MARINE MAMMAL MONITORING AND MITIGATION PLAN: SUPPLEMENT TO THE REQUEST FOR AN INCIDENTAL HARASSMENT AUTHORIZATION FOR THE NON-LETHAL TAKING OF MARINE MAMMALS IN CONJUNCTION WITH A PROPOSED MARINE 2D SEISMIC PROGRAM
CHUKCHI SEA, ALASKA, 2013

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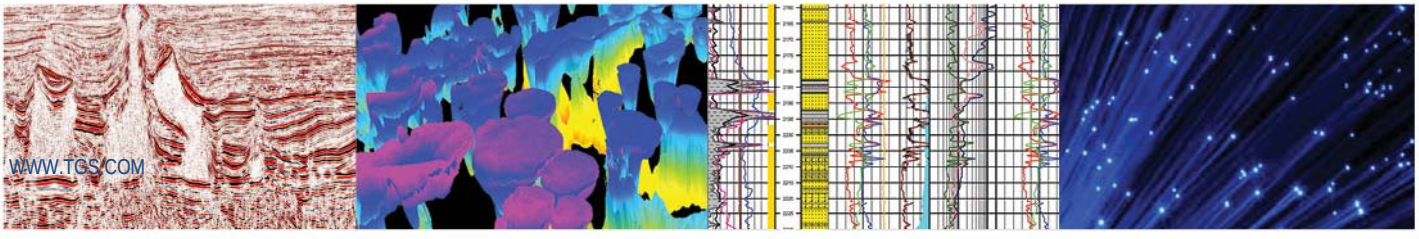

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ACRONYMS AND ABBREVIATIONS

2D	two-dimensional
4MP	Marine Mammal Monitoring and Mitigation Plan
AIS	Automatic Identification System
APSO	Acoustic Protected Species Observer
BOEM	Bureau of Ocean Energy Management
dB	decibel
dB re 1 µPa@1m	Decibels relative to 1 microPascal at 1 meter depth
FAA	Federal Aviation Association
ft	feet/foot
HSE	health, safety, and environment
IHA	Incidental Harassment Authorization
in^3	cubic inch
JASCO	JASCO Applied Sciences
kHz	kilohertz
km	kilometer(s)
LOA	Letter of Authorization
m	meter(s)
mi	mile(s)
MMPA	Marine Mammal Protection Act of 1972
nm	nautical mile
NMFS	National Marine Fisheries Service
NMML	National Marine Mammal Laboratory
NVD	night-vision devices
PAM	Passive acoustic monitoring
PSO	Protected Species Observer
rms	root mean square
SSV	sound source verification
TMA	targe motion analysis
UAV	unmanned aerial vehicles
USFWS	U.S. Fish and Wildlife Service
walrus	Pacific walrus
VPSO	Visual Protected Species Observer

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Executive Summary

TGS plans to conduct a two-dimensional (2D) marine seismic survey in the Chukchi Sea during the 2013 open-water season using a 3,280 cubic inches (in^3) towed airgun array. Seismic acquisition will take place in U.S. Federal waters and international waters (Figure 1).

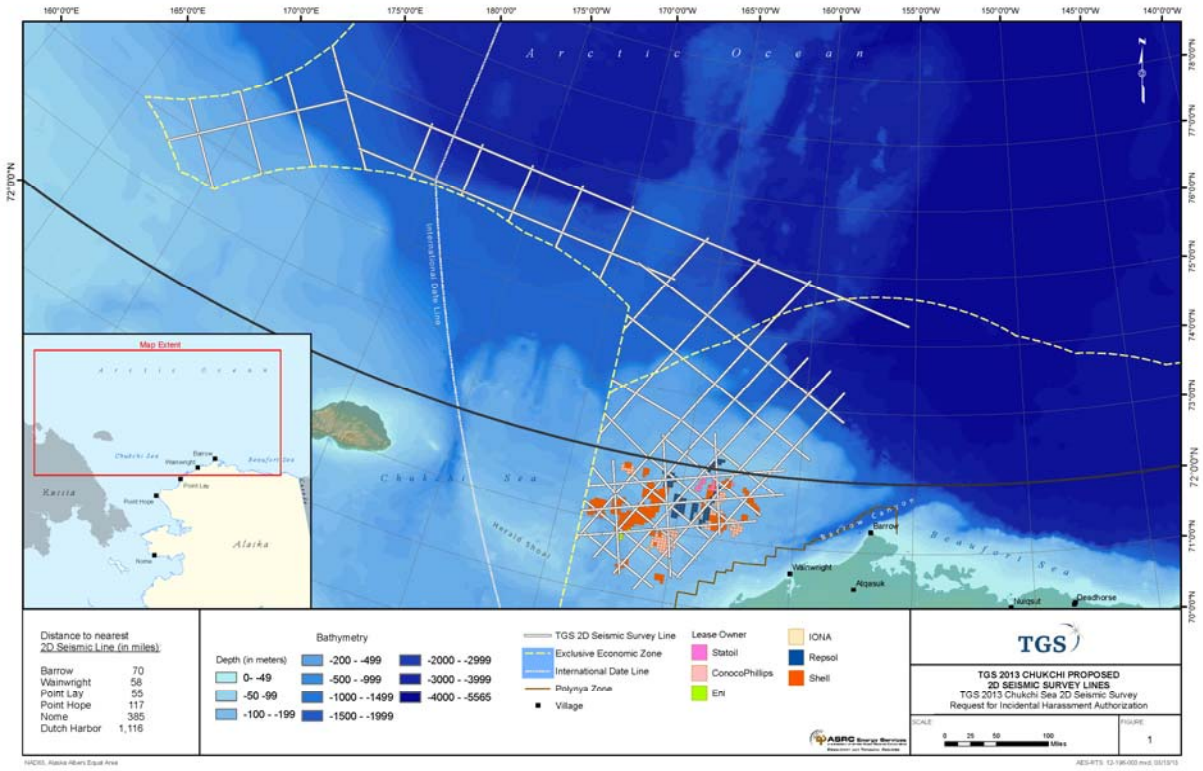

Figure 1. Proposed seismic survey lines for TGS 2D seismic survey project during the 2013 open water season in the Chukchi Sea

This marine mammal monitoring and mitigation plan (4MP) is being submitted to the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) to supplement TGS's Incidental Harassment Authorization (IHA) and Letter of Authorization (LOA) applications for the incidental taking of marine mammals in conjunction with a 2D seismic program. TGS submitted their final IHA application to NMFS on March 29, 2013 and submitted their LOA application to USFWS in April 2013.

Seismic operations are proposed to occur on approximately 68 days (35 days in U.S. Federal waters and up to 33 days in international waters) sometime between July 15 and October 31, 2013 (depending on ice and weather conditions).

TGS's seismic acquisition timing and locations are proposed so as to minimize potential impacts to marine mammal migrations and peak abundance periods, and subsistence hunts. For example, the closest survey point to an Alaskan community is 88 kilometers (km) (55 miles [mi]) west of Point Lay, and most lines are well over 200 km (125 mi) away to the northwest including in international waters. During proposed summer seismic operations, bowhead and beluga whales are predominantly east of the project area in the Beaufort Sea. During the fall bowhead and beluga migration periods, seismic operations are

scheduled to occur above 72°N and thus north and outside of the main known migration corridor. Project operations require open water, thus the two project vessels will avoid ice habitat associated with many marine mammal species. Reported densities of marine mammals in the project area are relatively low during the majority of the survey, particularly in more northern waters. In general, based on available studies, exposures of marine mammals to project-generated sounds above the NMFS-promulgated 160 decibel (dB) re 1 μPa (rms) "take" isopleth for impulsive noise are expected to be temporary [note that all dB references in this document refer to dB re 1 μPa (rms) unless otherwise noted]. These potential exposures would be expected to result in no more than short-term behavioral changes or displacement of individuals within ensonified zones associated with seismic operations. No biologically significant impacts to marine mammal populations are expected.

1.0 Introduction

TGS's monitoring methods in both U.S. Federal and international waters involve the following measures:

1. At least five vessel-based visual Protected Species Observers (VPSOs) stationed aboard the seismic vessel to visually monitor (generally two VPSOs at one time) the "near field" 180 dB and 190 dB exclusion zones, for cetaceans and pinnipeds, respectively.
2. At least three VPSOs and four acoustic monitoring PSOs (APSOs) aboard the scout vessel to monitor the "far-field" 160 dB disturbance zone. This will augment near-field observations both visually, with additional VPSOs, and acoustically, with a towed hydrophone array and APSOs.
3. VPSO use of 7x50 reticle binoculars and one pair high-powered "big eyes" binoculars (25x150) mounted on both vessels. Rugh et al. (2002) showed that VPSOs can successfully monitor distances up to 10 km (6.2 mi) from a 20 meter (m) (65.6 foot [ft]) platform. TGS's modeled 180 dB rms re 1 µPa exclusion zone is between 2.2 and 2.5 km (1.4 and 1.6 mi) from the seismic source and big-eyes are planned to be mounted at bridge level or higher on the proposed source vessel (estimated at 17 m [55.8 feet] or more). Therefore, under satisfactory weather conditions VPSOs should theoretically be able to visually monitor the entire 180 dB zone from the seismic vessel.
4. The use of custom Mysticetus™ software to facilitate efficient, accurate (instant error-checking), real-time data collection and inter- and intra-platform map display of marine mammal sightings and vessel locations, tracks, times, and headings and distance from the seismic source (via Automatic Identification System [AIS] technology). Visual platforms on both vessels and the PAM station platform are anticipated to have nearly instantaneous map-display sharing capabilities via this technique. This is expected to improve efficiency of communications related to potential marine mammal mitigation (e.g., power downs and shut downs).

Based on several discussions, NMFS recommended that TGS should consider additional monitoring techniques for VPSOs on the seismic and scout vessel as had been originally proposed by TGS for the entire survey area, including waters north of 72°N. Therefore, TGS conducted an extensive evaluation of far-field monitoring options identified by the NMFS Peer Review Panel as well as other experts in these realms. The monitoring options evaluated are listed below.

1. a second scout vessel;
2. manned aerial surveys monitored by VPSOs;
3. unmanned aerial vehicles (UAV);
4. fixed autonomous acoustic recorders (fixed-PAM);
5. sonobuoys; and
6. a towed acoustic hydrophone array (towed-PAM).

TGS concluded that among the above options, using a towed hydrophone array is the most effective approach in terms of:

- near- and far-field real-time mitigation;
- real-time and post-survey monitoring;
- knowledge and data gained;
- feasibility;
- logistics; and

- cost.

Rationale for this conclusion is explained below under each specific method.

1. Second Scout Vessel

TGS evaluated the option of using a second scout vessel to monitor the 160 dB zone. However, this option was eliminated due to the high costs associated with vessel operations.

2. Manned Aerial Surveys

Aerial monitoring by VPSOs was eliminated as an option for monitoring waters north of 72°N, as the safety risk is too high due to the great distance (200-605 nautical miles [nm] [230-700 mi]) from shore.

3. Unmanned Aerial Vehicles

TGS evaluated the option of using a UAV to monitor the 160 dB zone in waters north of 72°N. TGS understands this technology is improving and there is much interest in using it for marine mammal monitoring, However, they decided this option would not be the most efficient monitoring method for their program because of logistical constraints and health, safety, and environmental (HSE) concerns. Upon moving to waters north of 72°N, the scout vessel crew would need to switch from a towed-PAM system to the UAV system. This would require either:

- two crews proficient in both technologies present on board for the entire duration of the seismic program, resulting in significantly increased expense and HSE exposure risk to personnel; or
- an additional transit back to shore to switch the towed-PAM crew out with the UAV crew. If the timing of this crew change was not able to be aligned with the TGS-scheduled crew change (e.g., if the scheduled crew change occurred before moving north of 72°N), it would require a separate transit to shore resulting in increased HSE exposure risk to personnel. This would also increase the potential for interference with subsistence users nearshore.

In addition, this approach requires a Federal Aviation Association (FAA) permit to operate in the Arctic, and securing of this permit could not be guaranteed in time for the TGS monitoring effort.

4. Fixed Autonomous Acoustic Recorders (Fixed-PAM)

TGS also evaluated the option of using moored autonomous acoustic recorders (fixed-PAM), to monitor the 160 dB zone in waters north of 72°N. Specifically, the NMFS Peer Review Panel recommended that fixed-PAM be deployed for a year. NMFS indicated this approach would be acceptable for these waters, given the logistical complexity and infeasibility of other options associated with the great distance from shore. However, this approach greatly increases the complexity and expense of logistics and scheduling of specialized staff, even more so than Unmanned Aerial Vehicles. The use of fixed autonomous acoustic recorders would require using the scout vessel (or hiring a third vessel) to:

- deploy the recorders upon arrival in the Chukchi Sea in late July or early August (preferred) in an area along the shelf edge north of the southeastern corner of the survey area where TGS proposes to start seismic operations. If the scout vessel were used for deployment, the scout vessel would need to arrive at the survey area in advance of the seismic vessel so as not to avoid delaying seismic operations. If this were not possible, seismic operations would need to be delayed for the approximately 5-days while required for the scout vessel (required to monitor during all seismic operations) traveled north to deploy multiple recorders at multiple locations.
- retrieve the recorders at the end of the survey; and/or

- retrieve the recorders in 2014 although TGS does not plan to operate in 2014.

Furthermore, it is likely that waters north of 72°N will still be iced in at the start of seismic operations, resulting in the necessity of the scout vessel leaving the seismic ship for the ~5-day recorder deployment period. There would be a large expense for the seismic vessel to stand by for the scout vessel's return and an even greater expense and HSE exposure risk for a third vessel to be brought on. A third vessel would require a longer transit (approximately 10 days round trip) dependent on the port it departs from.

Fixed-PAM technology allows for longer-term marine mammal detections over a fixed area. However, given the large size of the project area north of 72°N, it is not feasible to cover the far-field 160 dB zone with the three to four proposed recorders that NMFS considered an acceptable number. (The detection range of fixed-PAM recorders for bowheads is estimated to be no more than 10-20 km (6.2-12.4 mi), while the east-west range of survey lines north of 72°N spans several hundred km—see Figure 1).

The recorders would instead be placed in a small area identified as important by bio-acousticians and biologists experienced in the Chukchi and Beaufort seas (including members of the NMFS Peer Review Panel). The recorder deployment location would be in the northern portion of TGS' project area. TGS would attempt to deploy the recorders upon arriving in the area after it becomes clear of ice and retrieve them at the end of its 2013 survey.

However, based on previous studies, recorders are recommended to stay out for a year (Hannay[1] *Pers. Comm.*). To accommodate this, TGS would then need to hire a vessel in 2014 to retrieve the recorders as they currently have no plans to operate in the same project area in 2014. Due to the remote, Arctic location, the vessel costs for retrieval would be significant. Consultations with acoustic contractors indicate that data collected from recorders retrieved near the end of the 2013 survey could be analyzed preliminarily in time for the 90-day report, and the same recorders re-deployed for the remainder of the year (with new hard drives/memory components), but 2013 data retrieval may not be possible due vessel availability and weather conditions.

Additionally, a large concern with most fixed-PAM technology is it is not real-time. TGS investigated this option and discussed the relatively new technology (real-time fixed-PAM via satellite transmission of data) with developers. The developers did not recommend the technology because the it is still in the research and development stages. Furthermore, while TGS understands fixed-PAM has proven to be valuable in providing data on the distribution and abundance of marine mammals; this option would not be the most effective in monitoring the far-field 160 dB zone during TGS's seismic program. The logistics would be much more complex and result in a higher cost than towed-PAM.

5. Sonobuoys

TGS evaluated the option of deploying sonobuoys to monitor marine mammals in waters north of 72°N. Although sonobuoys have good low-frequency sensitivity and the ability to localize with two to three sonobuoys deployed, the radio signals can only be received and recorded from a vessel up to a 18 km away (11.2 mi) depending on the height of the receiving antenna on the vessel, atmospheric conditions, and swell height (McDonald 2004, Miller 2012). In addition, and also depending on environmental conditions, the detection range of bowhead whale calls is typically less than 5-10 km (3.1 to 6.2 mi); less for most other Arctic marine mammal species. TGS would have to deploy many sonobuoys to obtain half- to full-time coverage of the expansive project area assuming the recording vessel was underway. For example, if TGS were to deploy two sonobuoys per day during 35 days of seismic acquisition north of 72°N, 70 sonobuoys would be needed to cover the entire distance and area. Several issues are raised:

- The cost of deploying the "disposable" units (approximately $1,500 per unit);

[1] Dave Hannay. JASCO Applied Sciences. March 2013.

- A potential lack of sufficient storage/deck space to store the units;
- Retrieval of sonobuoys would be unfeasible and time prohibitive, meaning the sonobuoys would be left in the sea as litter;
- The short life time (maximum eight hours) of the sonobuoys; and
- The relatively short radio-reception range of sonobuoys combined with the approximate 5-10 km detection range of acoustic signals of bowheads from the sonobuoy. The scout vessel would need to stay near the sonobuoys in order to receive radio-transmitted data and record marine mammal sounds from the sonobuoys.

These limitations prevented TGS from using sonobuoys.

6. Towed Acoustic Hydrophone Array (Towed-PAM)

TGS evaluated a towed-PAM array option that would deploy the array from the scout vessel, and monitor the 160 dB zone in waters north of 72°N. NMFS raised concerns regarding the ability of towed-PAM to localize marine mammals and the potential for vessel noise to mask marine mammal calls. TGS consulted with two different towed-PAM experts and understands there have been recent technological improvements for detection and localization of marine mammals. However, more complex systems are usually more costly and in some cases less reliable. Such complex systems may improve precision or reliability of localizations (i.e., allow instantaneous localizations, or resolve left/right ambiguity). However, some of these issues can be compensated for in towed-PAM by study design. For example, left/right ambiguity inherent in line array localizations of vocalizing marine mammals may be resolved by turning the tow (scout) vessel to confirm which side the animal is on. Furthermore, for monitoring purposes resolving the left/right ambiguity is not necessary to determine the distance of the calling animal to the vessel. This distance can be determined with left/right ambiguity.

In 2010, JASCO Applied Sciences (JASCO) analyzed the feasibility of using a towed-PAM array to detect and localize marine mammals in the presence of vessels in the Chukchi Sea (McPherson et al. 2012). The towed-PAM was deployed from the monitoring vessel during nighttime of September 27-30, 2010 and continuously from October 1-4, 2010 between 70° and 72°N (mostly within 71° and 72°N). The towed-PAM was able to detect both bowhead and beluga whale calls. The report states that bowheads were detected at a range of up to four nautical miles (nm) (7.4 km) using the towed-PAM array.

The NMFS Peer Review Panel emphasized they would like to see more data on bowhead and beluga whale locations and movement corridors in waters north of 72°N , as little is known about their (or other marine mammals') habits and distribution there. Use of a towed-PAM array during the TGS seismic survey is anticipated to provide such data on a much wider geographical scale (across the whole project area) than moored autonomous recorders could (localized areas of the project area). Furthermore, towed-PAM array would allow acoustic monitoring specifically during and near TGS seismic activity and specifically within and near the 160 dB radius as required and specified by NMFS for seismic monitoring.

For monitoring the far-field in waters north of 72°N, TGS believes a towed-PAM system, in combination with VPSOs on the source and scout vessels, 25x150 "big-eye" binoculars, and custom software (Mysticetus^{TM}) designed for logging and mapping marine mammal observation data using AIS is the most safe and logistically, scientifically, and cost-effective monitoring approach. This approach

- meets the intent of the Marine Mammal Protection Act (MMPA);
- fulfills the goals of NMFS as they have been described to TGS;

- is the most reliable, effective, and logistically feasible option for real-time monitoring in the large, harsh remote project area to be surveyed by TGS north of 72°N;
- assists in real-time mitigation; and
- provides useful information via post-survey analyses.

In summary, while fixed-PAM can record over an extended period (usually at the trade-off of a reduced duty cycle), it is limited to a fixed, relatively localized area (when compared to the entire area that can be surveyed with towed-PAM). Furthermore, unlike towed-PAM, fixed-PAM currently has very limited ability for reliable and cost-effective real-time monitoring capabilities. Manned aerial surveys are limited by distance from shore and thus safety constraints, while unmanned aerial surveys are limited by technological, logistical and FAA regulatory constraints. Sonobuoys are unable to be monitored continuously for long periods or over large areas because of limited radio-signal range and battery duration, and the number of sonobuoys required to do so; sonobuoys also leave associated debris in the marine ecosystem. Thus, TGS believes it would be most conservative from a safety standpoint and more logistically practicable and cost-effective to use VPSOs on both vessels and towed-PAM and APSOs on the scout vessel for mitigation and monitoring throughout the program.

2.0 Mitigation

The planned 2D seismic survey has been designed to minimize impact to marine mammal species and subsistence hunts as identified in Table 1. However, the survey schedule and plan are dependent on weather and sea-ice conditions and therefore may require modification. Mitigation methods summarized below will be employed to ensure avoidance of, or minimal impact to marine mammals and subsistence activities. Additionally, TGS does not anticipate interaction with other operators. However, TGS will maintain a minimum spacing of 24 km (15 mi) between all active seismic vessels. TGS will make every effort to acquire the lines that are located nearest to any projected drilling locations prior to the arrival of a drilling vessel. If a drilling vessel is occupying a location prior to the acquisition of the seismic line, TGS will maintain a safety radius from the drilling vessel agreed upon with the operator of the drilling vessel.

Table 1. Marine mammal and subsistence mitigation measures resulting from the TGS 2D seismic survey design

Proposed Plan	Timeframe (2013)	Resulting Mitigation
Start of seismic operations	Late-July or early-August (depending on ice conditions and weather)	After spring whale hunt complete
Remain in ice-free waters	Throughout survey	Avoid most encounters with ice-associated ice-seals, walruses, and polar bears
Survey south of 72°N first; beginning with nearshore lines moving offshore	July-August	Avoid bowhead/belugas and associated subsistence activities
Extend northward into international waters as ice recedes (>200 nm N/NW from shore)	September-October	Avoid main fall migration route of bowhead whales and avoid subsistence hunts

N = North
nm = nautical mile
NW = Northwest

Vessel operators associated with TGS's proposed 2013 seismic program anticipate monitoring Communication and Call Centers (i.e., Com- and Call-Centers) proposed to be operated in Barrow, Wainwright, Point Hope, and Point Lay. This will further enable vessel operators awareness of marine mammals and subsistence activity in the area. PSOs will be placed onboard the seismic and scout vessels to implement mitigation and monitoring measures. This will serve to avoid or minimize exposure of marine mammals to the NMFS-promulgated 180 and 190 dB re 1 μPa (rms) exposure criteria relative to the seismic sound source. Vessel-based mitigation measures include ramp-up procedures while initiating seismic operations, and power-down and shut-down procedures if a marine mammal is detected approaching or within designated distances from the sound source. These distances have been determined by acoustic propagation modeling conducted by JASCO (Zykov et al. 2013) and are summarized in Table 2. The full report is provided as an appendix in the IHA and LOA applications.

Table 2. Distances to NMFS-promulgated isopleths for impulse sounds at three water depth ranges in the TGS Chukchi Sea project area.

RMS Isopleth (dB re 1 µPa)	Distance (meters)		
	Depth (m): 17-40	Depth (m): 40-100	Depth (m): >100
190	930	920	430
180	2,200	2,500	2,400
160	8,500	9,900	15,000

These values include a 10 percent precautionary factor above the modeled results (Zykov et al. 2013).
These distances are based on results of JASCO sound modeling of the 3,280 in3 array.

A single 60 in^3 (or smaller) airgun in the seismic source array will be used as a mitigation seismic source. It will continuously produce a small amount of sound into the marine environment to alert marine mammals of the presence of the sound source. Furthermore, TGS has designed their program to mitigate impacts to marine mammals by incorporating the following operational procedures:

- No multi-beam sonar or sub-bottom profilers will be used, only standard vessel fathometers for safety and navigation will be used.
- Only one small source element (mitigation source) will operate during line changes. Each line change is expected to take between 5-12 hours each to complete.
- The number of seismic pulses of the single airgun mitigation source will be reduced during line changes to reduce the acoustic footprint and overall input of noise into the water.

2.1 Vessel-Based Marine Mammal Monitoring

To reduce incidental takes of marine mammals during proposed surveys, vessel-based PSOs will monitor for marine mammals from both the seismic vessel and the scout vessel, and will implement applicable mitigation measures. These observations will provide real-time data necessary to implement some of the key mitigation measures. They also will provide data that will be used to estimate exposures of marine mammals to various NMFS-regulated isopleths. PSOs will search for marine mammals to identify when they are approaching or are within designated exclusion zones where there is a possibility of significant effects on hearing or other physical effects. At such times, the PSO(s) will direct the appropriate personnel (i.e., Captain/crew and/or seismic source operator) to immediately power-down (to one operating airgun) or shut-down the seismic source.

TGS plans to conduct seismic operations 24-hours per day within the project area, including nighttime. Vessel-based PSOs will monitor for marine mammals during the following periods:

- 30 minutes prior to the first powering-on of the seismic array;
- during all daylight seismic operations;

- during ramp-up to the full seismic array from no airguns (during daylight only) or from the single-airgun mitigation source (including at night with night-vision devices [NVDs]); and
- as possible, during all daylight periods when no seismic activities are taking place, including during transits to and from the Chukchi Sea project area.

A 30-minute pre-ramp-up watch will be conducted any time no airguns have been operating for an extended shut-down period.

Vessel-based VPSOs are not required to observe during extended periods of darkness, except during a potential ramp-up to the full seismic array from a single mitigation airgun that has been operating since daylight, or as otherwise stipulated by NMFS/USFWS. In the latter case(s), NVDs will be available to aid in any nighttime visual observations. Acoustic PSOs (APSOs) will monitor the towed-PAM system during nighttime. However, mitigation measures (e.g., shut down, power down) are not planned to be implemented based solely on acoustic detections (without visual confirmation). Using acoustic detections alone to implement mitigation measures has not proven to be effective with Arctic species.

Nighttime seismic operations may only occur if the single mitigation source was initiated before dark and continuously operated since VPSO monitoring ended. The vessel captain/crew is to notify VPSOs of any marine mammal observations during nighttime seismic operations and adhere to the required mitigation measures as per the NMFS IHA and USFWS LOA. After a complete shutdown at night, seismic activity will be suspended until the entire exclusion zone is visible the following day.

TGS's approach to visual monitoring is to station a sufficient number of VPSOs aboard both the seismic vessel and scout vessel to:

- document the occurrence and location of marine mammals within the survey area;
- implement mitigation measures and requirements; and
- record any observed reactions of marine mammals to the survey activities.

All VPSOs will be trained in collecting marine mammal data, and at least one VPSO will be an Iñupiaq trained in collecting marine mammal data. Visual and acoustic PSOs will be on watch no more than four consecutive hours per shift for a maximum of 12 hours per day. Each VPSO will, while on duty, scan the area of operation for marine mammals using reticle binoculars (e.g., 7x50 Fujinon) and/or big-eye binoculars (25x150). VPSOs will record the species, location, distance from survey vessel, and behavior (and associated weather data) of all that are seen, and/or as stipulated in the NMFS IHA and/or USFWS LOA. The proposed monitoring plan is described in greater detail in Section 3.

2.2 Establishment and Monitoring of Exclusion Zones

Current NMFS and USFWS guidelines define "exclusion radii", hereafter referred to as exclusion zones, for marine mammals around industrial sound to be 180 dB re 1 µPa (rms) for cetaceans and Pacific walruses (walruses) and 190 dB re 1 µPa (rms) for pinnipeds and polar bears. Such guidelines are in place to minimize disturbance or behavioral effects to marine mammals and are based on the assumption that sound energy at lower received levels will not impair marine mammals' abilities to hear, but higher received levels may have such effects.

Upon arrival to the project area, sound source levels for the equipment will be measured and verified against the modeled sounds. This sound source verification (SSV) test will empirically establish more

exact distances to the 190 dB, 180 dB rms, and 160 dB isopleths. APSOs and VPSOs will monitor for marine mammals using the modeled exclusion radii (Table 2) during the SSV.

VPSOs aboard the seismic and scout vessels will perform a critical role in visually monitoring marine mammals and the implementing mitigation measures. VPSOs aboard the seismic vessel will monitor for marine mammals prior to initiation of the seismic source to ensure none are detected within the specified exclusion zones for a 30-minute period. The scout-vessel will be utilized to detect aggregations (12 or more) of baleen whales and walruses within the ≥160 dB zone and to notify VPSOs aboard the seismic vessel (via radio communications and Mysticetus™ using AIS) of any approaching marine mammals.

2.3 Marine Mammal Mitigation during Operations

TGS will adhere to the mitigation measures during the following periods:

- during seismic operations;
- when mobilizing to the project area;
- when demobilizing from the project area; and
- in the performance of any other operations in support of the 2D seismic program.

Specific mitigation measures that will be implemented, as applicable, include:

- Speed or course alterations will occur to avoid marine mammals or subsistence activities, provided that doing so will not compromise safety of the operations.
- VPSOs will alert the crew and/or seismic airgun operators to the presence of marine mammals so that appropriate mitigation measures (i.e., power-downs, shut-downs, and ramp-ups) can be initiated.
- The seismic source will only be initiated (i.e., powered on) during daylight after the full 180 dB zone is visible and clear of marine mammals for 30-minutes immediately prior to initiation, or as otherwise stipulated in the NMFS IHA and/or USFWS LOA.
- Vessels will not approach, other than in an emergency:
  - within 0.8 km (0.5 mi) of polar bear and walrus on ice
  - within 1.6 km (1 mi) of groups of walruses on land
  - within 0.8 km (0.5 mi) of polar bears on land.

During periods of poor visibility or nighttime, TGS will adhere to the following:

- If the entire 180 dB exclusion zone is not visible due to fog and/or darkness for a minimum of 30 continuous minutes immediately prior to start-up of the seismic source, initiations of the seismic source will not occur. For example, if fog encroaches and obscures the 180 dB exclusion zone part way through the 30-minute pre-ramp up period, then this 30-minute period must restart when the zone is fully visible again and must continue to be visible for 30 straight minutes. Passive acoustic monitoring using the towed hydrophone array from the scout vessel will be ongoing during periods of poor visibility or nighttime to monitor for marine mammals. However, the scout vessel is planned to be out ahead of the seismic vessel monitoring the larger 160 dB zone of influence, and therefore may not be able to monitor both the 160 and smaller 180 dB zones at the

same time. If marine mammals are acoustically detected from the scout vessel, APSOs will communicate acoustic detection data to VPSOs to aid in visual confirmation and mitigation actions, if necessary. Mitigation actions will only be implemented upon visual confirmation of marine mammals within the exclusion zones.

- If a single-airgun mitigation source or a seismic source array has been operational before visibility decreased or before nightfall, the seismic source operations may continue even though the entire exclusion zone may not be visible.

2.3.1 Speed or Course Alteration

In the event that a marine mammal is outside of the exclusion or disturbance zones and, based on its movements, is likely to enter the exclusion radius, the vessel will slow down and/or change its course to avoid disturbing the marine mammal. This procedure will be conducted with safety and practicality in mind, and further course alterations or seismic source power-downs will occur if necessary.

2.3.2 Power-down Procedures

Power-down procedures involve reducing the seismic source array volume (by reducing the number of active airguns) thereby reducing the distance to the 180 dB and 190 dB exclusion zones to an extent that the marine mammal(s) are no longer within the applicable zone. During a power-down, the seismic source array is reduced to a single 60 in^3 (or smaller) mitigation airgun or is shut-down completely. Power-downs may also occur when the seismic vessel is transitioning between survey lines if a marine mammal enters or is about to enter the smaller exclusion zones associated with the single mitigation airgun. The single mitigation airgun seismic source is intended to alert marine mammals of the presence of a sound source in the environment and retains the option to initiate seismic source ramp-up procedures under conditions of poor visibility or darkness.

If a marine mammal is detected outside, but approaching the appropriate exclusion zone, the VPSO will immediately request a power-down to the 60 in^3 (or smaller) mitigation airgun. Similarly, if a marine mammal is detected within the appropriate exclusion zone, the VPSO will immediately request a power-down as long as the marine mammal is not within or approaching the reduced exclusion zone of the single mitigation airgun seismic source. Measured reported distances for the 60 in^3 mitigation airgun were reported in Blees et al. (2010) as recorded by JASCO, and were 13 m (42.7 ft) for the 190 dB isopleth, 68 m (223.1 ft) for the 180 dB isopleth, and 1,500 m (4,921.3 ft) for the 160 dB isopleth. If the marine mammal continues to approach the reduced exclusion zone of the single mitigation airgun seismic source, the single airgun will be completely shut down.

Once powered-down, seismic source operations will only resume once the marine mammal has been confirmed outside the exclusion zone. A marine mammal is considered to have cleared the zone if:

- it has been visually detected outside of the exclusion zone;
- it has not been observed for 15 minutes (polar bears, pinnipeds, or small odontocetes);
- it has not been observed for 30 minutes (walruses and mysticetes; large odontocetes do not occur in the survey area); or
- as otherwise stipulated by the NMFS IHA and/or USFWS LOA.

2.3.3 Shut-down Procedures

Shut-down procedures include a complete cessation of the seismic source. These procedures will be implemented if a marine mammal is observed within the appropriate exclusion zone of the single mitigation airgun. Once shut-down, seismic source operations will only resume once the marine mammal has been confirmed outside the exclusion zone as described above.

Emergency shut-downs will occur immediately if observations are made or credible reports are received that one or more marine mammals within the seismic survey area are injured, dead, dying, or indicate acute distress due to seismic noise, unless otherwise stipulated by NMFS or USFWS. In the case of an emergency shut-down, NMFS (or USFWS for Pacific walrus and polar bear) will be contacted immediately. If it can be determined that the marine mammal injury or death is likely not due to seismic or drilling activities (e.g., obvious signs of killer whale predation; signs of hunting, such as bullet wounds), TGS will collect information as specified in Section 3 of this 4MP, notify NMFS or USFWS, and resume seismic activities. If cause of death cannot be attributed to causes other than the seismic program, the activities will not be restarted until NMFS or USFWS gives approval.

2.3.4 Ramp-up Procedures

Ramp-up procedures involve a step-wise increase in the number of operating airguns and thus the volume of the seismic source to provide a gradual increase of sound levels into the environment. This procedure is intended to alert marine mammals of seismic activity in the area and allow them time to leave the area and avoid injury or hearing impairment. Two VPSOs will observe for marine mammals during the 30-minute observation period prior to ramp-ups, during ramp-ups, and at least one VPSO will observe during all seismic source operations.

NMFS and USFWS normally require that, once ramp-up commences, the rate of ramp-up be no more than 6 dB per five-minute period. Ramp-up will likely begin with a single 60 in^3 (or smaller) airgun seismic source. The precise ramp-up procedure has yet to be determined. However, TGS intends to follow the standard NMFS-accepted ramp-up guidelines with a ramp-up rate of no more than 6 dB per five-minute period (unless otherwise required). During ramp-up, the exclusion zone of the full seismic source array will be maintained.

After a complete shut-down, ramp-up procedures will not commence until the 180 dB exclusion zone of the full array is completely visible for at least 30 minutes and no marine mammals have been observered within the exclusion zones for at least 15-30 minutes, depending on species. Specifically, if a marine mammal is observed within the appropriate exclusion zone (180 dB for cetaceans and walruses and 190 dB for pinnipeds and polar bears), a cold start may not be initiated until the animal is observed outside of the exclusion zone or not observed for at least 15 minutes for pinnipeds and polar bears, and 30 minutes for cetaceans and walruses, or as otherwise stipulated by NMFS or USFWS.

Ramp-up procedures will be adhered to when the seismic source array has been shut-down or operating with reduced volume (e.g. mitigation gun) for a specified duration of time. This specified time period (usually about five minutes) is generally the amount of time it would take the vessel to cover the 180 dB zone and depends on the speed of the seismic vessel, water depth, and array volume. If the seismic source array has been operating with one or more airguns (i.e., survey line changes), ramp-up procedures to the full seismic source array volume may commence during nighttime or periods of poor visibility on the assumption that marine mammals will be alerted by the sounds and able to move out of the area.

3.0 Monitoring

TGS plans to support marine mammal monitoring efforts throughout the project in order to implement the proposed mitigation measures, contribute to marine mammal knowledge of the study area, and satisfy the monitoring requirements of the NMFS IHA, USFWS LOA, and those agreed to as part of the Plan of Cooperation. TGS understands that the Monitoring Plan described in this section will be subject to review by NMFS and USFWS and that modification may be required. In addition to collecting marine mammal occurrence, distribution, and behavioral data, the visual and acoustic PSO program will provide information on marine mammal activities when seismic activities are taking place or not. TGS is prepared to discuss coordination of its monitoring program with any related work that might be done by other groups insofar as this is practical.

3.1 Monitoring Summary

TGS intends to use a combination of vessel-based visual monitoring and PAM (Table 3). TGS is proposing to use vessel-based VPSOs on board the seismic and scout vessels to monitor the 180 dB exclusion zone. Detailed monitoring methodology for the 180 dB and 190 dB exclusion zones are provided in Section 3.2.

TGS proposes to monitor the 160 dB zone using a towed-PAM array and VPSO who will monitor the 160 dB zone visually. Equipment details and methodologies used for the towed-PAM array and data analysis are described in Section 3.3.

Table 3. Summary of TGS's Proposed Monitoring Methods

Survey Location	180 dB Monitoring	160 dB Monitoring	Potential Contractor
South of 72°N	Seismic & scout vessel	Towed-PAM	TBD
North of 72°N	Seismic & scout vessel	Towed-PAM	TBD

3.2 Vessel-based Visual Monitoring

Vessel-based VPSOs will observe from both the seismic and scout vessel to monitor the presence of marine mammals during all daylight seismic operations. The in primary will be to monitor the exclusion zones and implement mitigation measures (e.g. ramp-ups, power-downs, and shut-downs of the seismic source). VPSOs will be appointed by TGS and approved by NMFS and USFWS. At least one VPSO on each vessel will be an Iñupiaq with knowledge of the marine mammals of the area. The vessel-based monitoring will provide:

- the foundation for real-time mitigation as required by the permitting agencies;
- information necessary to estimate the number of "takes" of marine mammals that must and will be reported to NMFS or USFWS;
- information necessary to evaluate the impact of activities authorized by the IHA and LOA on marine mammals and local subsistence activities; and
- marine mammal distribution, movement, and behavioral data in the survey area during seismic activities and non-seismic periods (i.e., transit)

3.2.1 Protected Species Observer Protocol

Weather and ice permitting, TGS intends to begin operations no earlier than July 15, 2013, when there are approximately 24-hours of daylight. To adequately monitor proposed exclusion zones during all daylight seismic operations, at least five VPSOs are proposed to be based aboard the seismic vessel with at least three, and up to five, aboard the scout vessel pending any bunk-space restrictions. As daylight decreases during the survey, the number of VPSOs aboard the seismic vessel may be reduced. At least one observer will be on duty during all daylight seismic source operations; however, two VPSOs will be on duty whenever possible (which is expected to be the majority of the survey). An observation schedule with five VPSOs allows for two VPSOs to be on duty at one time for 21 hours per 24 hour day. The three hours with only one VPSO on duty would be during nighttime hours when observations will be increasingly limited by daylight. During meal times observations may be conducted by one VPSO. In addition, two VPSOs will be on duty during all 30-minute periods prior to seismic source ramp-up and during all ramp-ups. VPSOs will be on duty for no longer than four consecutive hours with a maximum of 12-hours on duty per day.

Prior to mobilization, VPSOs will attend a NMFS- and USFWS- approved survey-specific training program and receive a detailed manual that summarizes the VPSO protocol and mitigation procedures stipulated in the permits issued by IHA and LOA. Once onboard the vessels, and prior to the start of the survey, the lead-VPSO aboard the seismic vessel will communicate the role of the visual and acoustic PSO-teams to the vessel crew(s) and establish a method of communication for relaying mitigation requests to the seismic source operators (see Section 3.2.2 below).

Marine mammal observations will be conducted from the bridge or other suitable platform on the source and scout vessels. The highest safe platform available will be stationed by VPSOs. During daylight, VPSOs will systematically scan the area around the vessel with reticle binoculars (7x50 Fujinon or equivalent), big-eye binoculars (Fujinon 25x150 or equivalent) and the naked eye. NVDs (ITT F500 Series Generation 3 binocular-image intensifier or equivalent) will be available to aid observations during periods of darkness as relevant. VPSOs will be provided a laser rangefinder to assist with distance estimation. These tools are more commonly used to train VPSOs to estimate distances visually, than for measuring distances to animals in the field.

3.2.2 Communication Procedures

When VPSOs observe marine mammals within or approaching the applicable exclusion zone, the seismic source will be powered-down or shut-down immediately as appropriate. To facilitate this, a direct line of communication with the seismic source operators will be established (i.e., VHF radio) and sightings will be mapped and displayed on a PC monitor relative to exclusion zones in real-time using Mysticetus™ (software further described in Section 3.5). VPSOs will continue to monitor the exclusion zones after implementation of a power- or shut-down. The VPSOs will communicate resumption of the array if the marine mammal(s) is observed outside and moving away from the applicable exclusion zone within five-minutes of power- or shut-down. If more than five-minutes have elapsed since the seismic source was reduced, then the exclusion zones must be free of marine mammals for at least 15 minutes for pinnipeds and polar bears and 30 minutes for cetaceans and walruses. Once the VPSOs confirm the zone is clear, they will communicate to the seismic source operators to initiate ramp-up procedures.

3.2.3 Data Recording

The VPSOs aboard the seismic vessel will maintain a digital log of seismic surveys, noting the date and time of all changes in seismic activity (ramp-up, power-down, changes in the active seismic source, shut-downs, etc.) and any corresponding changes in monitoring radii in a project-customized Mysticetus™

observation software spreadsheet. VPSOs will utilize this standardized format to record all marine mammal observations and mitigation actions (seismic source power-downs, shut-downs, and ramp-ups). Information collected during marine mammal observations will include the following:

- Vessel speed, position, and activity
- Date, time, and location of each marine mammal sighting
- Number of marine mammals observed, and group size, sex, and age categories
- Observer's name and contact information
- Weather, visibility, and ice conditions at the time of observation
- Estimated distance of marine mammals at closest approach
- Activity at the time of observation, including possible attractants present
- Animal behavior
- Description of the encounter
- Duration of encounter
- Mitigation action taken

Data will preferentially be recorded directly into a handheld computer or as a back-up, transferred from hard-copy data sheets into an electronic database. A system for quality control and verification of data will be facilitated by the pre-season training, supervision by the lead VPSOs, in-season data checks, and will be built into the Mysticetus™ software (i.e., Mysticetus™ will recognize and notify the operator if entered data are non-sensical). Computerized data validity checks will also be used. The data will be managed in such a way that it is easily summarized during and after the field program and transferred into statistical, graphical, or other programs for further processing. Mysticetus™ will be used to quickly and accurately summarize and display these data. See Section 3.5 for a description of the Mysticetus™ real-time monitoring program.

3.3 Passive Acoustic Monitoring

3.3.1 Sound Source Verification

Prior to or at the beginning of the seismic survey, sound levels will be measured as a function of distance and direction from the proposed seismic source array (full array and reduced to a single mitigation airgun). Results of the acoustic characterization and SSV will be used to empirically refine the modeled distance estimates of the pre-season 190 dB, 180 dB, and 160 dB isopleths. The refined SSV exclusion zones will be used for the remainder of the seismic survey. Distance estimates for the 120 dB isopleth will also be modeled; however, current acoustic criteria do not require mitigation be implemented for pulsed sounds beyond the 160 dB isopleths. A report of preliminary results will be submitted to NMFS shortly after data collection, usually within five days or as otherwise required by NMFS.

3.3.2 Towed Passive Acoustic Monitoring

TGS plans to use real-time towed-PAM to complement the visual monitoring conducted by VPSOs during the survey in waters north and south of 72°N. Studies have indicated that towed-PAM is a

practical and successful application for acoustically surveying low-frequency mysticetes (Clark and Fristrup 1997, Rankin et al. 2007). Passive acoustics methods, including towed hydrophone arrays, are most effective when visibility and/or sea conditions are poor, at nighttime or during low-light conditions when animals cannot be sighted easily. Additionally, towed-PAM is less likely to be constrained by environmental factors than visual monitoring (Guan 2010). Surveys in the Arctic have shown some species (e.g., bowhead whales and beluga whales) are often detected acoustically using towed-PAM without visual confirmation of the sighting (McPherson et al. 2012). Acoustically detecting animals not visually observed provides presence/absence data for animals that may have otherwise gone unsighted. The proposed towed-PAM system may allow notification of acoustically detected marine mammals not yet observed visually. If acoustically detected animals are visually confirmed or their location determined via localization methods (Section 3.3.2.2), then mitigation actions (i.e., power-down, shut-down) will be implemented if necessary. In addition to alerting VPSOs of marine mammal detections, passive acoustic technology has been developed to reliably localize vocalizing marine mammals and estimate density via post-season data processing. Proposed methods for localization and density estimation are briefly described below.

3.3.2.1 Passive Acoustic Monitoring Array Setup

The towed hydrophone array system consists of two parts: the "wet end" and the "dry end". The wet end consists of the hydrophone array and tow cable (i.e., the cable that is towed behind the vessel connecting to the array). The dry end includes the analog-to-digital interface, computer processing equipment, signal conditioning and filtering systems and a recording system/device. High pass filters will be used to reduce vessel and flow noise and to increase dynamic range. The towed hydrophone array will be deployed using a winch from the scout vessel. Details and specifications on the equipment will be determined at a later date once TGS has selected an acoustics contractor; each contractor has different equipment specifications. This specific information will also be provided in the 90-day report after completion of the survey.

Through consultations, Tom Norris, a bio-acoustic contractor with Bio-Waves, Inc., recommended array and survey design. TGS intends to incorporate these recommended methods and techniques to the greatest extent possible for this survey. TGS is planning to use a simple two-element hydrophone array (e.g., two hydrophones at the end of a single ≥300 m [984 ft] cable) (Figure 2). With customized processing software, this design will allow for localization of vocalizing marine mammals using a method known as target motion analysis (TMA) (see Section 3.3.2.2). In addition to using filters to reduce noise, TGS plans to limit vessel-speed (as possible without compromising safety and vessel steerage) and/or adapt the survey design to minimize flow- and vessel- self noise and address the left/right ambiguity inherent in line arrays. Assessment of the latter approach will be determined in the field based on empirical/situational data, and will be specific to the vessel used and the environmental conditions.

3.3.2.2 Localization of Marine Mammals

Localization of vocalizing marine mammals will be accomplished using TMA (see preceding paragraph). This is the most commonly used method of localization for marine mammals by researchers (including NOAA/NMFS). It was originally developed for the Navy to track submarines and ships from towed hydrophone arrays. With this approach, the sequential bearings to a target sound source (e.g., marine mammal) are obtained via estimation of the time differences of signal arrival from two closely spaced hydrophones that are towed by a vessel passing the 'target' (Figure 2). If multiple bearings to the source can be obtained over some time period, then over time, these bearings will converge on the source's location (Figure 3).

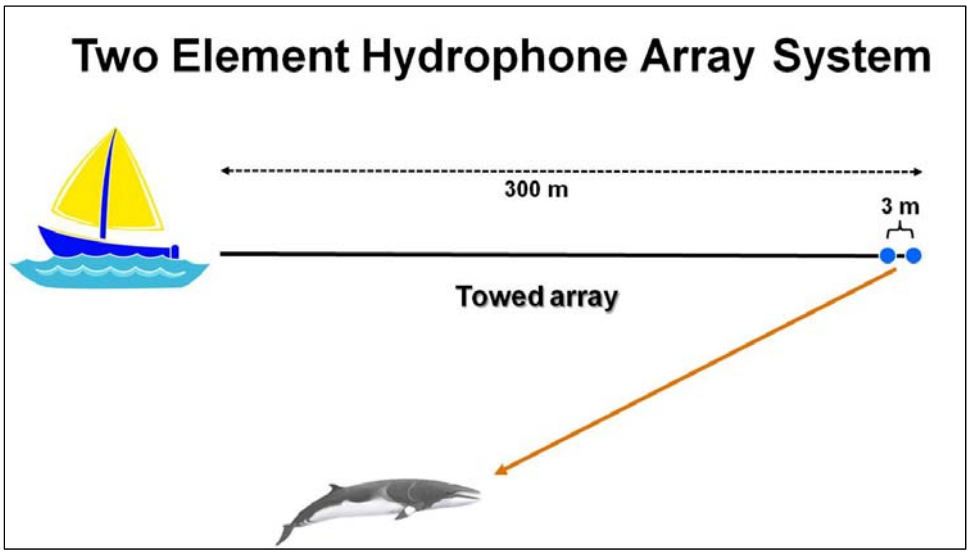

Figure 2. Two element TMA towed hydrophone array system.

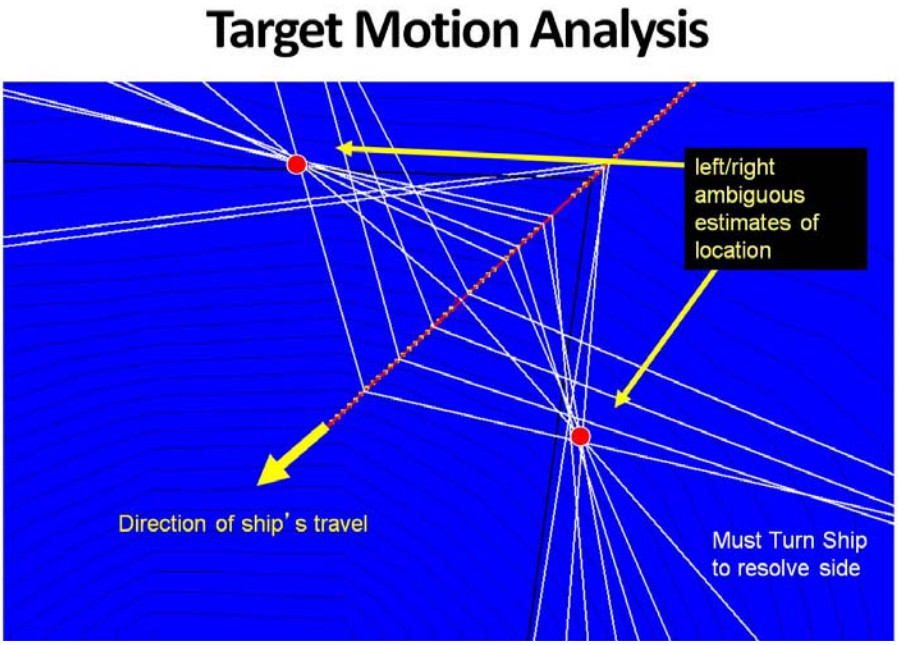

Figure 3. Localization using TMA.

The TMA method requires multiple assumptions, including the following:

- The target (i.e., sound source) must remain relatively stationary, or move slow relative to the survey vessel.
- The survey vessel (and towed hydrophone array) must travel in a straight line.
- Marine mammals must call relatively frequently (at least every few minutes).

- If multiple animals are calling, they must occur in compact groups, or calls from the same individuals must be differentiated.
- Animals detected close to the vessel are not diving deeper than the horizontal distance to the array's hydrophones.

If most of these assumptions can be met, then target motion analyses works very well. In fact, it is one of the most common methods used for localizing marine mammals. If these assumptions cannot be met, then the accuracy and reliability of localization is reduced and may reduce the reliability or in extreme cases, prevent localization of animals for survey or mitigation needs. With the TMA method, it is possible with a single towed hydrophone array to obtain a bearing to vocalizing animals with a single towed hydrophone.

Due to the linear alignment of hydrophones, there is a left/right ambiguity that cannot be resolved without turning the tow vessel. The left/right ambiguity, however, is not a critical concern for mitigation during the TGS 2D seismic survey because the exclusion zones are circular; therefore, the distance to the calling animal is the same on the right and left side of the vessel (Figure 4). Furthermore, unambiguous localization can be achieved in circumstances where the vessel towing the array can turn and the calling animals call multiple times or continuously.

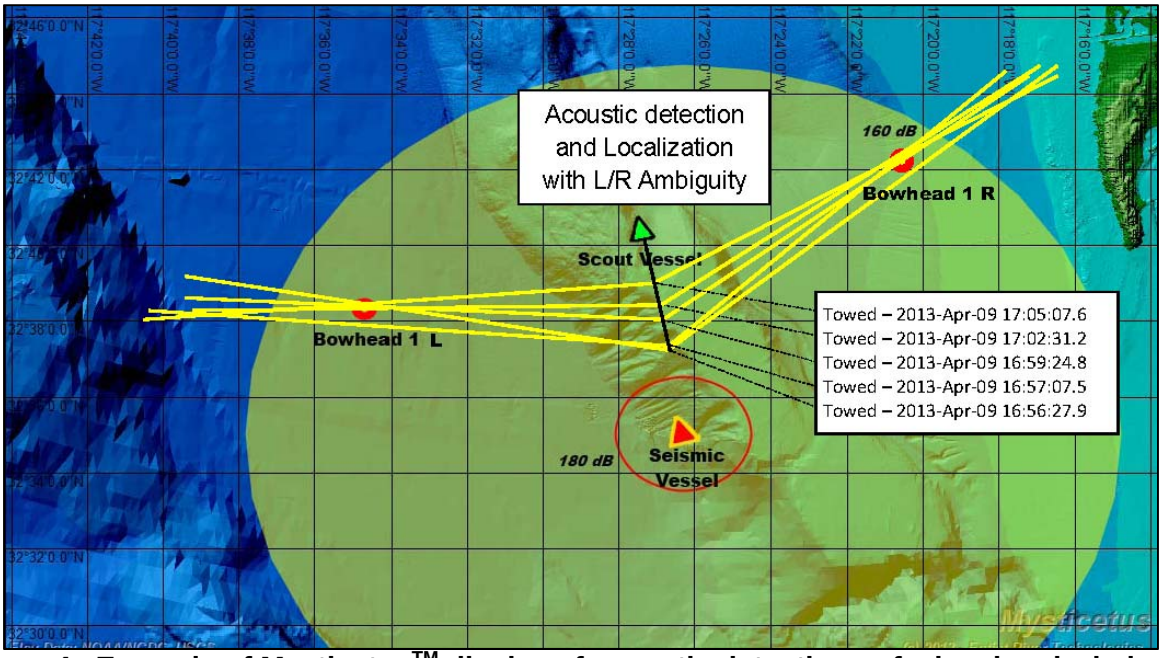

Figure 4. Example of Mysticetus™ display of acoustic detections of a bowhead whale and localization with left/right ambiguity. Vessels are denoted by triangles and acoustic detections by circles. The scout vessel is towing the passive acoustic array, hydrophones denoted by the solid black line. Yellow localization lines cross at the estimated location of the detection, with left/right ambiguity. Note, there is always error associated with localizations which should be considered when determining the location of animals.

3.3.2.3 Density Estimation

Line-transect density estimation is well developed and field-proven using visual-based methods, but also possible using data collected from a towed hydrophone array if sufficient encounters with individuals or groups of individuals occur. This has not been attempted previously in the Arctic but has been successfully accomplished using combined visual observations and towed hydrophone array during a number of vessel surveys elsewhere (e.g., Barlow and Taylor 2005; Van Parijs et al. 2009; Gerrodette et al. 2011). TGS intends to estimate density using a towed-hydrophone array as an effort to test this technique for Arctic species of marine mammals, specifically the bowhead and beluga whales and Pacific walrus.

The scout vessel towing the hydrophone array will follow a systematic pattern (e.g., zig-zag) ahead of the source vessel suitable for estimating line-transect density and abundance estimates (Buckland et al. 1993). The maximum distance at which the scout vessel moves ahead of the source vessel will depend upon the detection range of the towed hydrophone array for the species of interest, but focus will be on bowhead whales. This distance will be ascertained in the field relative to environmental conditions affecting sound attenuation at the time (e.g., Beaufort sea state, water depth, etc.). For reference, a similar towed-PAM array used during Statoil's 2010 3D seismic survey in the Chukchi Sea detected bowhead whales at distances of up to approximately 7.5 km (4.7 mi) (McPherson et al. 2012).

For acoustic line-transect surveys, acoustic survey methods are based on the same concepts and assumptions as for visual line-transect methods. The main differences lie in the assumptions that are violated and the biases that are inherent in visual versus acoustic methods. It is beyond the scope of this 4MP to discuss all the biases and potential violation of assumptions; however, we will briefly introduce and address the major issues. (Reviews are provided in Buckland et al. 1993 and Barlow et al. 2005)

The first assumption/condition inherent in using data from towed hydrophone arrays to obtain density estimates is that animals are calling enough to detect them in an unbiased manner. This assumption typically holds when species are consistently vocally active, but may be biased when animals change their vocal behaviors based on activity (e.g., noise) from the survey vessel or related activities (e.g., the seismic vessel). With sufficient data, changes in vocal behavior can be detected but these are often difficult to differentiate from biases associated with animal movements (discussed further below).

It is important to note that estimates that result from passive acoustic data are relevant for calling animals only. Any animals that are not calling cannot be sampled directly. To include animals that are not calling in the overall abundance estimate requires applying a correction factor based on the proportion of the population that is calling versus not calling. For example, in most baleen whales, songs are typically only sung by males. If the population will be surveyed using acoustic methods to detect and localize songs, and if the population is made up of 50 percent males and 50 percent females, then the acoustic density/abundance estimate should be multiplied by two in order to obtain a corrected estimate for the entire population (assuming that all males sing and enough can be localized to estimate a detection function).

Another important assumption is that there are not significant distance measurement errors (or at least that the errors are not biased, but rather, are random). The perpendicular distance of an animal from the trackline is the essential variable that needs to be estimated for each localization when using line-transect methods (Figure 5). With a good localization method/system, these measurement errors are usually not severe enough to be a concern, but in some cases they might

be. For example, if animals are moving away from the survey vessel at a similar speed to the vessel, the TMA localization method will overestimate distances. The opposite is true if animals are moving towards the vessel. Errors can also result if animals are moving in the same direction as the survey vessel, but these are less severe. These over-/under-estimations in distance will result in a bias in the estimate if the errors are not random.

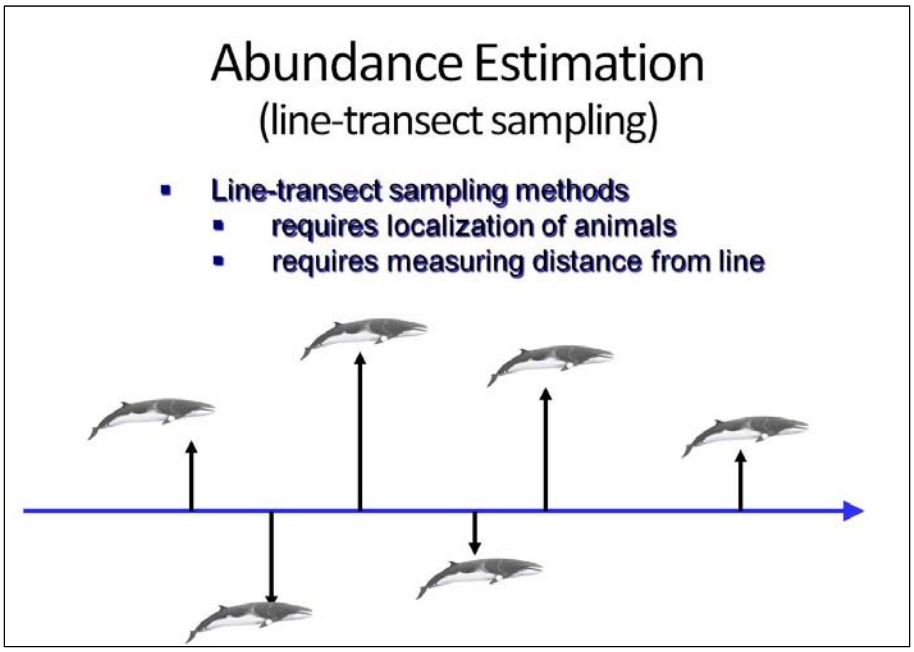

Figure 5. Line-transect sampling requires estimating perpendicular distances from the survey track to animals.

Group size estimates are another important variable in the line-transect estimate process. Group sizes tend to be quite variable for many species of marine mammals and are a significant source of uncertainty in the final density estimates. Acoustically estimating group size is difficult if there are more than two to three whales in a group being localized. Estimating group sizes for delphinids is even more difficult. In most cases, it is necessary to use visual methods to estimate group size. Visual group-size estimates can then be used to supplement acoustic data during the abundance estimation procedure. If it is possible to go on 'chase' to visually locate acoustically detected (but not visually sighted) animals, then it is strongly recommend to do so. If this is not possible (due either to visibility, weather, or logistical/safety constraints), then archival or other data on average group sizes must be used. It is preferable to use data collected from the same survey (as opposed to other studies) for this. This approach was used in the Barlow & Taylor (2005) study in which sperm whale densities were estimated using a combination of acoustic data (to estimate the 'encounter rate' and 'detection function' components of the line-transect formula) and visual data (to estimate the average group size). In the case of bowhead, gray and beluga whales in the proposed TGS survey area, historical data are available on the range and mean of group sizes for waters south of approximately 72°N from NMFS/National Marine Mammal Laboratory (NMML)/Bureau of Ocean Energy Management (BOEM) aerial surveys conducted there since 2008 (Clarke et al. 2011, 2012). Such data are also available from various vessel-based surveys. However, little or not such data area available for waters north of 72°N.

The final important assumption of line-transect methods is that all animals on the track-line are seen (or acoustically detected). This assumption is frequently violated, but often can be assessed and corrected for visual estimates. The probability of animals being detected on the track-line is

referred to as g(0). In most line-transect surveys, g(0) is assumed to equal 1 (i.e. all animals on the track-line are detected). Because acoustic detection using a towed hydrophone array is known to suffer from poor detection capabilities both in front of and behind the array (known as 'end-fire'), g(0) cannot be directly estimated. However, it is possible to address this issue during analysis by truncating (i.e. deleting) localizations near the track-line. This approach is common for data in which the trackline cannot be effectively surveyed (e.g. during aerial surveys when the trackline cannot be seen). This approach assumes that animals are not reacting to the survey vessel (e.g. by changing vocalization rates or moving away from/towards the track-line). If these assumptions are violated, the resulting abundance estimate will be biased, and correcting this bias may be difficult or in extreme cases, not possible.

TGS intends to use the recommended methods similar to those used in Barlow & Taylor (2005), and those recently used by Bio-Waves, Inc. for estimating the density of minke whales in the tropical Pacific Ocean using towed hydrophone array methods (Norris et al. 2012).

3.3.2.4 Monitoring Methods

The hydrophone array will be monitored 24-hours per day, weather permitting, from the scout vessel operating ahead of the source vessel. Based on JASCO's modeling results (Zykov et al. 2013), the modeled 180 dB rms re 1 µPa exclusion zone is between 2.2 and 2.5 km (1.4 and 1.6 mi) from the seismic source, and can be monitored sufficiently by VPSOs during clear weather using 25x150 "big eye" binoculars (up to 10 km [6.2 mi] from 20 m [65.6 ft] platform; see Rugh et al. 2002) and 7x50 reticle binoculars. For comparison, big-eyes will be mounted at bridge level or higher on the proposed source vessel, estimated at 17 m (55.8 ft) or higher. The scout vessel plans to conduct systematic transects from 2 km (1.2 mi) to 10 km (6.2 mi) ahead of the source vessel (based on water depth and weather conditions) to effectively monitor the 160 dB zone of influence and to also monitor the edge of the 180 dB isopleth. Exact layout of the most effective survey trackline design will be determined in consultation with a line-transect density/ DISTANCE analysis expert. Vessel speed is preferred to be approximately 5 knots to limit vessel self-noise for the towed array monitoring; however, it may be increased in the event of poor weather, therefore causing greater vessel noise (McPherson et al. 2012).

The 160 dB zone of influence was modeled by JASCO to range from 8.5 to 15 km (5.3 to 9.3 mi) in shallow (17-40 m [56-131 ft]) to deep (>100 m [328 ft]; Table 2; Zykov 2013) waters. Only 14 percent of the proposed seismic lines occur in deep waters (i.e., 15 km [9.3 mi] 160 dB radius) and the other 86 percent have a smaller 160 dB zone. By employing the bowhead whale acoustic maximum detection range of approximately 7.5 km (4.7 mi) from a towed-array (see Section 3.3.2.3), during similar or better conditions, the TGS scout vessel theoretically can monitor for vocalizing bowheads within the full 15 km (9.3 mi) 160 dB radius ahead of the seismic. This can be done by positioning the scout vessel with towed-array ahead of and at approximately the midpoint between the seismic source and the forward edge of the 160 dB zone (Figure 6).

Because the towed-hydrophone array is located on the scout vessel, there is complete control over which area(s) to monitor, and how often the scout vessel is turned when a marine mammal call is heard (to improve localization and resolve left-right ambiguity). Understanding that towed-PAM arrays are unable to 'look' forward and backward (i.e., they are restricted by about 20 degrees on either side of 0° and 180°, if 0° is straight ahead), TGS intends to operate the scout vessel in a zig-zag pattern (as feasible) to most effectively monitor the zone in front of the seismic vessel. Another, advantage of using towed-hydrophone arrays over other passive acoustic methods is (presumably) visual observers are also monitoring during daylight hours. This allows visual validation of species, group size and location, and provides the opportunity to acoustically detect

animals that are potentially missed by visual methods (because they are diving or because of poor sighting conditions).

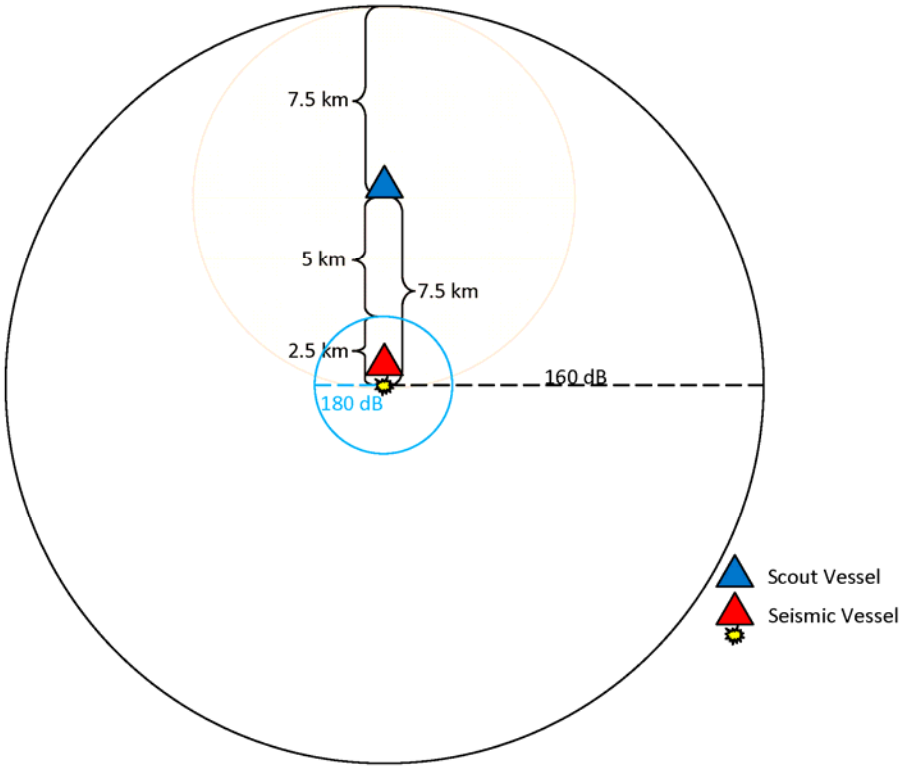

Figure 6. Diagram of a theoretical survey design based on the maximum bowhead detection distance documented during towed-PAM operations in the Chukchi Sea (McPherson et al. 2012). The scout vessel is the PAM tow-vessel. Orange shading indicates the theoretical maximum detection zone of the towed-PAM array with an assumed monitoring radius of 7.5 km (4.7 mi) relative to the JASCO-modeled 160 dB radius of 15 km (9.3 mi) in deep waters (>100 m [328 ft]). The scout vessel will follow a zig-zag pattern to maximize acoustic coverage ahead of the seismic vessel.

The area of the 160 dB isopleth is between 227 and 706 km^2 (88 and 273 mi^2). This is about 15-40 times the size of the 180 dB isopleth area, depending on water depths and other environmental factors that affect signal propagation. Monitoring an area this large requires a range of acoustic detections between 8.5 and 15 km (5.3 and 9.3 mi), depending on propagation conditions. For sounds produced by many species (e.g., odontocetes and pinnipeds), this is well beyond the 'typical' detection ranges of towed hydrophone array systems. Because ranges of marine mammal detections are influenced by environmental noise, self-noise, propagation conditions, source levels, and a host of other uncontrollable factors, it is important to optimize the survey design. TGS intends to employ the survey design recommendations to the extent possible to improve the effectiveness of marine mammal monitoring and mitigation for this survey program.

3.3.2.5 Communications and Mysticetus™ Real-time Display

PAM technicians experienced in detecting/processing marine mammal vocalizations will monitor the PAM system and immediately notify visual PSOs via radio of detections (PSOs may

supplement PAM technicians). In addition, PAM detections will be logged directly into the Mysticetus™ observation software and be visible both on the PAM technician's visual monitor map display and transmitted immediately to the equivalent display of the visual-PSO's computer on the bridge. This communication will be accomplished via networking aboard the vessel. The observations will also then be transmitted from the PSO computer on the bridge of the scout vessel to the PSO computer display on the seismic vessel using AIS technology and Mysticetus™ (Figures 4 and 7; see Section 3.5 for details).

3.4 Aerial Monitoring

TGS evaluated the feasibility, technology (including real-time unmanned aerial systems), and risk associated with aerial surveys and does not intend to conduct aerial surveys as part of the monitoring and mitigation plan for the Chukchi Sea seismic survey as they would be impractical and unsafe due to the location and extent of offshore waters of the survey.

3.5 Real-time Monitoring and Communication between Vessels

TGS proposes to incorporate Mysticetus™ software as an "all-in-one" PSO platform for data collection, vessel and marine mammal detection real-time display, summary analyses, and mapping. In addition, each vessel will be equipped with an AIS; a vessel tracking system that will allow for information to be electronically shared between the vessels within VHF range. The Mysticetus™-AIS system will be used by PSOs to quickly enter marine mammal observations into a program and real-time map display that can be seen by both vessels on a laptop computer screen monitor. This is achieved by placing an AIS transceiver and antenna on each vessel. The program also creates automatic high-resolution mapping, so animals can be tracked relative to locations of the vessels and the seismic array and associated mitigation and monitoring isopleths. PSOs will be able to see and monitor exclusion zones on the map display and Mysticetus™ will instantly plot where a marine mammal occurs relative to its exclusion zone. This ability adds confidence and improves the speed and accuracy of communicating sighting locations between vessel platforms to implement real-time mitigation measures. In addition, the distance from sightings to the array and mitigation zones is instantly displayed in real-time. Headings and multiple sighting locations of the same sightings can also be displayed. Both vessels can view the same data and map display, thus creating another mode of real-time communication between vessels. An example of marine mammals plotted relative to a seismic vessel and its exclusion zones is shown in Figure 7.

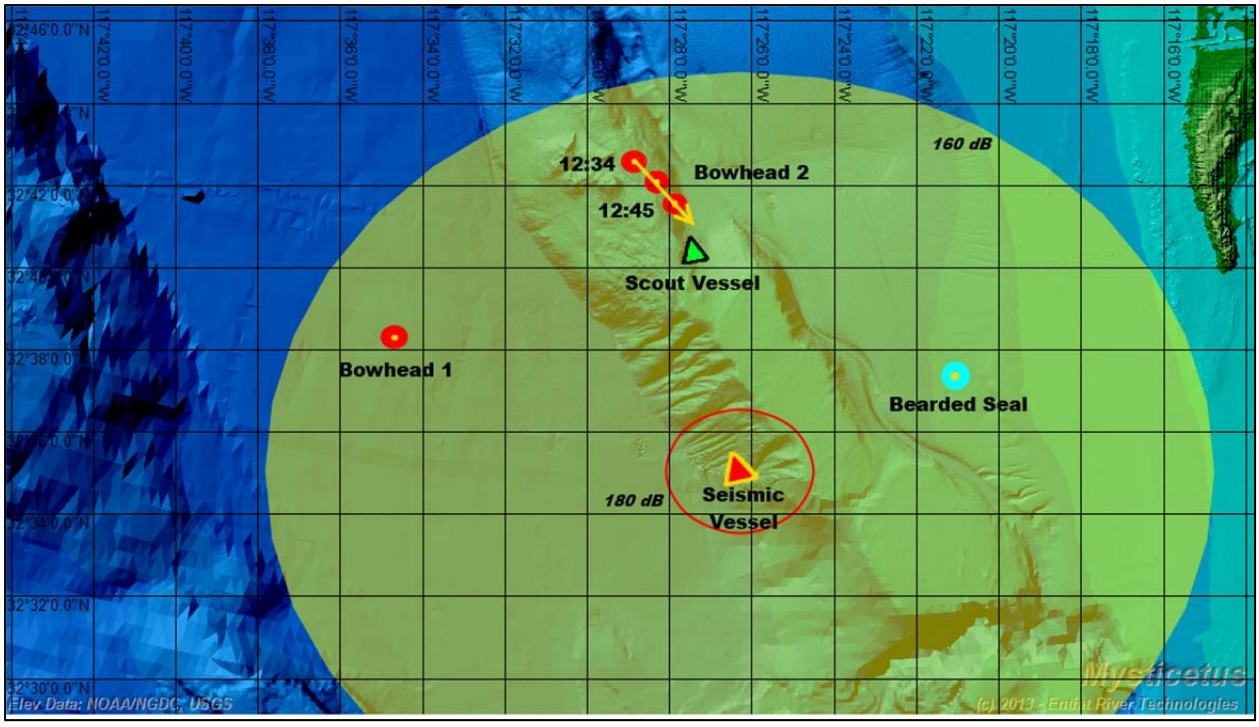

Figure 7. Example display of AIS real-time mapping displaying the 180 dB exclusion zone (red circle), the 160 dB monitoring zone (green circle), marine mammal sightings, and relative vessel locations in MysticetusTM. Circles indicate marine mammal sightings, arrows indicate direction of repeat sightings, and triangles represent vessels. The map can be zoomed in or out instantly for more or less detail.

4.0 Reporting

During the field season, brief summary reports will be provided to NMFS and USFWS, if required per the IHA and LOA, on a schedule specified in the permits. A report summarizing the preliminary results of the SSV and refined monitoring exclusion zones for the seismic sources will be submitted shortly after the measurements are complete at the beginning of the field season.

In order to contribute to the research goals of the MMPA, TGS is proposing several ways to further marine mammal knowledge in the Arctic. TGS has agreed to upload its marine mammal sighting data to the publically-available website, Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations, also known as OBIS-SEAMAP. Furthermore, TGS intends to integrate their program with other 2013 studies as possible, and will send NMFS and USFWS digital sighting and effort data. In addition, TGS will provide a digital summary and chronological log of vessel tracklines, seismic operation times, marine mammal locations, and associated other data to NMFS and USFWS for archiving and future reference and use.

4.1 90-day Reports for NMFS and USFWS

Results of the vessel-based PSO program, including estimates of takes by harassment, will be described in a report to be submitted within 90 days of the end of the program. This report will adhere to the requirements established by the NMFS IHA and USFWS LOA and will include the following:

- a summary of the monitoring effort;
- analysis of factors affecting the visibility and detectability of marine mammals by monitoring;
- analysis of distribution and abundance of marine mammal sightings, and description of marine mammal behavior in relation to date, location, ice conditions, and operations;
- estimates of NMFS/USFWS-defined “takes” based upon density estimate derived from monitoring and survey efforts;
- reporting of acoustic monitoring results to include: sound source levels of source- and scout-vessels and seismic surveys; acoustic detections of marine mammals, and continuous sound levels at the stationary recording locations; and
- estimates of “take by harassment.”

4.1.1 Polar Bear and Walrus Observation Reports for USFWS

TGS will adhere to USFWS-required reporting requirements, including reporting all polar bear and walrus sightings to USFWS. Reports of walrus observations will be provided weekly and include the following:

- date, time, and location of each sighting;
- number, sex, and age of walruses (if determinable);
- observer name, company name, vessel name, LOA number, and contact information;
- weather, visibility, and ice conditions at the time of each observation;
- estimated distance from animal/group when initially sighted, at closest point of approach, and at the end of the observation;

- industry activity at the time of the sighting and throughout the encounter, including the estimated radius of the zone of ensonification;
- behavior of animals at the initial sighting, any change in behavior during the observation period, and distance from observers associated with those behavioral changes;
- detailed description of the encounter;
- duration of any behavioral response; and
- any actions taken.

Reports of polar bear observations will be provided within 24 hours of the observation and will include the following:

- date, time, and location of each sighting;
- number, sex, and age of bears (if determinable);
- observer name, company name, vessel name, LOA number, and contact information;
- weather, visibility, and ice conditions at the time of each observation;
- estimated distance of closest point of approach for bears from personnel and/or vessel;
- industry activity at time of the sighting and any possible attractants;
- behavior of animals at the initial sighting and after the encounter;
- detailed description of the encounter;
- duration of the encounter; and
- any actions taken.

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