

**MARINE MAMMAL MONITORING AND MITIGATION
PLAN**

for

**Exploration Drilling of Selected Lease Areas in
the Alaskan Chukchi Sea**



Shell Gulf of Mexico Inc.

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ACRONYMS

| | |
|-----------------|---|
| °C | degrees Celsius |
| °T | degrees True North |
| μPa | micropascal(s) |
| 4MP | Marine Mammal Monitoring and Mitigation Plan |
| AEWC | Alaska Eskimo Whaling Commission |
| AMAR | Advanced Multi-channel Acoustic Recorder |
| BOEM | Bureau of Ocean Energy Management |
| BSEE | Bureau of Safety and Environmental Enforcement |
| DASAR | Directional Autonomous Seafloor Acoustic Recorder |
| dB | decibel |
| CD | Compact Disc |
| cm ³ | cubic centimeter |
| ESW | effective strip width |
| ft | feet |
| GPS | Global Positioning System |
| Hz | Hertz |
| IHA | Incidental Harassment Authorization |
| JASCO | JASCO Applied Sciences |
| kHz | kilohertz |
| km | kilometer |
| LBCHU | Ledyard Bay Critical Habitat Unit |
| Leq | sound energy equivalent level |
| LOA | Letter of Authorization |
| m | meter(s) |
| mi | mile(s) |
| psi | pounds per square inch |
| PSO | Protected Species Observer |
| MMS | Minerals Management Service |
| NMFS | National Marine Fisheries Service |
| NSB | North Slope Borough |
| NVD | Night-vision Device |
| rms | Root Mean Square |
| Shell | Shell Gulf of Mexico Inc. |
| UAS | Unmanned Aerial System |
| USFWS | U.S. Fish and Wildlife Service |
| VSI | vertical seismic imager |
| ZVSP | Zero-offset Vertical Seismic Profile |

INTRODUCTION

Shell Gulf of Mexico Inc. (Shell) will conduct a Marine Mammal Monitoring and Mitigation Plan (4MP) for exploration drilling activities in the Chukchi Sea during the 2012 drilling season. The 4MP developed for Shell's 2012 exploration drilling program supports protection of the marine mammal resources in the area, fulfills reporting obligations to the Bureau of Ocean Energy Management (BOEM), Bureau of Safety and Environmental Enforcement (BSEE), the National Marine Fisheries Service (NMFS), and the U.S. Fish and Wildlife Service (USFWS), and establishes a means for gathering additional data on marine mammals for future operations planning.

Shell plans to conduct exploration drilling within existing lease holdings in the Chukchi Sea. Exploration drilling will be conducted from the Motor/Vessel (M/V) *Noble Discoverer* drillship owned and operated by Noble Corporation. The drillship is an ice-class drilling vessel designed, engineered and constructed to safely operate in arctic waters like the Chukchi Sea. In addition to the drillship, several support vessels will be required. The support vessels will include tugs and barges, an icebreaker, anchor handler/ice management vessel, and oil spill response vessels.

At, or near the end of each well a zero offset vertical seismic profile (ZVSP) will be conducted. During ZVSP surveys, an airgun array is deployed adjacent to the drillship, while receivers are placed in the wellbore. The sound source (airgun array) is fired repeatedly, and the reflected sonic waves are recorded by receivers (geophones) located in the wellbore. The survey will last 10-14 hours as the receivers are moved through the length of the wellbore and the airguns are fired 5-7 times after each movement. The purpose of the ZVSP is to gather geophysical information at various depths, which can then be used to tie-in or ground-truth geophysical information from the previous seismic surveys with geological data collected within the wellbore.

Shell'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. Monitoring will provide information on the numbers of marine mammals potentially affected by the exploration operations and facilitate real time mitigation to prevent injury of marine mammals by industrial sounds or activities. These goals will be accomplished by conducting vessel-based, aerial photographic surveys, and acoustic monitoring programs to document the potential reactions of marine mammals in the area to the various sounds and activities and to characterize the sounds produced by the exploration drilling activities, support vessels, and a ZVSP.

An unmanned aerial photographic survey around the offshore drilling operations, manned aerial surveys for monitor marine mammals in coastal and nearshore areas of the Chukchi Sea, and recordings of ambient sound levels and vocalizations of marine mammals along the Chukchi Sea coast will be used to interpret potential impacts to marine mammals around the offshore exploration drilling operations and in subsistence use areas closer to shore. Acoustic measurements will be made to establish safety radii for real time mitigation around ZVSP operations, and to verify pre-season estimates of the sound footprints and disturbance radii for exploration drilling activities. Preliminary sound source analyses will be supplied to NMFS within 120 hours of completion of the measurements, if possible. A detailed report will be issued to NMFS as part of the 90-day report following the end of the exploration drilling season. Shell will continue to measure the sound propagation of the drillship at various times or throughout the

exploration drilling program. Sound energy from support vessels will also be measured. Bottom-founded hydrophones will also be placed in a large array across the Chukchi Sea to collect information on the use of the region by marine mammals and additional information on the propagation of sounds from human activities.

VESSEL-BASED MARINE MAMMAL MONITORING PROGRAM

Introduction

The vessel-based operations of Shell's 4MP are designed to meet the requirements of the Incidental Harassment Authorization (IHA) and the Letter of Authorization (LOA) which Shell requested from the NMFS and the USFWS, respectively, and to meet any other stipulated agreements between Shell and other agencies or groups. The objectives of the program will be to ensure that disturbance to marine mammals and subsistence hunts is minimized, that effects on marine mammals are documented, and to collect data on the occurrence and distribution of marine mammals in the project area.

The 4MP will be implemented by a team of experienced protected species observers (PSOs). These PSOs will be trained, experienced field observers, including both biologists and Inupiat personnel. The PSOs will be stationed aboard the drillship and associated support vessels throughout the exploration drilling period. The duties of the PSOs will include watching for and identifying marine mammals; recording their numbers, distances, and reactions to the exploration drilling operations; initiating mitigation measures when appropriate; and reporting the results. Reporting of the results of the vessel-based monitoring program will include the estimation of the number of marine mammal "exposures" as defined by the NMFS and stipulated in the IHA.

The vessel-based operations of Shell's 4MP will be required to support the vessel-based exploration drilling activities in the Chukchi Sea. The dates and operating areas will depend upon ice and weather conditions, along with Shell's arrangements with agencies and stakeholders. The *Discoverer* and associated support vessels will transit through the Bering Strait into the Chukchi Sea on or about July 1, arriving on location at the Burger Prospect as soon as ice and weather conditions allow. Exploration drilling activities will then commence on or about July 4, as ice, weather and other conditions allow for safe exploration drilling operations, and may last until October 31. Vessel-based monitoring for marine mammals will be done throughout the period of operations to comply with provisions in the anticipated IHA and LOA from NMFS and USFWS, respectively.

The vessel-based work will provide:

- the basis for real-time mitigation, if necessary, as required by the various permits that Shell receives;
- information needed to estimate the number of "exposures" of marine mammals to sound levels that may result in harassment, which must be reported to NMFS and USFWS;
- data on the occurrence, distribution, and activities of marine mammals in the areas where the exploration drilling program is conducted;
- information to compare the distances, distributions, behavior, and movements of marine mammals relative to the drillship at times with and without exploration drilling activity;
- a communication channel to coastal communities including Inupiat whalers,

- employment and capacity building for local residents, with one objective being to develop a larger pool of experienced Inupiat PSOs.

The 4MP will be operated and administered consistent with monitoring programs conducted during seismic and shallow hazards surveys in 2006–2010 or such alternative requirements as may be specified in the IHA and LOA received from NMFS and USFWS, respectively for this project. Any other agreements between Shell and agencies or groups such as BOEM, BSSE, USFWS, the North Slope Borough (NSB), and the Alaska Eskimo Whaling Commission (AEWC) will also be fully incorporated. All PSOs will be provided training through a program approved by NMFS and Shell, as described in the PSO section of this 4MP. 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 various subsistence harvests) directly with Inupiat subsistence advisors and/or hunters and whalers. Details of the vessel-based marine mammal monitoring program are described below.

Mitigation Measures during Exploration Drilling Activities

Shell's planned exploration drilling 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 of the mitigation measures have been described in the IHA (Section 12 of the IHA application to which this 4MP is appended) and LOA applications submitted to NMFS and USFWS, respectively and are not repeated in entirety here. Survey design features include:

- timing and locating exploration drilling and support activities to avoid interference with the annual subsistence hunting by the peoples of the Chukchi villages;
- conducting pre-season acoustic modeling to establish the appropriate safety zones and behavioral or disturbance radii;
- vessel-based monitoring to implement appropriate mitigation if necessary, and to determine the effects of project activities on marine mammals,
- acoustic monitoring of drillship and vessel sounds and marine mammal vocalizations;
- aerial surveys with photographic equipment over operations and in coastal and nearshore waters with photographic equipment and PSOs to help determine the effects of project activities on marine mammals; and
- seismic activity mitigation measures during performance of ZVSP surveys.

The potential disturbance of marine mammals during exploration drilling operations will be minimized further through the implementation of several vessel-based mitigation measures (see Section 12 of the IHA application to which this 4MP is appended) if mitigation becomes necessary.

Safety and Disturbance Zones

Under current NMFS guidelines (e.g., NMFS 2000), "safety radii" for marine mammals around industrial sound sources are customarily defined as the distances within which received pulse levels are ≥ 180 dB re 1 μ Pa (rms) for cetaceans and ≥ 190 dB re 1 μ Pa (rms) for pinnipeds. These safety criteria are based on an assumption that sound energy received at lower 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). NMFS assumes that marine mammals exposed to underwater impulsive sounds at received levels ≥ 160 dB (rms) have the potential to exhibit behavioral reactions great enough to meet the definition of “harassment” in the MMPA. For continuous sounds NMFS has established a similar disturbance threshold at ≥ 120 dB (rms).

Exploration Drilling Activities

Expected safety and disturbance radii based on sound propagation from the drillship *Discoverer* were modeled by JASCO Applied Sciences (JASCO) at the three potential drill sites (JASCO 2009). Changes in the water column of the Chukchi Sea through the course of the exploration drilling season will likely affect the propagation of sounds produced by drilling activities, so models were run for expected oceanographic conditions in July and October to bracket the seasonal variability. The water profiles considered for modeling drilling sound for both times did not include the stratified profiles of warm saline water overlying cold brackish water that occasionally occur in this area. The non-stratified profiles lead to more conservative (greater) sound threshold radii because the stratified profiles produce downward acoustic refraction and more bottom interactions that reduce radii. The modeled radii will be used for mitigation purposes, should they be necessary, until direct measurements are available early during the exploration drilling activities. Shell will measure the received levels of underwater sound versus distance and direction from the sound sources 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 and disturbance radii.

Sounds from the *Discoverer* have not previously been measured in the Arctic. However, measurements of sounds produced by the *Discoverer* were made in the South China Sea in 2009 (Austin and Warner 2010). The results of those measurements were used to model the sound propagation from the *Discoverer* (including a nearby support vessel) at planned drilling locations in the Chukchi and Beaufort seas (Warner and Hannay 2011). Broadband source levels of sounds produced by the *Discoverer* varied by activity and direction from the ship, but were generally between 177 and 185 dB re 1 μ Pa @ 1 m rms (Austin and Warner 2010). Propagation modeling at the Burger prospect resulted in an estimated distance of 0.814 miles (mi) (1.31 kilometers [km]) to the point at which drillings sounds would likely fall below 120 dB. The estimated 0.814 mi (1.31 km) distance was multiplied by 1.5 (= 1.22 mi [1.97 km]) as a further precautionary measure before calculating the total area that may be exposed to continuous sounds ≥ 120 dB re 1 μ Pa rms by the *Discoverer* at each drill site on the Burger prospect. Assuming one well will be drilled in each season (summer and fall), the total area of water ensonified to ≥ 120 dB rms in each season is estimated to be 4.6 square miles (mi²) (12 square kilometers [km²]). As noted above, broadband source levels from the *Discoverer* generally were close to 180 dB rms (Austin and Warner 2010). Source levels by definition are measured at a 1 m distance. Therefore the 180 dB rms distance is 1 m. The distance to which sounds ≥ 160 are expected to propagate are estimated to be less than 33 feet (ft) (10 meters [m]) from the vessel and were not included in modeling results.

The source levels noted above for exploration drilling activities are not high enough to cause a temporary reduction in hearing sensitivity or permanent hearing damage to marine mammals. Consequently, mitigation as described for seismic activities including ramp ups, power downs, and shut downs should not be necessary for exploration drilling activities. However, Shell plans to use PSOs onboard the drillship and the various support vessels to

monitor marine mammals and their responses to industry activities and to initiate mitigation measures should in-field measurements of the operations indicate conditions represent a threat to the health and well-being of marine mammals.

ZVSP Surveys

The sound source likely to be used by Shell for the ZVSP survey in 2012 is the ITAGA eight-airgun array, which consists of four 150 in³ (2,458 cu cm³) airguns and four 40 in³ (655 cu cm³) airguns, for a total of 760 in³ (12,454 cm³). A similar airgun source was used in the region in 2008 during the BP Liberty seismic survey. Preseason estimates of the propagation of airgun sounds from the ITAGA VSP sound source have been estimated based on the measurements of the seismic source reported in BP's 90-day report (Aerts et al. 2008). The BP Liberty source was also an eight-airgun array, but had a slightly larger total volume of 880 in³. Because the number of airguns is the same, and the difference in total volume only results in an estimated 0.4 dB decrease in the source level of the ZVSP source, the 100th percentile propagation model from the measurements of the BP Liberty source is almost directly applicable. However, the BP Liberty source was towed at a depth of 1.8 m, while the ZVSP source will be lowered to a target depth of 4 m (from 3-7 m). The lower depth of the ZVSP source has the potential to increase the source strength by as much as 6 dB. Thus, the constant term in the propagation equation from the BP Liberty source has been increased from 235.4 to 241.4 while the remainder of the equation ($-18 \cdot \text{LogR} - 0.0047 \cdot R$) has been left unchanged. This equation results in the following estimated distances to maximum received levels: 190 dB = 524 m; 180 dB = 1240 m; 160 dB = 3670 m; 120 dB = 10,500 m.

PSOs on the drillship will initially use these estimated safety radii for monitoring and mitigation purposes. An acoustics contractor will perform direct measurements of the received levels of underwater sound versus distance and direction from the ZVSP array using calibrated hydrophones. The acoustic data will be analyzed as quickly as reasonably practicable (within 5 days) in the field and used to verify (and if necessary adjust) the safety distances during later ZVSP activities. The mitigation measures to be implemented will include pre-ramp up watches, ramp ups, power downs and shut downs as described below.

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 (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 ZVSP surveys, the operator will ramp up the airgun arrays slowly. Full ramp ups (i.e., from a cold start when no airguns have been firing) will begin by firing a single airgun in the array. A full ramp up will not begin until there has been a minimum of 30 min of observation of the safety zone by PSOs 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.

Power Downs and Shut Downs

A power down is the immediate reduction in the number of operating energy sources to some smaller number. A shut down is the immediate cessation of firing of all energy sources. The arrays will be immediately powered down whenever a marine mammal is sighted approaching close to or within the applicable safety zone of the full arrays, but is outside the applicable safety zone of the single source. If a marine mammal is sighted within the applicable safety zone of the single energy source, the entire array will be shut down (i.e., no sources firing).

Protected Species Observers

Vessel-based monitoring for marine mammals will be done by trained PSOs throughout the period of exploration drilling operations to comply with expected provisions in the IHA and LOA that Shell receives. The observers will monitor the occurrence and behavior of marine mammals near the drillship and support vessels during all daylight periods during the exploration drilling operation, and during most periods when exploration drilling is not being conducted. PSO duties will include watching for and identifying marine mammals; recording their numbers, distances, and reactions to the exploration drilling operations; and documenting exposures of animals to sound levels that may constitute harassment as defined by NMFS.

Number of observers

A sufficient number of PSOs will be onboard each vessel to meet the following criteria

- 100 percent monitoring coverage during all periods of exploration drilling operations in daylight;
- maximum of four consecutive hours on watch per PSO; and
- maximum of approximately 12 hours on watch per day per PSO.

PSO teams will consist of trained Inupiat and field biologist observers. An experienced field crew leader will be a member of every PSO team aboard the drillship and each support vessel during the exploration drilling program. The total number of PSOs aboard may decrease later in the season as the duration of daylight decreases assuming NMFS does not require continuous nighttime monitoring. Inupiat PSOs will also function as Native language communicators with hunters and whaling crews and with the Communications and Call Centers (Com Centers) in Native villages along the Chukchi Sea coast.

Crew Rotation

Shell anticipates that there will be provision for crew rotation at least every three to six weeks to avoid observer fatigue. During crew rotations, detailed hand-over notes will be provided to the incoming crew leader by the outgoing leader. Other communications such as email, fax, and/or phone communication between the current and oncoming crew leaders during each rotation will also occur when possible. In the event of an unexpected crew change Shell will facilitate such communications to insure monitoring consistency among shifts.

Observer Qualifications and Training

Crew leaders and most other biologists serving as observers in 2012 will be individuals with experience as observers during one or more of the 2006–2011 monitoring projects for Shell or recent experience with other operators in Alaska or the Canadian Beaufort, or Chukchi Seas.

Biologist-observers will have previous marine mammal observation experience, and field crew leaders will be highly experienced with previous vessel-based marine mammal monitoring projects. Resumés for those individuals will be provided to NMFS for approval. All observers will be trained and familiar with the marine mammals of the area. A marine mammal observers' handbook, adapted for the specifics of the planned Shell exploration drilling program will be prepared and distributed beforehand to all PSOs (see below).

Most 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 2012 exploration drilling 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 adopted, or specified by NMFS or USFWS in the IHA or LOA, by BOEM, BSEE, or other agreements in which Shell may elect to participate;
- review of marine mammal sighting, identification, (photographs and videos) and distance estimation methods, including any amendments specified by NMFS or USFWS in the 2012 IHA or LOA,;
- review of operation of specialized equipment (reticle binoculars, Big eye 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, exploration drilling and monitoring operations, environmental conditions, and entry error control. These procedures will be implemented through use of a customized computer database and laptop computers; and
- review of specific tasks of the Inupiat communicator.

PSO Handbook

A Protected Species Observers' Handbook will be prepared for Shell's monitoring program. The Handbook will contain maps, illustrations, and photographs as well as copies of important documents and descriptive text and are intended to provide guidance and reference information to trained individuals who will participate as PSOs. The following topics will be covered in the PSO Handbook:

- summary overview descriptions of the project, marine mammals and underwater sound energy, the marine mammal monitoring program (vessel-based, aerial, acoustic measurements, special studies), the NMFS IHA and USFWS LOA and other regulations/permits/agencies, the Marine Mammal Protection Act;
- monitoring and mitigation objectives and procedures, including 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, and drilling data recording, field data sheet;
- use of specialized field equipment (reticle binoculars, Big-eye 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 PSOs and crew;
- drug and alcohol policy and testing;
- scheduling of cruises and watches;
- communications;
- list of field gear provided;
- suggested list of personal items to pack;
- suggested literature, or literature cited;
- field reporting requirements and procedures;
- copies of the NMFS IHA and USFWS LOA will be made available; and
- Coordinates delineating areas where ships cannot operate such as the Ledyard Bay Critical Habitat Unit (LBCHU).

Monitoring Methodology

The observer(s) will watch for marine mammals from the best available vantage point on the drillship and support vessels. Ideally this vantage point is an elevated stable platform from which the PSO has an unobstructed 360° view of the water. The observer(s) will scan systematically with the naked eye and 7 × 50 reticle binoculars, supplemented with Big-eye 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. New or inexperienced PSOs will be paired with an experienced PSO or experienced field biologist so that the quality of marine mammal observations and data recording is kept consistent.

Information to be recorded by marine mammal observers will include the same types of information that were recorded during previous monitoring projects (e.g., Moulton and Lawson 2002, Reiser et al. 2010, Reiser et al. 2011). When a mammal sighting is made, the following information about the sighting will be carefully and accurately recorded:

- species, group size, age/size/sex categories (if determinable), physical description of features that were observed or determined not to be present in the case of unknown or unidentified animals, behavior when first sighted and after initial sighting, heading (if consistent), bearing and distance from observer, apparent reaction to activities (e.g., none, avoidance, approach, paralleling, etc.), closest point of approach, and behavioral pace;
- time, location, speed, and activity of the vessel, sea state, ice cover, visibility, and sun glare, on support vessels the distance and bearing to the drillship will also be recorded; and
- positions of other vessel(s) in the vicinity of the observer location.

The ship's position, speed, water depth, sea state, ice cover, visibility, 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 (Fujinon 7 × 50 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 showed that a Class 1 eye-safe device was not able to measure distances to seals more than about 230 feet (ft) [70 meters (m)] away. The device was very useful in improving the distance estimation abilities of the observers at distances up to about 1,968 ft (600 m)—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 percent when given immediate feedback about actual distances during training.

Maximizing time with eyes on the water is strongly promoted during training and is a goal of the PSO program. Each ship will have voice recorders available to PSOs. This will allow PSOs to remain focused on the water in situations where a number of sightings occur together. Additionally, we have moved entirely to real-time electronic data recording (described below) and automated as much of the process as possible to minimize time spend recording data as opposed to focusing eyes on the water.

PSO's are instructed to identify animals as unknown when appropriate rather than strive to identify an animal when there is significant uncertainty. We also ask that they provide any sightings cues they used and any distinguishable features of the animal even if they are not able to identify the animal and record it as unidentified. Emphasis is also placed on recording what was not seen, such as dorsal features.

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. However, past experience with night-vision devices (NVDs) in the Beaufort Sea and elsewhere indicates that NVDs are not nearly as effective as visual observation during daylight hours (e.g., Harris et al. 1997, 1998; Moulton and Lawson 2002). Data will be collected to further evaluate night-vision equipment.

Specialized Field Equipment

Shell will provide or arrange for the following specialized field equipment for use by the onboard PSOs: reticle binoculars, Big-eye binoculars, GPS unit, laptop computers, night vision binoculars, and possibly digital still and digital video cameras. Big eye binoculars will be mounted and used on key monitoring vessels including the drillship, ice management vessels and the anchor handler.

Field Data-Recording, Verification, Handling, and Security

The observers on the drillship and support vessels will record their observations directly into computers using a custom software package. 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 PSO duties, 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 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.

PSOs will be able to plot sightings in near real-time for their vessel. Significant sightings from key vessels (drillship, ice management, anchor handlers and aircraft will be relayed between platforms to keep observers aware of animals that may be in or near the area but may not be visible to the observer at any one time. Emphasis will be placed on relaying sightings with the greatest potential to involve mitigation or reconsideration of a vessel's course (e.g., large group of bowheads, walrus on ice).

Both Inupiat and trained-biologist observers will be encouraged to record comments about their observations into the “comment” field in the marine mammal sightings database. Observer training will emphasize the use of “comments” for sightings that may be considered unique or not fully captured by standard data codes.

In addition to the standard marine mammal sightings forms, a specialized form was developed for recording traditional knowledge and natural history observations. MMOs will be encouraged to use this form to capture observations related to any aspect of the arctic environment and the marine mammals found within it. Examples might include relationships between ice and marine mammal sightings, marine mammal behaviors, comparisons of observations among different years/seasons, etc. Copies of these records will be available to all observers for reference if they wish to prepare a statement about their observations for reporting purposes. If prepared, this statement would be included in the 90-day and final reports documenting the monitoring work.

Field Reports

Throughout the exploration drilling program, the biologists will prepare a report each day or at such other interval as required 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 as required.

Reporting

The results of the 2012 vessel-based monitoring, including estimates of exposure to key sound levels, will be presented in the 90-day and final technical report(s). Reporting will address the requirements established by NMFS in the IHA, and USFWS in the LOA (if so stipulated).

The technical report(s) will include:

- summaries of monitoring effort: total hours, total distances, and distribution of marine mammals through study period for sea state, and other factors affecting visibility and detectability of marine mammals;
- analyses of the effects of various factors influencing detectability 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 (when discernable), group sizes, and ice cover;
- analyses of the effects of exploration drilling operations:
 - sighting rates of marine mammals during periods with and without exploration drilling activities (and other variables that could affect detectability),
 - initial sighting distances versus drilling state,
 - closest point of approach versus drilling state,
 - observed behaviors and types of movements versus drilling state,
 - numbers of sightings/individuals seen versus drilling state,
 - distribution around the drillship and support vessels versus drilling state,
 - estimates of “take by harassment”.

Data will be visualized by plotting sightings relative to the position of the drillship. We will also overlay the sightings data with acoustic data that indicates the sound levels associated with the exploration drilling activity and with maps of call locations determined by the seafloor recorders. Additionally, sightings data will be incorporated into animations of the call locations around the exploration drilling activity. Seafloor recorders used in the Chukchi Sea do not have the ability to localize calls. Larger groups of recorders, however, can localize calls using arrival times of the calls captured on several nearby recorders.

Shell will consider requests for data collected during the marine mammal monitoring only after the data have been put through a quality control/quality assurance program. Such requests may include incorporating the data with other companies’ data and/or integrating the raw data with data from other marine mammal studies.

ACOUSTIC MONITORING PLAN

Exploration Drilling, ZVSP and Vessel Sound Measurements

Objectives

Exploration drilling sounds are expected to vary significantly with time due to variations in the level of operations and the different types of equipment used at different times onboard the drillship. The goals of these measurements are:

- to quantify the absolute sound levels produced by exploration drilling and to monitor their variations with time, distance and direction from the drillship,
- to measure the sound levels produced by vessels operating in support of exploration drilling operations. These vessels will include crew change vessels, tugs, ice-management vessels, and spill response vessels; and

- to measure the sound levels produced by an end-of-hole vertical seismic profiling (ZVSP) survey using a stationary sound source.

Exploration Drilling Sound Characterization

Sound characterization and measurements of all exploration drilling activities will be performed using autonomous and real-time acoustic monitoring systems deployed relative to the drillship as depicted in Figure 1. One real-time monitoring station will be deployed at 1,640 to 3,280 feet (500-1,000 m) off the side of the drillship. This system will consist of a bottom-mounted hydrophone that is cabled to a surface float housing a JASCO Advanced Multi-channel Acoustic Recorder (AMAR) 24-bit digital acquisition system. The AMAR will stream digital audio data, sampled at least at 32 kHz, through a radio-telemetry system back to a monitoring station on the drillship. Here, the data will be stored and analyzed on an hourly basis to calculate rms levels and hourly 1/3-octave band SEL. Spectrograms will be calculated daily, and all information will be included in a weekly report that discusses the drillship and vessel activities that occurred during the week.

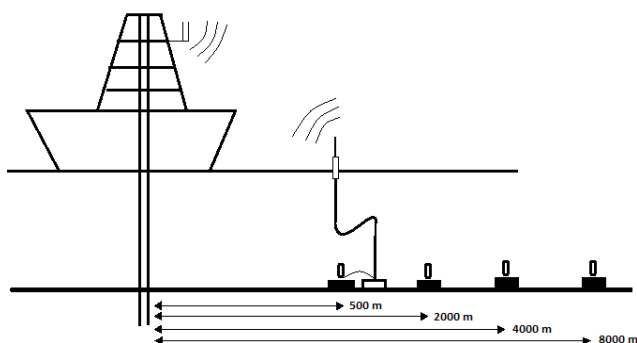


FIGURE 1. Geometry of the real-time telemetered acoustic system and three autonomous acoustic recorders that will sample sound produced by exploration drilling operations of drillship *Discoverer*.

The real-time acoustic measurement station will be augmented by 3 more AMAR autonomous acoustic recording stations (Figure 2) deployed on the seabed along the same radial at distances of 1.2, 2.5 and 5 mi (2, 4 and 8 km) from the drillship. The telemetered station nearest the drillship will also record autonomously to ensure data are acquired even in the case of interrupted radio transmissions. All four recording stations will sample at least at 32 kHz, providing precisely calibrated acoustic measurements in the 5 Hz to 16 kHz frequency band. The logarithmic spacing of the recorders is designed to sample the attenuation of drillship sounds with distance. The autonomous recorders will sample through completion of the first well, to provide a detailed record of sounds emitted from all activities. These recorders will be retrieved and their data analysed and reported in the project's 90-day report.

To sample directivity in exploration drilling-related sounds, measurements from the Directional Autonomous Seafloor Acoustic Recorder (DASAR) recorder array will be included in a post-season analysis. The DASAR deployment locations are discussed in the later section: Acoustic Study of Bowhead Call Distributions. This array will incorporate several recorders at 4-

8 km at multiple directions from each drill site. While those recorders sample only at 1,000 Hz, their data will be useful for examining the primary sound emission frequencies from the drillship, below 500 Hz.



FIGURE 2. AMAR autonomous acoustic recorder for acoustic monitoring of drilling activities.

The deployment of drilling sound monitoring equipment will occur before, or as soon as possible after the *Discoverer* is on site. Activity logs of exploration drilling operations and nearby vessel activities will be maintained to correlate with these acoustic measurements. All results, including back-propagated source levels for each operation, will be reported in the 90-day report

Vessel Sound Characterization

Vessel sound characterizations will be performed using dedicated recorders deployed at sufficient distance from exploration drilling operations so that sound produced by those activities does not interfere. Three AMAR acoustic recorders will be deployed on and perpendicular to a sail track on which all Shell vessels will transit. The deployment geometry will be as shown in Figure 3. This geometry is designed to obtain sound level measurements as a function of distance and direction. The fore and aft directions are sampled continuously over longer distances to 3 and 6 miles (5 and 10 km) respectively, while broadside and other directions are sampled as the vessels pass closer to the recorders.

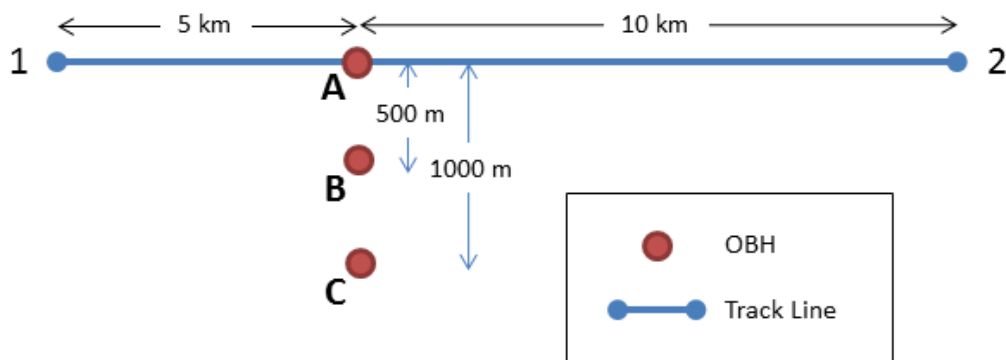


FIGURE 3. AMAR recorder deployment geometry relative to vessel sail track for support vessel sound characterization measurements.

Vessel sound measurements will be processed and reported in a manner similar to that used by Shell and other operators in the Beaufort and Chukchi Seas during seismic survey operations. The measurements will further be analyzed to calculate source levels. Source directivity effects will be examined and reported. Preliminary vessel characterization measurements will be reported in a field report to be delivered 120 hours after the recorders are retrieved and data downloaded. Those results will include sound level data but not source level calculations. All vessel characterization results, including source levels, will be reported in 1/3-octave bands in the project 90-day report.

Zero Offset Vertical Seismic Profiling Sounds Monitoring

Sounds produced by the ZVSP survey at, or near the end of each well will be recorded using the drilling sounds monitoring equipment. During ZVSP surveys, an airgun array, which is typically much smaller than those used for routine seismic surveys, is deployed at a location near or adjacent to the drillship, while receivers are placed (temporarily anchored) in the wellbore. The sound source (airgun array) is fired repeatedly, and the reflected sonic waves are recorded by receivers (geophones) located in the wellbore. The geophones, typically a string of them, are then raised up to the next interval in the wellbore and the process is repeated until the entire wellbore has been surveyed. The purpose of the ZVSP is to gather geophysical information at various depths, which can then be used to tie-in or ground-truth geophysical information from the previous seismic surveys with geological data collected within the wellbore.

During the ZVSP the sound source is maintained at a constant location near the wellbore. A typical sound source likely to be used by Shell in 2012 is the ITAGA eight-airgun array, which consists of four 150 in³ (2,458 cu cm³) airguns and four 40 in³ (655 cu cm³) airguns, for a total of 760 in³ (12,454 cm³). The airgun array is depicted within its frame or sled, which is approximately 6 ft x 5 ft x 10 ft, in Figure 4. The receivers will consist of a Schlumberger wireline four level Vertical Seismic Imager (VSI) tool, which has four receivers 50-ft (15.2-m) apart.

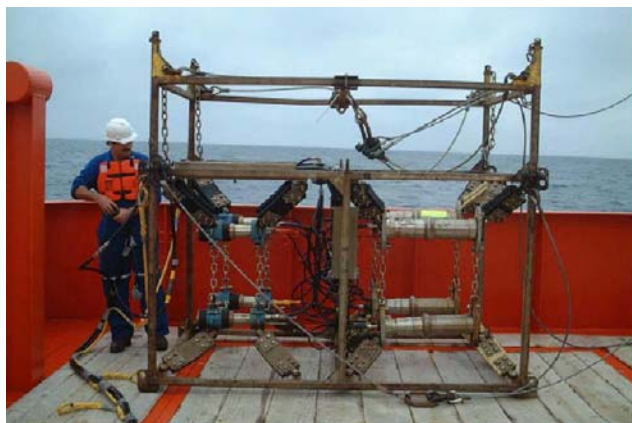


FIGURE 4. Photograph of ITAGA 8-airgun array in sled.

A ZVSP survey will be conducted at each well after total depth is reached. For each survey, Shell will deploy the sound source (airgun array) over the side of the drillship *Discoverer* with a crane (sound source will be 50-200 ft / 15-60 m from the drillship depending on crane location), to a depth of approximately 10-23 ft (3-7 m) below the water surface. The VSI with its four receivers will be temporarily anchored in the wellbore at depth (Figure 5). The sound source will be pressured up to 2,000 pounds per square inch (psi), and activated 5-7 times at approximately 20-second intervals. The VSI will then be moved to the next interval of the wellbore and re-anchored, after which the airgun array will again be activated 5-7 times. This process will be repeated until the entire well bore is surveyed in this manner. The interval between anchor points for the VSI will be approximately 200 ft (60 m) along the wellbore up to a depth of 1,440 ft, and 150 ft in the shallow portion of the wellbore. This would result in a total of about 216 activations of the airgun array. Each survey is expected to be conducted over a period of about 10-14 hours.

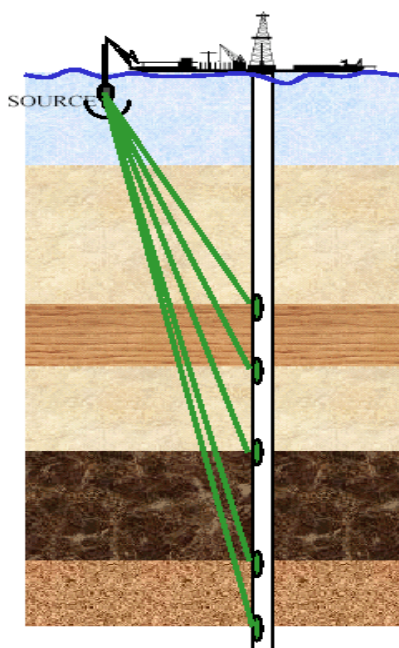


Figure 5. Schematic of ZVSP

ZVSP sound verification measurements will be performed using either the AMARs, that are deployed for drillship sound characterizations, or by JASCO Ocean Bottom Hydrophone (OBH) recorders. The use of AMARs or OBH's depends on the specific timing these measurements will be required by NMFS; the AMARs will not be retrieved until several days after the ZVSP as they are intended to monitor during retrievals of drillship anchors. If the ZVSP acoustic measurements are required sooner, four OBH recorders would be deployed at the same locations and those could be retrieved immediately following the ZVSP measurement. We propose that these measurements be performed using the AMARs as their data and measurement results will be available before any subsequent ZVSP operations. The ZVSP measurements can be delivered within 120 hours of retrieval and download of the data from either instrument type.

Acoustic Data Analyses

Exploration drilling sound data will be analyzed to extract a record of the frequency-dependent sound levels as a function of time. Figure 6 shows the results of this type of analysis. These results are useful also for correlating measured sound energy events with specific survey operations and capturing marine mammal vocalizations. The analysis provides absolute sound levels in finite frequency bands that can be tailored to match the highest-sensitivity hearing ranges for species of interest. For example, bowhead hearing is thought to be most acute in the 100 Hertz (Hz) – 1,000 Hz frequency range that corresponds with the blue dotted line in the upper plot of Figure 6.

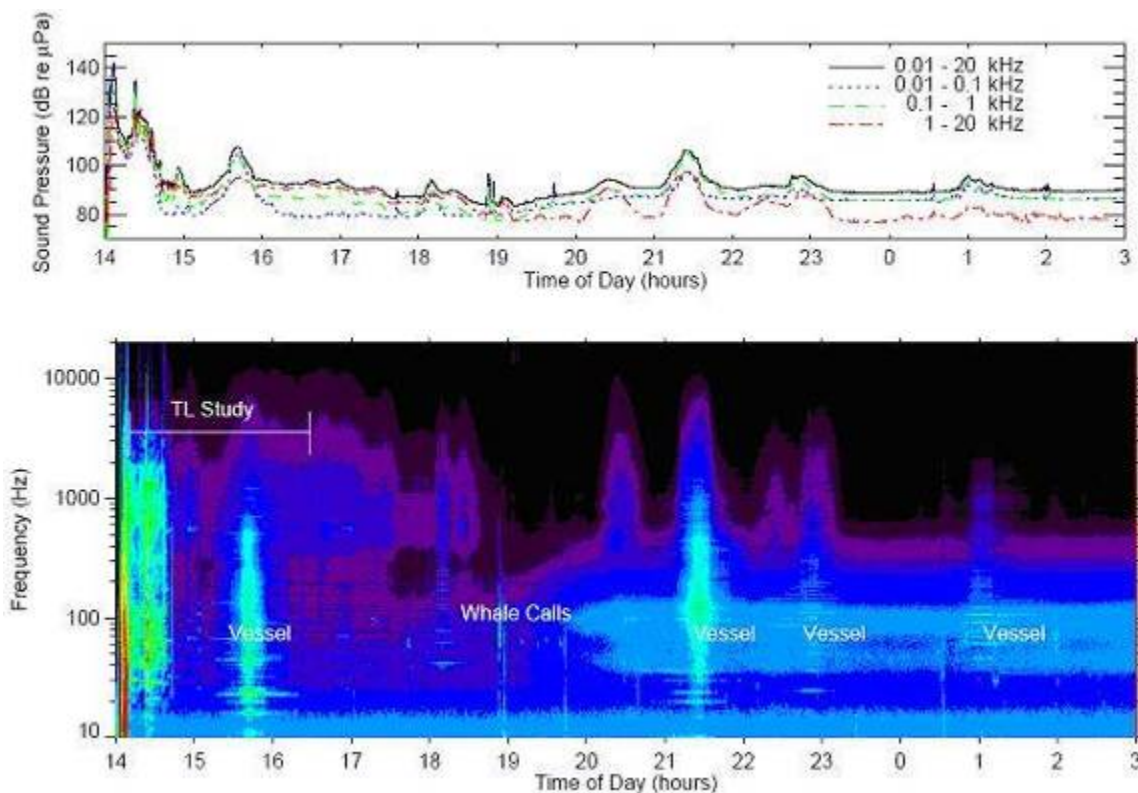


Figure 6. Lower: spectrogram of sound level measurements obtained from a hydrophone recording system. Upper: broadband and selected band level variation with time.

The analyses will also consider sound level integrated through 1-hour durations (referred to as sound energy equivalent level Leq (1-hour)). Figure 7 (upper) shows an example of a Leq analysis of hydrophone data. Similar graphs for long time periods will be generated as part of the data analysis performed for indicating exploration drilling sound variation with time in selected frequency bands.

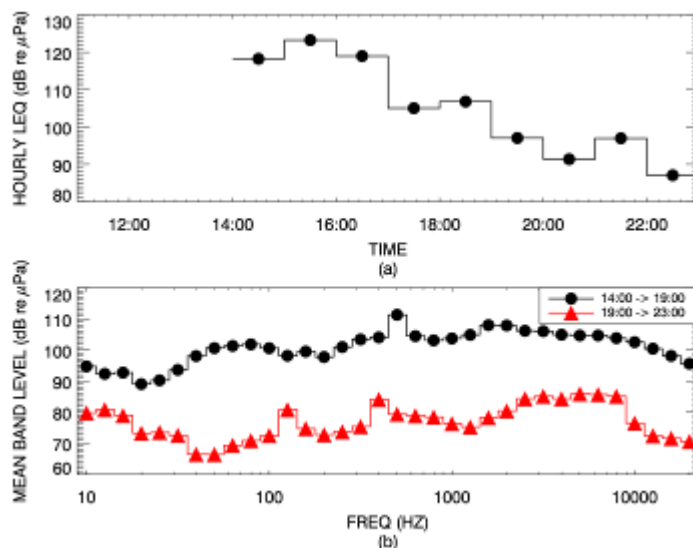


Figure 7. Upper: 1-hour Leq levels that will be calculated from acoustic measurements for use in correlating with bowhead whale deflection data.

Reporting of Results

Acoustic sound level results will be reported in the 90-day and comprehensive reports for this program. The results reported will include:

- sound source levels for the drillship and all exploration drilling support vessels;
- spectrogram and band level versus time plots computed from the continuous recordings obtained from the hydrophone systems;
- hourly Leq levels at the hydrophone locations; and
- correlation of exploration drilling source levels with the type of exploration drilling operation being performed. These results will be obtained by observing differences in exploration drilling sound associated with differences in the drill rig activity as indicated in detailed drillship logs.

Acoustic “Net” Array in Chukchi Sea

Background and Objectives

This section describes acoustic studies that were undertaken from 2006 through 2011 in the Chukchi Sea as part of the Joint Monitoring Program that will be continued by Shell during exploration drilling operations in 2012. The acoustic “net” array used during the 2006–2011 field seasons in the Chukchi Sea was designed to accomplish two main objectives. The first was to collect information on the occurrence and distribution of marine mammals (including beluga

whale, bowhead whale, walrus and other species) that may be available to subsistence hunters near villages located on the Chukchi Sea coast and to document their relative abundance, habitat use, and migratory patterns. The second objective was to measure the ambient soundscape throughout the eastern Chukchi Sea and to record received levels of sounds from industry and other activities further offshore in the Chukchi Sea.

Technical Approach

A net array configuration similar to that deployed in 2007–2011 is again proposed for 2012. The basic components of this effort consist of autonomous acoustic recorders deployed widely across the US Chukchi Sea through the open water season and then winter season. These precisely calibrated systems will sample at 16 kHz with 24-bit resolution, and are capable of recording marine mammal sounds and making anthropogenic noise measurements. The net array configuration will include a regional array of 24 AMAR recorders deployed July-October off the four main transect locations: Cape Lisburne, Point Hope, Wainwright and Barrow as shown in Figure 8. These will be augmented by 6 AMAR recorders deployed August 2012 – August 2013 at Hanna Shoal. Six additional AMAR recorders will be deployed in a hexagonal geometry at 16 km from the nominal drillship location to monitor directional variations of drilling-related sounds and to examine marine mammal vocalization patterns in vicinity of exploration drilling activities. One new recorder will be placed 32 km northwest of the drillship to monitor for drilling sound propagation toward the south side of Hanna Shoal, which acoustic and satellite tag monitoring has identified as frequented by walrus in August. All of these offshore systems will capture exploration drilling sounds, where present, over large distances to help characterize the sound transmission properties in the Chukchi Sea. They will continue to provide a large amount of information related to marine mammal distributions in the Chukchi Sea.

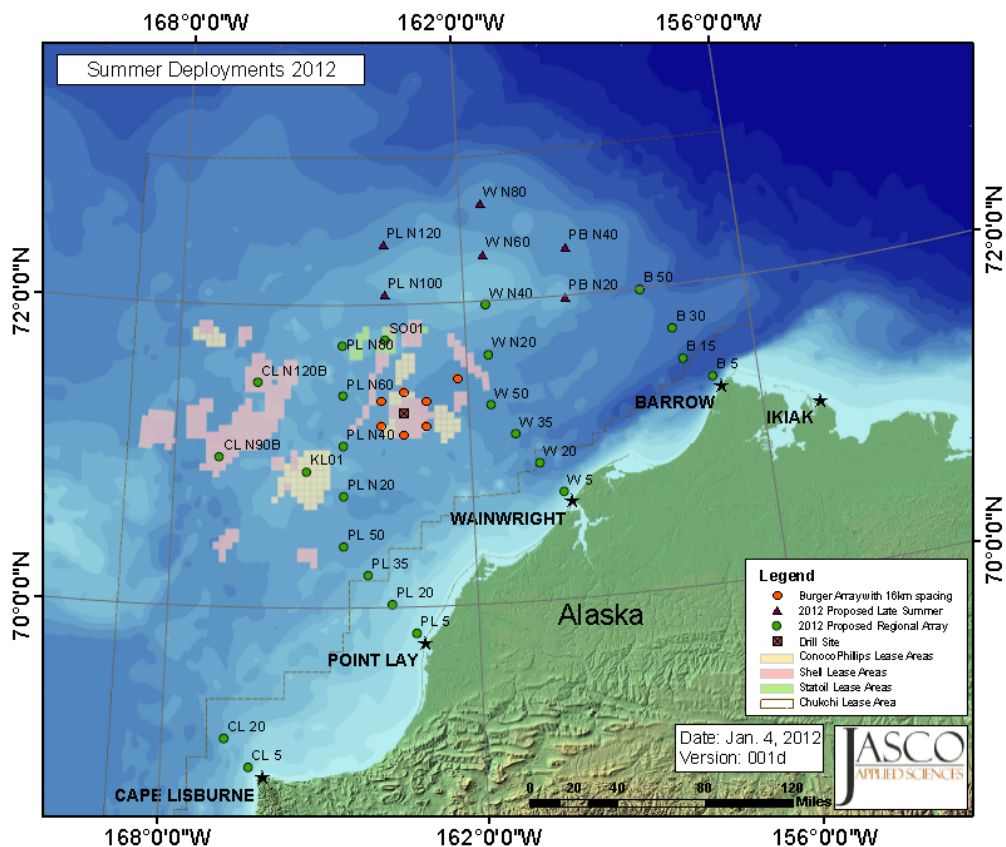


Figure 8. Proposed open water deployment locations of acoustic recorders in the eastern Chukchi Sea, Alaska 2012.

In early October, all of the regional recorders will be retrieved except for the 6 Hanna Shoal recorders, which will continue to record on a duty cycle until August 2013. An additional set of 9 Aural winter recorders will be deployed at the same time at the same locations that were instrumented in winter 2011 - 2012 (Figure 9). These recorders will sample at 16 kHz on a 17% duty cycle (40 minutes every 4 hours). The winter recorders deployed in previous years have provided important information about bowhead, beluga, walrus and several seal species migrations in fall and spring.

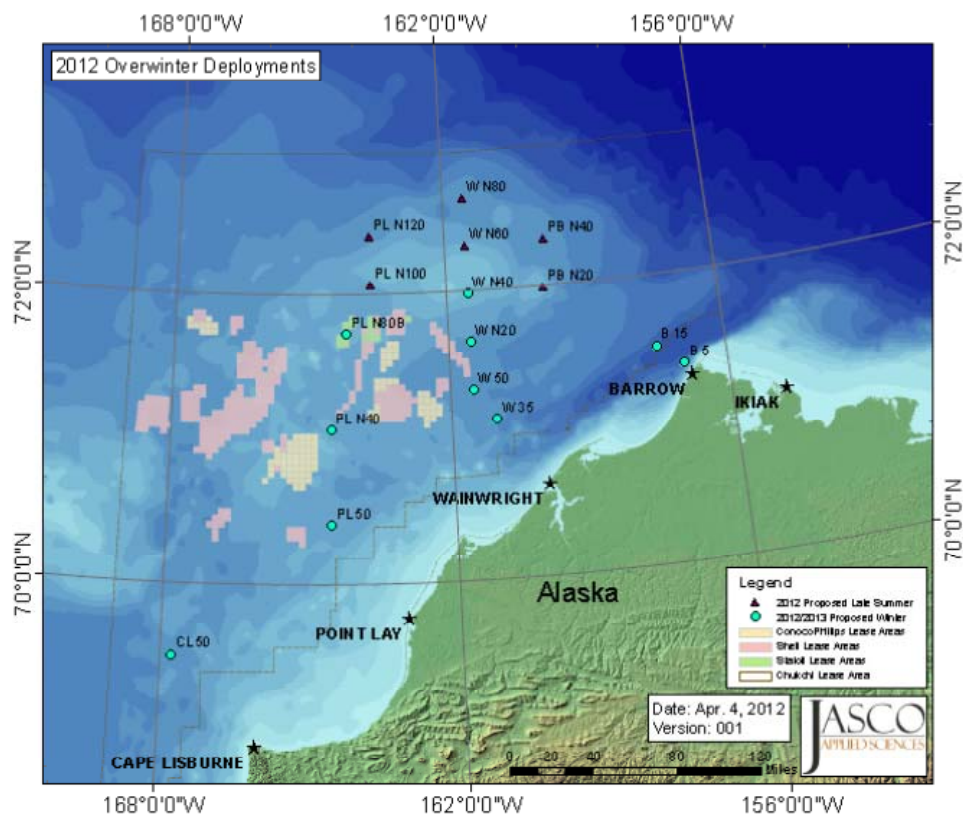


Figure 9. Proposed winter deployment locations of acoustic recorders in the eastern Chukchi Sea, Alaska 2012. The Hanna Shoal recorders (triangles) are deployed in August. The winter recorders (dots) are deployed in early October.

Analysis and Reporting

The Chukchi acoustic net arrays 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 analysis methods will incorporate automated vocalization detection algorithms that have been developed over several years. While the hydrophones 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 provides a measure of the relative spatial distribution of some marine mammal species, assuming that vocalization patterns are consistent within a species across the spatial and geographic distribution of the hydrophone array. These results therefore provide information such as timing of migrations and routes of migration for belugas and bowheads.

A second purpose of the Chukchi net array is to monitor the amplitude of exploration drilling sound propagation over a very large area. It is expected that sounds from drilling activities will be detectable on hydrophone systems within approximately 30 km of the drillship when ambient sound energy conditions are low. The drilling sound levels at recorder locations will be quantified and reported.

Analysis of all acoustic data will be prioritized to address the primary questions. The primary data analysis questions are to (a) determine when, where, and what species of animals are acoustically detected on each recorder (b) analyze data as a whole to determine offshore

distributions as a function of time, (c) quantify spatial and temporal variability in the ambient sound energy, and (d) measure received levels of exploration drilling survey events and drillship activities. The detection data will be used to develop spatial and temporal animal detection distributions. Statistical analyses will be used to test for changes in animal detections and distributions as a function of different variables (e.g., time of day, season, environmental conditions, ambient sound energy, and drilling or vessel sound levels).

2012 CHUKCHI OFFSHORE AERIAL PHOTOGRAPHIC MONITORING PROGRAM

Shell has been reticent to conduct manned surveys in the offshore Chukchi Sea because conducting those surveys on a regular basis puts people at risk. There is a strong desire; however, to obtain data on marine mammal distribution in the offshore Chukchi Sea and Shell will conduct a photographic aerial survey in 2012 that would put fewer people at risk as an alternative to the manned aerial survey. The photographic survey would reduce the number of people on board the aircraft from six persons to two persons (the pilot and copilot) and would serve as a pilot study for future surveys that would use an Unmanned Aerial System (UAS) to capture the imagery. Currently UAS are not authorized to fly in civilian airspace in the US except under very restricted conditions but legislation is in place to permit use of UAS by mid-2013. The proposed photographic surveys in the Chukchi and Beaufort Seas would collect data that will allow direct comparisons of photographic techniques for data collection with data collected by human observers aboard the aircraft. The aerial survey program in the Beaufort Sea will provide side-by-side comparisons of data collected by PSOs on the survey aircraft with digital imagery collected at the same time by still and video cameras. Surveys in the Chukchi Sea will use only digital cameras when flying offshore, but will have observers and digital data collection when the nearshore and coastline surveys are conducted. Data from surveys that use both observers and cameras will permit direct comparisons to evaluate the efficacy of the digital platform in comparison to observer collected data and development of correction factors to account for any differences between data that can be collected by PSOs and digital imagery.

Aerial photographic surveys have been used to monitor distribution and estimate densities of marine mammals in offshore areas since the mid-1980s, and before that, were used to estimate numbers of animals in large concentration areas. For example, Koski and Davis (1980), Koski et al. (2002) and Richard et al. (1990) used aerial photography to provide more precise estimates of numbers of belugas in concentration areas during aerial surveys of Lancaster Sound and Hudson Bay, respectively. Later Richard et al. (1994), Witting et al. (2005) and Heide-Jørgensen et al. (2010) used aerial photography to estimate numbers and densities of narwhals and minke whales in their survey areas.

Digital photographs provide many advantages over observations made by people if the imagery has sufficient resolution. With photographs there is constant detectability across the imagery, whereas observations by people decline with distance from the center line of the survey area, to the point that observations at the outer limits of the transect decline to 5-10% of the animals present. The distance from the trackline of sightings is more accurately determined from photographs; group size can be more accurately determined; and sizes of animals can be measured, and hence much more accurately determined, in photographs. As a result of the latter capability, the presence or absence of a calf can be more accurately determined from a photograph than by in-the-moment visual observations. Another benefit of photographs over

visual observations is that photographs can be reviewed by more than one independent observer allowing quantification of detection, identification and group size biases.

In the past, the major impediment to use of aerial photography for some studies has been the resolution of the cameras and the resulting area that can be captured on film or digital media; that is, the area recorded by a single camera was too narrow to provide sufficient sightings for meaningful analyses. Current 35 mm cameras have more pixels (5,616 pixels in horizontal resolution), and hence higher resolution, than the 70 mm cameras used during the studies described above (2,656 pixels horizontal resolution) and numbers of sightings that will be captured on film or digitally will likely match or exceed the numbers captured by humans surveying in an aircraft using current camera technologies.

During the 2012 field season Shell will conduct a photographic survey using two Cannon 5D Mk II cameras mounted in a Twin Otter to record marine mammals around their drill sites in the Chukchi Sea. A 36.6 mp Nikon D800 DSLR camera has recently been released, but due to high demand, it is not available for purchase. If we are able to obtain Nikon D800s, we will upgrade our system to the Nikon D800. In addition, a HD video camera will be tested and compared to the still camera for evaluation as a tool for real-time monitoring during future studies. An additional justification for the photographic survey is that it would obtain imagery that could be used to evaluate the ability of future studies to use the same image capturing systems in an UAS where people would not be put at risk. Although the two platforms are not the same, the slower airspeed and potentially lower flight altitude of the UAS would mean that the data quality would be better from the UAS. If the photographic approach is implemented, comparisons will be made between data collected by human observers on board both the Chukchi and Beaufort aerial survey aircraft and the digital imagery as described below in the section “Data Processing and Reporting”.

Camera Specifications

The camera that will likely be used is a Cannon 5D Mk II which is a 21.1 megapixel camera that stores imagery in a 5,616×3,744 pixel array. If it is possible to obtain a Nikon D800 cameras, they will be used and they are 36.3 megapixel cameras that store imagery in a 7,360×4,912 pixel array. If the Cannon camera is used, it will have a 20 mm lens which will cover a swath ~720 m on the water surface with one pixel representing a 12 cm square at the water surface. This pixel size is one quarter of the pixel size (25 cm square) tested by Koski et al. (2009) during their tests with a video camera for detection of kayaks and is a smaller pixel size (better resolution) than was tested by Amanda Hodgson (16.8 cm) during her surveys of humpback whales off Australia and which proved adequate for counting humpback whales in their imagery. It is expected that this resolution will permit identification of all medium and large cetaceans and counting of small cetaceans, except for perhaps harbor porpoises, and will permit counting of walrus/bearded seals. It may not permit differentiation of bearded seals from walrus, especially when they are in the water. This imagery resolution provides slightly better ability for determining species and detecting animals than people would have in an aircraft flying at 1,000 feet above sea level.

Two options are available for operation of the two cameras and the option that will be used depends on monitoring requirements for walrus. One option has one camera with the 20 mm lens pointed vertically and covering a 720 m swath and a second camera with a 100 mm lens pointed vertically covering a 144 m swath. This option provides the ability to detect marine mammals too small to reliably detected and identified during manned surveys such as ringed, spotted and

ribbon seals and harbor porpoise and to classify animals such as walrus to age/sex categories that could not be identified during manned surveys; it also permits us to accurately count walrus hauled out on ice. The longer lens would also permit accurate classification of bearded seals and female walrus which cannot be done during manned surveys in most situations. Figure 10 shows imagery taken during resolution tests by Shell at Camp Roberts, California, in December 2009. This is an example of imagery that can be obtained with a resolution of 3 cm at the water surface, which is similar to, but slightly poorer than, the 2.4 cm resolution that we propose for the camera with a 100 mm lens. A ringed seal would be about the width of the second largest square in the bottom left photograph (40 cm) and about 3 times longer.



Figure 10. Photograph taken from an UAS during resolution tests at Camp Roberts, California, during December 2009. The upper photographs were taken with a 12 megapixel camera with resolution on the ground of 2.9 cm. The colored patches in the lower left photograph vary in size from 15 cm squares to 50 cm squares and are a magnified view of the upper photograph. The lower right photograph is a magnified view of a 2 m square checkerboard with each checkerboard square 40 cm by 40 cm.

The second option is to point one DSLRs to the right and one to the left side of the trackline, with the inner edge of both cameras' field of view overlapping slightly at the centerline. This would provide coverage of a wider swath, on the order of 1,400 m, instead of 720 m. This option would increase the area being surveyed but would not collect detailed information on the individuals seen or data on smaller or more cryptic species which are currently not being systematically collected during manned surveys. The peer review panel recommended that we deploy the second option to increase the number of large cetaceans recorded during the survey. However, walrus are a major species of concern near the exploration drilling operation and if better information on walrus are required by our permits, we will use option one during July to mid-September and switch to option two in mid-September. In mid-September walrus have started to move south of the exploration drilling operation but the main bowhead whale migration through the Chukchi Sea has not begun.

The proposed aerial photographic coverage with one DSLR pointed vertically would provide an Effective Strip Width (ESW) of 360 m (720/2). The ESW for manned surveys varies depending on the species being recorded due to different physical and behavioral characteristics of the species. The ESW for bowhead whales has varied between ~500 m and ~700 m during our 2006-2010 surveys in the Beaufort Sea. The ESW for belugas in the Chukchi Sea during the same period was ~300 m and the ESW for most other species was narrower. Thus the proposed coverage using a single DSLR swath width would be slightly lower for the most obvious species such as gray whales and bowheads, but better for smaller and more cryptic species such as belugas, minke whales, harbor porpoise (which would only be detected on the camera with the 100 mm lens). During the latter part of the season the coverage with two DSLR cameras would be about the same or better than during manned surveys.

The HD video that will be used is the Canon XF305 which has 1,920×1,080 resolution. This resolution is about 3 times better in width than the NTSC video (640×480) tested by Koski et al. (2009). This will allow the video to collect constant imagery along the flight path and will not require scanning back and forth as was done during earlier tests. It will be set to capture data along a 600 m wide swath at the same resolution as was tested during the Koski et al. (2009) study. By having the camera fixed on the trackline, the problems encountered by Koski et al. (2009) of uneven coverage, short time that many areas were in view, and different pixel size when the camera was pointed to the sides will be eliminated or reduced. Options for scanning and covering smaller or larger swaths will also be tested and compared to the data from the still camera.

Route planning and data storage software are off-the-shelf products assembled by VDOS LLC. The set up includes a harness to connect the camera and GPS to the Photo Coupler Controller which is connected to a GPS for triggering capture of images and recording of metadata for each image (Figure 11). The system can be powered by 10-32 volt DC or a custom power source and has a back-up battery power source to prevent interruption to data capture. Acquisition of imagery can be controlled from a laptop and/or preprogrammed route plan and there is live view of what the sensors are viewing on the water surface.

The system is "plug-and-play" and does not require input from persons on board the aircraft during the flight. The system can be pre-programmed to take photographs starting and stopping at predetermined locations or times. A laptop computer in the cockpit can be used to override the preprogrammed instructions and take additional images whenever desired.



Figure 11. Camera mount and associated data storage and control devices that can be mounted as a module in a Twin Otter.

Survey Timing and Frequency

Photographic surveys would start as soon as the ice management, anchor handler and drillship are at or near the first drill site and would continue throughout the drilling period and until the drilling related vessels have left the exploration drilling area. Since the current plans are for vessels to enter the Chukchi Sea about 1 July, surveys would be initiated on about 3 July. This start date differs from past practices of beginning five days prior to initiation of an activity and continuing until five days after cessation of the activity because the presence of vessels with helidecks in the area where overflights will occur is one of the main mitigations that will allow for safe operation of the overflight program this far offshore. The surveys will be based out of Barrow and the same aircraft will conduct the offshore surveys around the drillship and the coastal saw-tooth pattern. Two surveys around the drillship and one survey of the nearshore sawtooth transects will be conducted each week, weather permitting. The surveys of offshore area around the drillship will take precedence over the sawtooth survey, but if weather does not permit surveying offshore, the nearshore survey will be conducted if weather permits.

Surveys in the Chukchi Sea are planned to start about 3 July to collect information on animal distribution before the first vessels enter the Chukchi Sea in early July. As in past years, we anticipate that we will not be permitted to fly the southern part of our survey grid near Point Lay before the end of the Beluga hunt, which normally ends in late June to early July. In past years permission to fly in that area has been granted about 15 July so surveys during 3 July to 15 July will be restricted to photographic surveys around the offshore exploration drilling operation

or nearshore and coastal surveys from south of Wainwright to Barrow. A 3 July start date for surveys may not however be possible if Search and Rescue capability along the Chukchi Sea coast is not available at that time. Additionally, vessels associated with the exploration drilling program may not yet be in the area. Should an aircraft go down having multiple vessels in the area to help with rescue operations could be extremely important.

Survey Pattern

The survey grid will be designed to cover a circular area with a radius 40 km around the drillship as shown in Figure 12. Transects will be spaced 7.2 km apart which will allow even coverage of the survey area during a single flight if weather conditions permit completion of a survey. A random starting point will be selected for each survey and the evenly spaced lines will be shifted NE or SW along the perimeter of the circular survey area based on the start point. The total length of survey lines will be about 1,200 km and the exact length will depend on the location of the randomly selected start point.

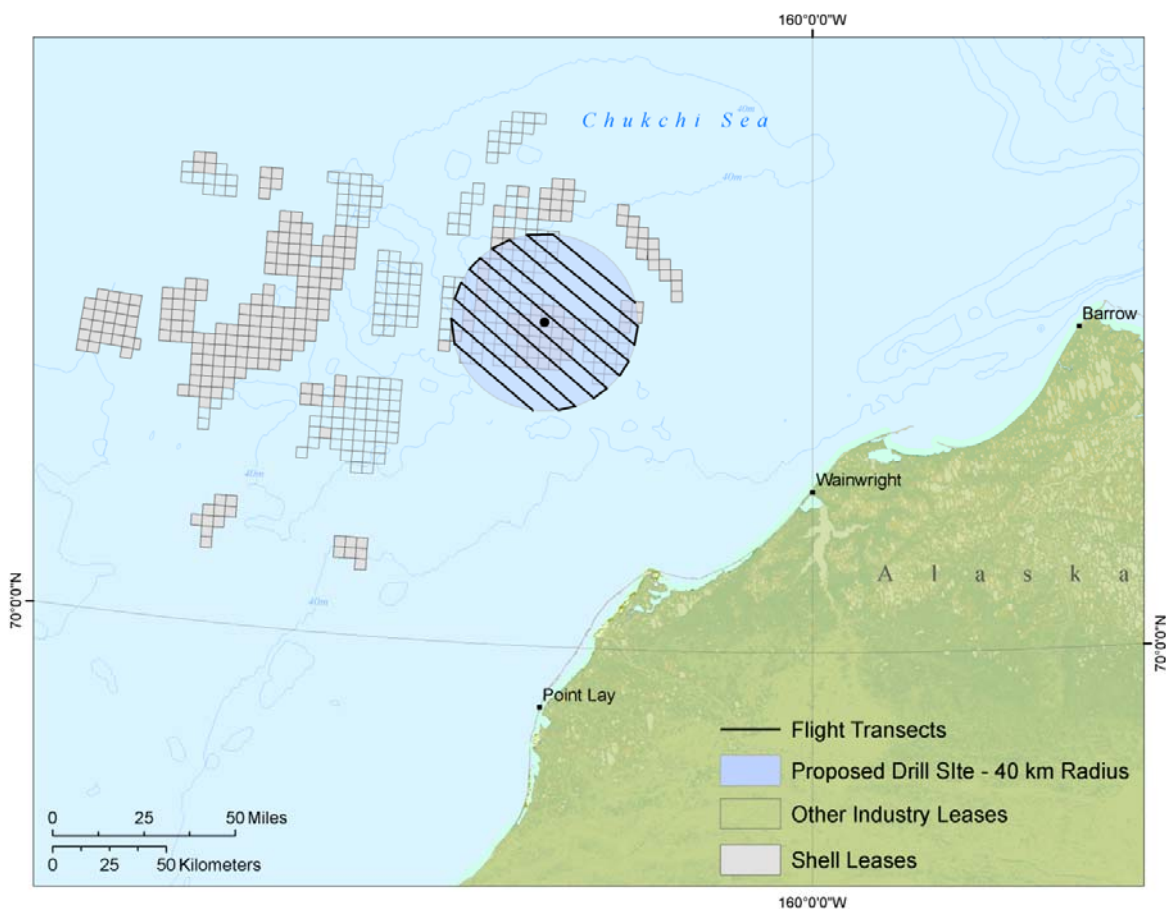


Figure 12. Aerial photographic survey design for the Chukchi Sea drill sites. This design maximizes the area covered in a single flight and assumes 7.2 km between transect lines.

Data Analyses

Following each survey, the imagery will be backed up on a second hard drive and stored at accommodations in Barrow until it can be transferred to Anchorage. The survey crew conducting the nearshore sawtooth surveys will conduct analyses of the photographic, and video

imagery when time permits while they are in the field. Because nearshore surveys will be conducted only 1-2 days per week or less (they will be secondary to the offshore survey), PSOs will have time to conduct preliminary analyses of the imagery while in the field. The survey crew will make a single pass through the imagery and enter the data into the same database format as is used for the manned aerial surveys and the photographic sightings will be reported in the same manner as the other PSO sightings. Programs to assist in the finding and identification of marine mammals in the imagery will not be available for the 2012 field season, but imagery obtained during 2012 will be used to develop those programs for future studies. If time permits, a second review of the data will be conducted while in the field, but the sightings recorded during the second pass will be identified in the database as secondary sightings, so that biases associated with the detection in the imagery can be quantified. If time does not permit that review to be conducted while in the field, the review will be conducted by personnel in the office during or after the field season.

Verification of Imagery

Shell will install the same HD video and DSL camera system in a Twin Otter that will fly aerial surveys around their exploration drilling program in the Beaufort Sea. In the Beaufort Sea, we will use two cameras with 20 mm lenses to cover a swath 700 m on both sides of the flight line. That swath is equal to or greater than the ESW of observers during manned flights which will facilitate comparisons between the two data collection methods. That aircraft will have visual observers recording data using the same procedures as during earlier aerial surveys conducted in the Alaska Arctic. In addition, the digital imagery will also be collected during the nearshore surveys in the Chukchi Sea. This will permit a direct comparison of data collected by people on board an aircraft with data from digital photographs taken during the same survey. These comparisons will include, but not be limited to, the number and species detected by each method at each distance from the trackline, species identification, densities calculated using sightings data from each method allowing for appropriate correction factors, and comparison of age class and sex, when determinable, of sightings. The imagery will be reviewed two or more times to quantify biases associated with detectability of sightings in the digital imagery and to develop correction factors that can be used to account for missed sightings during single reviews of the imagery.

Other Imagery and Sensors

In addition to the imagery indicated above, Shell is examining systems that are in development that would allow collection of additional imagery. They include collection of multi-spectral/hyperspectral imagery and a multi-camera system that would allow collection of imagery over a wider area. If these systems are ready for testing in 2012, Shell will attempt to incorporate these systems into the Chukchi Sea program.

Shell is also considering adding other types of sensors to the survey aircraft. One of these sensors, a sea surface temperature sensor, was tested successfully during 2009 surveys in the Canadian Beaufort Sea. We will be installing one of these sea surface temperature sensors on each of our aerial survey aircraft in 2012.

CHUKCHI SEA COASTAL AERIAL SURVEY

Nearshore aerial surveys of marine mammals in the Chukchi Sea were conducted over coastal areas to approximately 23 miles (mi) [37 kilometers (km)] offshore in 2006–2008 and in 2010 in support of Shell’s summer seismic exploration activities. These surveys provided data on the distribution and abundance of marine mammals in nearshore waters of the Chukchi Sea. Shell plans to conduct these nearshore aerial surveys in the Chukchi Sea in 2012 as opportunities unfold and those surveys will be similar to the previous programs. As noted above, the first priority will be to conduct photographic surveys around the offshore exploration drilling activities, but nearshore surveys will be conducted whenever weather does not permit flying offshore, or after two complete surveys have been conducted of the offshore survey area for that week. The nearshore survey will be initiated about 3 July at the same time as the offshore photographic survey around the planned exploration drilling operation subject to previously indicated conditions. As in past years, surveys in the southern part of the nearshore survey area will depend on the end of the beluga hunt near Point Lay. In past years, Point Lay has requested that aerial surveys not be conducted until after the beluga hunt has ended and so the start of surveys has been delayed until mid-July.

Alaskan Natives from 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 exploration activities 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, Point Lay, Wainwright and Barrow. Other species of concern in the Chukchi Sea include the gray whale, bearded, ringed, and spotted seals, and walrus. Gray whale and harbor porpoise are expected to be the most numerous cetacean species encountered during the proposed aerial survey, although harbor porpoise are difficult to detect from aircraft. Beluga whales may occur in high numbers early in the season. 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 but will be limited in its ability to collect similar data on pinnipeds and harbor porpoises because they are not reliably detectable during surveys conducted at 305 m above sea level.

Objectives

The aerial survey program objectives in 2012 will be:

- to collect data on the distribution and abundance of marine mammals in coastal areas of the eastern Chukchi Sea;
- 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; and
- to collect marine mammal sighting data using PSOs and digital media and compare the data recorded by the two methods.

Survey Considerations

With agreement from hunters in the coastal villages, manned aerial surveys of coastal areas to approximately 23 mi (37 km) offshore between Point Hope and Point Barrow will begin in early July and will continue until exploration drilling operations in the Chukchi Sea are completed. In past years, it has been required that no surveys be conducted in the southern part of

the survey area until after the beluga hunt is confirmed to be over, which has been about mid-July. Weather and equipment permitting, nearshore surveys will be conducted once per week during this time period or more often depending on our ability to fly offshore. In addition, during the 2012 exploration drilling season, aerial surveys will be coordinated in cooperation with the aerial surveys funded by BOEM and conducted by NMFS and any other groups conducting surveys in the region.

Survey Procedures

Transects will be flown in a saw-toothed pattern between the shore and 23 mi (37 km) offshore as well as along the coast from Point Barrow to Point Hope (Figure 13). This design will permit completion of the survey in one to two days and will provide representative coverage of the nearshore region. Sawtooth transects were designed by placing transect start/end points every 34 mi (55 km) along the offshore boundary of this 23 mi (37 km) 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. The coastline transect will simply follow the coastline or barrier islands. 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.

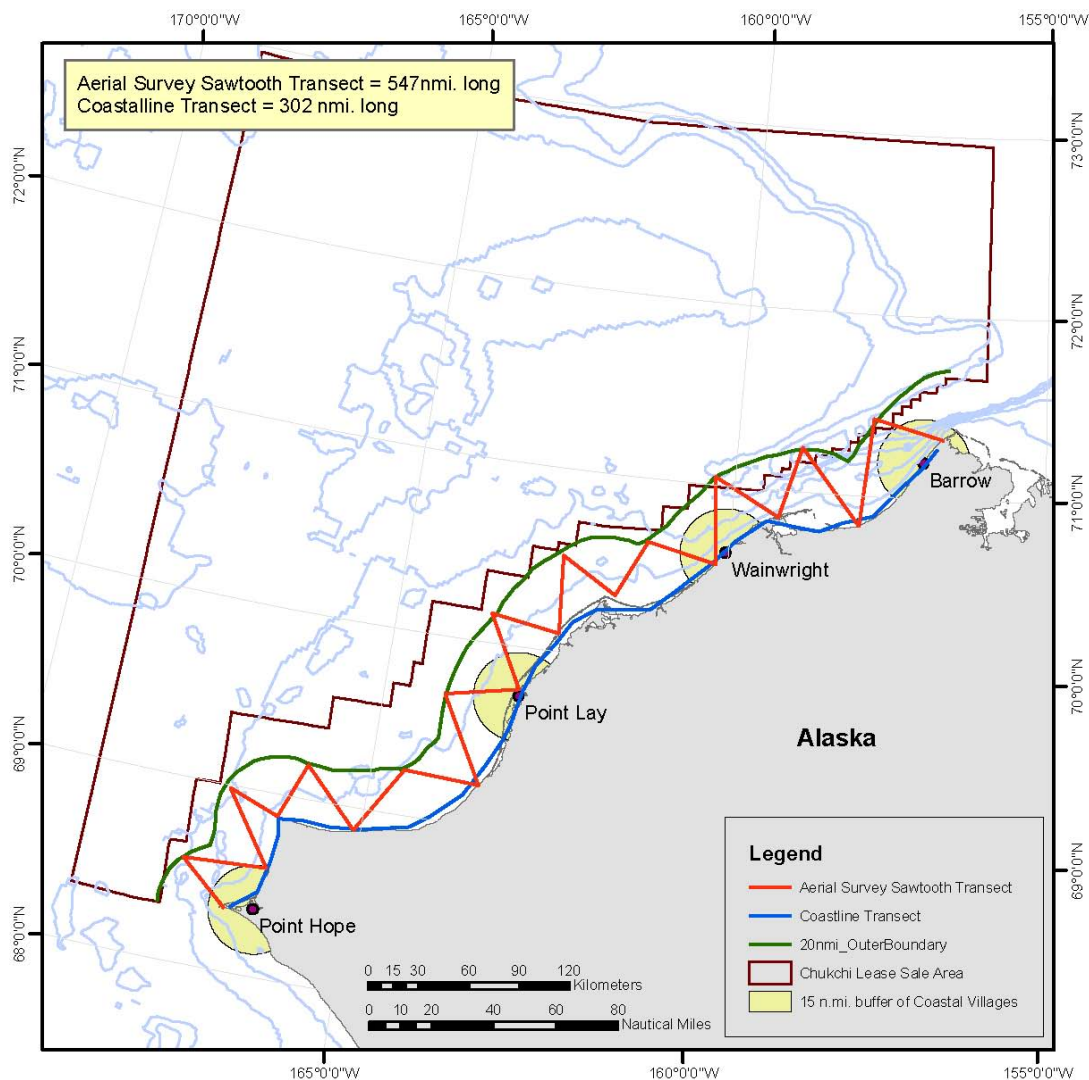


Figure 13. Aerial survey transects location and general pattern for the eastern Chukchi Sea, 2012. Specific transect start-/end-points will be altered randomly from survey to survey, and hunting areas will be avoided when hunting is occurring.

Standard aerial survey procedures used in previous marine mammal projects (by Shell as well as by others) will be followed. This will facilitate comparisons and (as appropriate) pooling with other data, and will minimize controversy about the chosen survey procedures. The aircraft will be flown at 110–120 knots ground speed and usually at an altitude of 1,000 ft (305 m). In accordance with anticipated stipulations in the LOA, survey aircraft will be flown at 1,500 ft (457 m) over the LBCHU after 1 July. Aerial surveys at an altitude of 1,000 ft (305 m) do not provide much information about seals but are suitable for bowhead, beluga, and gray whales. The need for a 1,000+ ft (305+ m) or 1,500+ ft (454+ m) 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 during which surveys would be possible, impairing the ability of the aerial program to meet its objectives.

The surveyed area will include waters where belugas are normally available to subsistence hunters. If large concentrations of belugas are encountered during the survey, the survey may be

interrupted to photograph the groups to obtain better counts of the number of animals present. If whales are photographed in lagoons or other shallow-water concentration areas, the aircraft will climb to ~10,000 ft (3,050 m) altitude to avoid disturbing the whales and cause them to leave the area. If whales are in offshore areas, the aircraft will climb high enough to include all whales within a single photograph; typically about 3,000 ft (914 m) 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 (see Richardson et al. 1995 for a review). They frequently leave shallow estuaries when over flown at altitudes of 2,000–3,000 ft (610-904 m), whereas they rarely react to aircraft at 1,500 ft (457 m) 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 and 2010, we will attempt to photograph the animals and provide location information to interested stakeholders.

Five PSOs will be aboard the aircraft during surveys. Two observers (primary observers) will be looking for marine mammals within 2.5 km of the survey track line; one at a bubble window on each side of the aircraft. A third person will record data and a fourth person will rest and alternate with the other observers throughout the flight so that none of the primary observers are on duty for more than two hours at a time. The fifth observer will serve as an ice observer and will record data pertinent to Shell's ice observation program. 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. The sighting information and additional data on each sighting will be entered into a digital voice recorder and entered into the database after the survey and will be used to check the data entry during the survey.

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 conditions (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 on the probability of detecting animals (see Davis et al. 1982; Miller et al. 1999; Thomas et al. 2002, Manly 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 custom GPS recording and data entry software. The computer will automatically store the time and aircraft position at pre-selected intervals (typically at 6 seconds for straight-line transect surveys) and store the records to a file as they are obtained. Records can be edited or supplemented while in flight or after the flight.

Coordination with Other Aerial Surveys

The BOEM, the NMFS, the USFWS, the NSB, or other organizations may also conduct aerial surveys in the Chukchi Sea during the exploration drilling season. Shell will consult with any groups or organizations conducting aerial surveys along the eastern Chukchi Sea coast regarding coordination during the exploration drilling season. The objectives will be:

- to ensure aircraft separation when both crews conduct surveys in the same general region;
- to coordinate the 2012 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

During the field program, preliminary maps and summaries of the daily surveys will be provided to NMFS as normally required by the terms of the IHA. While in the field, data will be checked for entry errors and files will be backed up to CDs or portable memory drives and transferred to the office in Anchorage via the internet. Reporting of results will focus on the distribution of the observed species along the coast and the seasonal timing (if any) of the observed species.

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

Following the 2012 exploration drilling season a comprehensive report describing the acoustic, vessel-based, and aerial monitoring programs will be prepared. The comprehensive report will describe the methods, results, conclusions and limitations of each of the individual data sets in detail. The report will also integrate (to the extent possible) the studies into a broad based assessment of industry activities and their impacts on marine mammals in the Chukchi Sea during 2012. The report will help to establish long term data sets that can assist with the evaluation of changes in the Chukchi 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.

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