR-MMO should rotate between the search methods (see below) every 30 minutes in the suggested routine:
    - 00:00-00:30: Method I
    - 00:30-01:00: Method II, Port side
    - 01:00-01:30: Method I
    - 01:30-02:00: Method II, Starboard side

FLIR Search Methods

The FLIR system consists of a camera that will be mounted on high point in front of the vessel (see below for specification of the model to be used). The camera is connected to a joystick control unit (JCU) and a display monitor that will be located on the bridge of the vessel. The IR-MMO will manually control the view that is displayed by adjusting the pan (360° continuous pan) and tilt (+/-90° tilt) settings using the JCU. The FLIR manufacturer has indicated that they have tested the FLIR unit (model M626L) to -25 C (-13 F), but expect that it will operate at colder temperatures. During the time of the proposed seismic survey, the average minimum temperatures at Prudhoe Bay in Oct and Nov are +10 F and -10 F, respectively. Colder temperatures are certainly likely at times, but overall the temperatures should generally be within the operational range of the equipment.

As noted above, two different search methods will be implemented for FLIR monitoring and results from the two will be compared. The first method involves a back-and-forth panning motion and the second utilizes the FLIR unit focused on a fixed swath ahead and to one side of the vessel track:

Method I. Set the horizontal tilt of the camera to an angle that provides an adequate view out in front of the vessel and also provides good resolution to potential targets (this will likely mean that the lower portion of the view displayed on the monitor is of an area relatively close to the vessel (<100 m) while the middle and upper portions of the view are at greater distances (500–2,000 m). Pan back and forth across the forward 180° of the vessels heading at a slow-scanning rate of approximately 1-2°/sec, as you would with binoculars. This method is intended to replicate the type of observations conducted using binoculars and cover a relatively wider swatch compared to Method II. It should produce sightings data that can be analyzed using line-transect methodologies to estimate marine mammal densities in the survey area.

Method II. Set the horizontal tilt of the camera to an angle that provides an adequate view out in front of the vessel (similar or identical to the above), and then set the camera at a fixed position that creates a swath of view off the bow and to one side of the vessel (Figure 1). This method essentially establishes a fixed-strip width that is intended to produce sightings data that can be analyzed using strip-transect methodologies to estimate marine mammal densities.

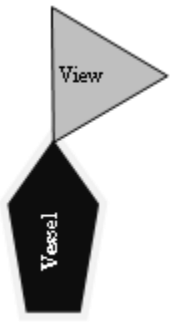

Figure 2. Diagram of FLIR Method II, where the camera is fixed forward and starboard at ~30°, such that the field of view is from 0 to ~60°.

NVD Methods

The NVDs are goggles worn by the observer and are to be used in a similar fashion as binoculars (see below for specifications). When observing in conjunction with the FLIR system, the objective will be to replicate the monitoring methodology being employed by the FLIR system. Method I requires a full 180° scan (or as large of a range as possible from the observer's location) with the NVDs, and Method II requires a focused scan of the ~60° swath being monitored by the FLIR system.

Effort and Sightings Data collection Methods

Observation effort data will be designed to capture the amount of MMO effort itself, environmental conditions that impact an observer's ability to detect marine mammals, and the equipment and method of monitoring being employed. These data will be collected every 30 minutes or when an effort variable changes (e.g., change in the equipment or method being used to monitor, on/off-signing MMO, etc.), and will be linked to sightings data. Effort and sightings data forms are the same forms used during other marine mammal monitoring in the open water season, but additional fields have been included to capture information specific to monitoring in darkness and to more accurately describe the observation conditions. The additional fields include the following.

- **Observation Method**: FLIR, NVD, spotlight, eye (naked eye or regular binoculars), or multiple methods. This data is collected every 30 minutes with the Observer Effort form and with every sighting.
- **Cloud Cover**: Percentage. This can impact lighting conditions and reflectivity.
- **Precipitation Type**: Fog, rain, snow, or none.
- **Precipitation Reduced Visibility**: Confirms whether or not visibility is reduced due to precipitation. This will be compared to the visibility distance (# km) to determine when visibility is reduced due to lighting conditions versus precipitation.
- **Daylight Amount**: Daylight, twilight, dark. The addition of the *twilight* field has been included to record observation periods where the sun has set and observation distances may be reduced due to lack of light.

- **Light Intensity**: Recorded in footcandles (fc) using an incident light meter. This procedure was added to quantify the available light during twilight and darkness periods and may allow for light-intensity bins to be used during analysis.

Analysis of the sightings data will include comparisons of nighttime (FLIR and NVD) sighting rates to daylight sighting rates. FLIR and NVD analysis will be independent of each other and according to method (I or II) used. Comparison of NVD and FLIR sighting rates will allow for a comparison of marine mammal detection ability of the two methods. However, results and analyses could be limited if relatively few sightings are recorded during the survey.

Equipment Specifications

NVD

U.S. Night Vision-Night Vision Goggles (AN/PVS-7B)

- Generation III Auto-Gated
- Magnification: 1x; optional 3x magnification lens
- Field of View: 40°
- Eyepiece focus: +2 to -6 dipoters
- Focus Range: 25 cm to infinity
- Operating temperature: -51°C to +52°C
- Illumination required: Overcast to straight moonlight
- Battery: 2AA or 1 Lithium (BA-5567/U)

FLIR

FLIR M-Series (Ranges for models M-626L and M-320L)

- Sensor type: 640 x 480 or 320 x 240 VOx microbolometer
- Field of View: 20-26° x 15-20° (NTSC)
- Focal length: 35mm
- E-Zoom: 2x (& 4x for M-626L)
- Pan/Tilt coverage: 360° continuous pan; +/-90° tilt
- Video output: NTSC or PAL
- Power Requirements: 12 VDC to 24 VDC
- Operating Temperature: -25°C to +55°C

Acoustic Monitoring Plan

Sound Source Measurements

As described above, received sound levels were modeled for the full 26 airgun, 4450 in^3 array in relation to distance and direction from the source (Zykov et al. 2010). These modeled distances will be used as temporary safety radii until measurements of the airgun sound source are conducted. The measurements will be made at the beginning of the field season and the measured radii used for the remainder of the survey period. An acoustics contractor with experience in the Arctic conducting similar measurements in recent years will use their equipment to record and analyze the underwater sounds and write the summary reports as described below.

The objectives of the sound source measurements planned for 2012 in the Beaufort Sea will be (1) to measure the distances in potentially ice covered waters in the broadside and endfire directions at which broadband received levels reach 190, 180, 170, 160, and 120 dB (rms) for the energy source array combinations that may be used during the survey activities, and (2) measure the sounds produced by the icebreaker and seismic vessel as they travel through sea ice. Conducting the sound source and vessel measurements in ice-covered waters using bottom founded recorders creates a risk of not being able to retrieve the recorders and analyze the data until the following year. If the acoustic recorders are not deployed or are unable to be recovered because of too much sea ice, Ion will use measurements of the same airgun source taken in the Canadian Beaufort Sea in 2010, along with sound velocity measurements taken in the Alaskan Beaufort Sea at the start of the 2012 survey to update the propagation model and estimate new safety zones. These modeled results will then be used for mitigation purposes during the remainder of the survey.

The airgun configurations measured will include at least the full 26 airgun array and the single 70 in^3 mitigation airgun that will be used during power downs. The measurements of airgun array sounds will be made by an acoustics contractor at the beginning of the survey and the distances to the various radii will be reported as soon as possible after recovery of the equipment. 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 (rms).

Data will be previewed in the field immediately after download from the hydrophone instruments. An initial sound source analysis will be supplied to NMFS, USFWS, and the airgun operators within 120 hours of completion of the measurements. The report will indicate the distances to sound levels based on fits of empirical transmission loss formulae to data in the endfire and broadside directions. A more detailed report will be issued to NMFS and USFWS as part of the 90-day report following completion of the acoustic program.

Seismic Hydrophone Streamer Recordings of Vessel Sounds

Although some measurements of icebreaking sounds have previously been reported, acoustic data on vessels traveling through relatively light ice conditions, as will be the case during the proposed survey, are not available. In order to gather additional information on the sounds produced by this type of icebreaking, Ion proposes to use the hydrophones in the seismic streamer on a routine basis throughout the survey. Once every hour the airguns will not be fired at 2 consecutive intervals (one seismic pulse interval is typically ~18 seconds, so there will be ~54 seconds between seismic pulses at this time) and instead a period of background sounds will be recorded, including the sounds generated by the vessels. Over the course of the survey this should generate as many as 750 records of vessel sounds traveling

through various ice conditions (from open water to 100% cover juvenile first year ice or lighter multi-year ice). The acoustic data during each sampling period from each hydrophone along the 9 km streamer will be analyzed and used to estimate the propagation loss of the vessel sounds. The acoustic data received from the hydrophone streamer will be recorded at an effective bandwidth of 0–400 Hz. In order to estimate sound energy over a larger range of frequencies (broadband), results from previous measurements of icebreakers could be generalized and added to the data collected during this project.

Over-winter Acoustic Recorders

In order to collected additional data on the propagation of sounds produced by icebreaking and seismic airguns in ice-covered waters, as well as on vocalizing marine mammals, Ion intends to collaborate with other Industry operators to deploy acoustics recorders in the Alaskan Beaufort Sea in fall of 2012, to be retrieved during the 2013 open-water season.

During winter 2011–2012 AURAL acoustic recorders were deployed at or near each of the 5 acoustic array sites established by Shell for monitoring the fall bowhead whale migration through the Beaufort Sea, as well as one site near the shelf break in the central Alaskan Beaufort Sea (Fig. 3). These recorders will be retrieved in July of 2012 when Shell deploys DASARs at the 5 array locations. When the DASAR arrays are retrieved in early October Ion intends to coordinate with Shell to re-deploy the 6 AURAL recorders to the same locations used during the 2011–2012 winter. Redeploying the recorders in the same locations will provide comparable data from a year with little to no offshore industrial activity (2011) to a year with more offshore industrial activity (2012). Acoustic data from the over-winter recorders will be analyzed to address the following objectives:

1. Characterize the sounds and propagation distances produced by Ion's source vessel, icebreaker, and airguns on and to the edge of the U.S. Beaufort Sea shelf,
2. Characterize ambient sounds and marine mammal calls during October and November to assess the relative effect of Ion's seismic survey on the background conditions, and to characterize marine mammal calling behavior, and
3. Characterize ambient sound and enumerate marine mammal calls through acoustic sampling of the environment form December 2012 through July 2013, when little or no anthropogenic sounds are expected.

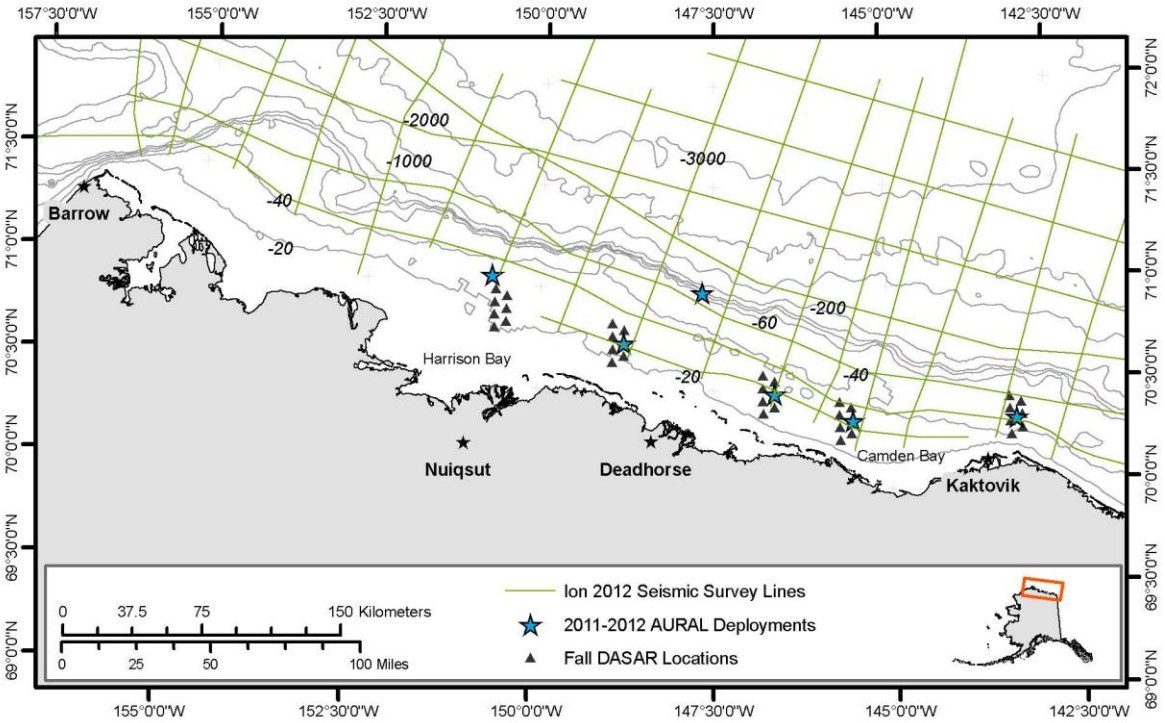

Figure 3. Map showing locations of AURAL acoustic recorders deployed overwinter 2011-2012 by Shell. Ion will coordinate with Shell to re-deploy the recorders in approximately the same locations for the 2012–2013 winter.

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