Alaska LNG™

APPLICATION FOR INCIDENTAL HARASSMENT AUTHORIZATION FOR THE NON-LETHAL HARASSMENT OF CETACEANS AND PINNIPEDS:

2016 GEOPHYSICAL & GEOTECHNICAL PROGRAM IN COOK INLET

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EXECUTIVE SUMMARY

In support of the Alaska LNG Project (Project), ExxonMobil Alaska LNG LLC (EMALL) plans to conduct a geophysical and geotechnical (G&G) program in Cook Inlet, Alaska, to collect data for use in route selection and technical design of a proposed natural gas pipeline across Upper Cook Inlet and marine facilities near Nikiski. The planned activities would occur for up to 16 weeks during the 2016 open-water season with equipment deployed from several vessels.

Section 101(a)(5)(D) of the Marine Mammal Protection Act (MMPA) of 1972, as amended (16 U.S.C. 1361 et seq.) directs the Secretary of Commerce to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals of a species or population stock, by U.S. citizens who engage in a specified activity (other than commercial fishing) within a specified geographic region if, after the National Marine Fisheries Service (NMFS) provides a notice of a proposed authorization to the public for review and comment; NMFS makes certain findings; and the taking is limited to harassment.

The following specific aspects of the G&G program have the potential to result in the take by Level B harassment only of marine mammals: use of a small air gun or air gun array, sub-bottom profiler (chirp and boomer), and a vibracore.

EMALL is therefore requesting an Incidental Harassment Authorization (IHA) from the National Marine Fisheries Service (NMFS) for non-lethal incidental harassment only of four species of marine mammals anticipated to result from the specified activities. Other aspects of the G&G program that do not generate sound within the hearing range of the four species of marine mammals are beyond the scope of this IHA application.

Marine mammals that regularly inhabit Cook Inlet waters within the survey areas are the beluga whale (*Delphinapterus leucas*), harbor porpoise (*Phocoena phocoena*), and harbor seal (*Phoca vitulina*). These species are found there in low numbers and generally only during the summer fish runs (Nemeth et al. 2007, Boveng et al. 2012). The belugas belong to the Cook Inlet Stock, which is listed under the Endangered Species Act (ESA) as endangered. The fourth species which is covered by this application is the killer whale (*Orcinus orca*), which are occasionally observed in Upper Cook Inlet (Shelden et al. 2003).

Table E-1 lists the estimated numbers of exposures of marine mammals to Level B harassment without mitigations, the number of authorized exposures requested by EMALL, and the percent of the estimated population that potential exposure represents. Each requested authorization of exposures represents a small number relative to the estimated abundance of the stock. The requested authorization for Cook Inlet beluga whales is increased given the larger average group size which may be encountered for this species.

The calculations of estimated exposures include conservatism which has resulted in estimated values that are similar or higher than results of actual observations from past marine mammal monitoring programs in Cook Inlet. The method used at the request of NMFS for calculating estimated exposures (commonly referred to as the ‘daily method’) includes the potential for repeated exposures of the same animal; this circumstance is unlikely given the small area of the operations when compared to the habitat available in Cook Inlet, the slow speed of vessel transit during data gathering operations, and the implementation of mitigation measures. The method used at the request of NMFS for calculating Level A and Level B harassment radii for vibracore and sub-bottom profiler (referred to as the “practical” spreading model) significantly underestimates far-field transmission loss, resulting in large radii and therefore increased exposures. Previous acoustical studies in Cook Inlet have developed transmission loss models more similar to the spherical spreading model. This application compares exposure estimates using both models, but ultimately requests harassment authorization based on the results of the spherical spreading model because the exposure estimates are more realistic.

Table E-1: Calculated Exposures and Requested Non-lethal, Incidental Level B harassment of Marine Mammals

Species	Calculated Number of Exposures (without mitigation) using Spherical Spreading Model	Authorized Exposures Requested	Authorized Exposures Requested as Percent of Population
Beluga Whale [1]	26	34 [2]	10%
Killer Whale [3]	9	9	1.5% [4]
Harbor Porpoise [3]	24	24	0.1%
Harbor Seal [5]	799	799	3.4%

The mitigation measures which EMALL will implement to reduce the potential for exposure of marine mammals to sound from planned activities, and therefore to request authorizations, further supports a determination that the potential for unintentional, incidental acoustic harassment is low, and if it occurs, will have a negligible impact on the species or stocks. Protected species observers (PSOs) will be stationed onboard the vessels from which chirp and boomer sub-bottom profilers, air gun, and vibracores are operating. The PSOs will “clear” monitoring zones (Level A and Level B) by observing the water for signs of marine mammals before activity occurs, and will continue to monitor the zones during and after operations. The PSOs will direct vessel operators to implement mitigations (i.e., speed or course alterations, power-down, shut-down) as appropriate, and will record observations that will be provided to NMFS through weekly, monthly, and end of program reporting.

EMALL will engage with local subsistence communities to identify and minimize potential conflicts with subsistence hunting activities in the survey area to avoid unmitigatable adverse impact on the species or stocks for subsistence uses.

[1] Exposures based on 1-km cell densities in Goetz et al. (2012)
[2] The requested authorization is increased to 10% of the population given the larger average group size which may be encountered for this species
[3] Exposures based on average raw densities
[4] Based on Alaska transient stock
[5] Exposures based on average raw densities with correction factor to reflect previously reported observations in survey area

0.0 INTRODUCTION

ExxonMobil Alaska LNG LLC (EMALL), in support of the Alaska LNG Project, is seeking authorization from the National Marine Fisheries Service (NMFS) for Level B incidental and unintentional acoustic harassment of marine mammals in accordance with Section 101(a)(5) of the Marine Mammal Protection Act (MMPA) of 1972, as amended. Harassment is a form of "take" as defined under the MMPA and is subject to governance under the MMPA (16 U.S.C. 1361 et seq.).

Section 101(a)(5)(D) of the MMPA directs the Secretary of Commerce to allow, upon request, the incidental, but not intentional, taking of small numbers of marine mammals of a species or population stock, by U.S. citizens who engage in a specified activity (other than commercial fishing) within a specified geographical region if, after NMFS provides a notice of a proposed authorization to the public for review and comment: NMFS makes certain findings; and the taking is limited to harassment. NMFS must determine that the activities have a negligible impact on affected marine mammal species or stocks, that the numbers taken are small, and that the activities would not have an unmitigable adverse impact on the availability of marine mammals for taking for subsistence uses.

MMPA regulations at 50 CFR 216.104 "Submission of Requests" identify 14 specific items that must be addressed when applying for an IHA in order to provide sufficient information to NMFS to support a determination that the unintentional, incidental taking will have a negligible impact[6] on the species or stock(s), will result in harassment of only small numbers of the applicable marine mammal stocks, and will not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence uses.

The 14 items required by 50 CFR 216.104 are set forth below.

[6] Negligible impact is defined in 50 CFR 216.103 as "an impact resulting from the specified activity that cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival."

1.0 DESCRIPTION OF ACTIVITY

1.1 BACKGROUND

The Alaska Gasline Development Corporation, BP Alaska LNG LLC, ConocoPhillips Alaska LNG Company, ExxonMobil Alaska LNG LLC, and TransCanada Alaska Midstream LLP (a wholly-owned affiliate of AGDC, and with AGDC, collectively referred to herein as "AGDC") plan to construct one integrated liquefied natural gas (LNG) Project (Project) with interdependent facilities for the purpose of liquefying supplies of natural gas from Alaska, in particular from the Point Thomson Unit (PTU) and Prudhoe Bay Unit (PBU) production fields on the Alaska North Slope (North Slope), for export in foreign commerce and opportunities for in-state deliveries of natural gas. Proposed Project facilities include: a Liquefaction Facility on the eastern shore of Cook Inlet in the Nikiski area of the Kenai Peninsula, which will be supplied by an approximately 800-mile, large diameter natural gas pipeline from the North Slope (Mainline). The Liquefaction Facility is comprised of an LNG Plant and Marine Terminal

EMALL, in support of the Project, is conducting a multi-year geophysical and geotechnical (G&G) program in Cook Inlet, Alaska to support the technical design and engineering of a proposed natural gas pipeline corridor across Cook Inlet and marine facilities near Nikiski. Equipment which was used in the 2015 G&G program which required authorization from NMFS under an Incidental Harassment Authorization (IHA) was covered under an IHA issued to EMALL for the period of August 14, 2015, to August 13, 2016 (NMFS 2015). EMALL plans to continue these surveys in 2016, with some modifications to G&G program areas. The modifications to equipment which were proposed in the original 2016 IHA application submitted to NMFS on October 1, 2015, have been removed from this final IHA application since EMALL has recently acquired the necessary data from other Cook Inlet operators to avoid the need for a larger air gun array. The program proposed herein reflects the maximum scope of work currently anticipated to be necessary, however EMALL will continue to identify and pursue opportunities to avoid and reduce potential impacts of the program to marine mammals in Cook Inlet.

1.2 SURVEY ACTIVITIES

The 2016 G&G program survey methods and equipment have been selected to characterize the bottom surface and subsurface, directly evaluate seabed features and soil conditions, and collect information on the properties of in-situ soils.

Chirp and boomer sub-bottom profilers and a small air gun or air gun array up to 60 in^3 in total volume will be deployed from a survey vessel to characterize the subsurface of Cook Inlet, which will subsequently provide information for pipeline design, construction, and operation. Two separate equipment configurations will be used: chirp sub-bottom profiler with boomer sub-bottom profiler, and chirp sub-bottom profiler with air gun. The air gun may also be used from a stationary platform. Vibracoring will be conducted from a separate survey vessel to gather information on the properties of in-situ soils. This data will be used in the probabilistic seismic hazard assessment, route selection, and design of mitigations for the proposed facilities. Equipment and survey methods are described in subsequent sections.

Additional equipment that may be deployed in 2016, but that do not generate sound in the hearing range of marine mammals potentially present in the survey area, include single-beam and multi-beam echo sounders, side-scan sonar, geophysical resistivity, magnetometers, cone penetrometer tests, geotechnical borings (rotary and/or oscillatory), grab samples, and sediment bedload sampling. Permits and authorizations required for these activities will be obtained from local, state, and federal authorities as applicable.

1.2.1 Sub-bottom Profiler – Chirp

The chirp sub-bottom profiler emits high-energy sounds and is used to penetrate and profile seafloor sediments. The system may be pole-mounted or towed behind the survey vessel. At operating frequencies of 2 to 16 kHz, this system will be operating at the lower end of the full hearing range of beluga whales, killer whales, harbor porpoises, and harbor seals, and below the most-sensitive hearing range of beluga whales (45-80 kHz, Castellote et al. 2014), killer whales (18-42 kHz; Szymanski et al. 1999), and harbor porpoises (16-140 kHz; Kastelein et al. 2002). Only the most sensitive hearing range of harbor seals (10-30 kHz; Wartzok and Ketten 1999) overlaps with the operating frequency of the chirp sub-bottom profiler. The source level is estimated at 202 dB re 1 μPa-m (rms). The beam width is 24 degrees and the tilt angle is 90 degrees below the horizontal plane. The chirp sub-bottom profiler will be used in combination with the boomer sub-bottom profiler, and separately in combination with the air gun.

1.2.2 Sub-bottom Profiler – Boomer

A boomer sub-bottom profiler will also be used to penetrate and profile seafloor sediments. The system will be towed behind the survey vessel. With a sound energy source level of approximately 205 dB re 1 μPa-m (rms) at frequencies of 0.5 to 6 kHz, most of the sound energy generated by the boomer will be at frequencies that are well below peak hearing sensitivities of beluga whales (45-80 kHz; Castellote et al. 2014), and below the peak sensitivities of killer whales (18-42 kHz; Szymanski et al. 1999), harbor porpoises (16-140 kHz; Kastelein et al. 2002), and harbor seals (10-30 kHz; Wartzok and Ketten 1999), but would still be detectable by these animals. The tilt angle is 90 degrees below the horizontal plane, but the equipment is omnidirectional so the physical orientation is not relevant.

1.2.3 Small Air Gun or Air Gun Array

A 0.983 L (60 in^3) air gun or an air gun array of similar or smaller total volume will be used to gather high resolution profiling at greater depths below the seafloor. The system will be towed behind a vessel and/or deployed from a stationary platform. The published source level from Sercel (the manufacturer) for a 0.983 L (60 in^3) air gun is 216 dB re 1 μPa-m (equating to about 206 dB re 1 μPa-m (rms). These air guns typically produce sound levels at frequencies of less than 1 kHz (Richardson et al. 1995, Zykov and Carr 2012), or below the most-sensitive hearing of beluga whales (45-80 kHz; Castellote et al. 2014), killer whales (18-42 kHz; Szymanski et al. 1999), harbor porpoises (16-140 kHz; Kastelein et al. 2002), and harbor seals (10-30 kHz; Wartzok and Ketten 1999).

1.2.4 Vibracores

Vibracoring will be conducted to obtain cores of the seafloor sediment from the surface down to a depth of approximately 6.1 m (20 ft). The cores are later analyzed in the laboratory for characteristics such as moisture, organic and carbonate content, shear strength, and grain size. Vibracore samplers consist of a 10-cm (4.0-in) diameter core barrel and a vibratory driving mechanism mounted on a frame, which is lowered to the seafloor. The electric motor driving mechanism oscillates the core barrel into the sediment where a core sample is then extracted. The duration of the operation varies with substrate type, but generally the sound source (driving mechanism) is operable for only the few minutes it takes to advance the 6.1-m (20-ft) barrel to full depth.

Chorney et al. (2011) conducted sound measurements on an operating vibracore in Alaska and found that it emitted a sound pressure level at 1-m source of 187.4 dB re 1 μPa-m (rms), with a frequency range of between 10 Hz and 20 kHz, which overlaps with the most sensitive hearing of killer whales, harbor porpoises, and harbor seals, but not beluga whales.

1.2.5 Vessels

Vessels used in the program will be approximately 15–42 m (50–140 ft) in length and 4.5–15 m (15–50 ft) in width (beam) with approximately 750–1500 horsepower. When used in combination, the air gun and chirp and boomer sub-bottom profilers will typically be deployed from the same survey vessel. Vibracoring may be conducted from a separate survey vessel. The air gun may also be used from a stationary platform or barge.

1.3 SAFETY (LEVEL A) ZONE RADII

NMFS defines sound level thresholds for acoustical injury and harassment of marine mammals. The NMFS threshold for Level A harassment is 180 dB for cetaceans and 190 dB for pinnipeds (all rms) (NOAA 2015). Information on the acoustic characteristics of applicable sound sources is summarized in Table 1.

Table 1. Acoustical Characteristics of Equipment Planned for Use in 2016

Type	Model [7]	Operating Frequency (kHz)	Source Level (dB re 1 μPa-m [rms]) [8]
Sub-bottom profiler – chirp	EdgeTech 3200	2-16 [9]	202 [10]
Sub-bottom profiler - boomer	Applied Acoustics AA301	0.5-6 [9]	205 [10]
Air gun	0.983 L (60 in^3)	<1 [11]	206 [12]
Vibracore	Alpine	0.01-20 [13]	187 [13]

To avoid exposing marine mammals to the received sound levels, Level A zones are identified based on measured or modeled values for distances to the 180 and 190 dB isopleths. Previous acoustical studies conducted in Cook Inlet by Blackwell and Greene (2002), Blackwell (2005), Collins et al. (2007), SFS (2009), Austin and Warner (2012), and I&R (2014) show underwater transmission loss rates of between 17.5 Log r and 28 Log r, averaging around 20 Log r. URS (2007) assumed a transmission loss of 25 Log r from their acoustical studies conducted at the Port of Anchorage, which was the average of the 22 Log r and 28 Log r rates measured by Blackwell (2005). Heath et al. (2014) assumed a spherical 20 Log r transmission loss when estimating safety zone radii for Apache's Cook Inlet seismic operations.

When transmission loss information specific to the proposed equipment to be used and the water body where the work would occur is lacking, NMFS has requested that radii to thresholds be estimated using the more conservative practical spreading model of 15 Log r. At shorter distances, such as to the 190 dB and 180 dB isopleths, there is generally only a small difference between the spherical and practical spreading model results. However, at far-field distances, and out to the 120 dB isopleth, the compounding effect of the practical spreading model can result in unrealistically large distances (in the tens and sometimes hundreds of kilometers) for loud non-impulsive sound sources. For example, using the practical spreading model versus the spherical

[7] A similar model may be used
[8] rms = root mean square
[9] Information from manufacturer brochure
[10] Manufacturer provided peak value converted to rms (using a -10 dB offset)
[11] Richardson et al. 1995
[12] O'Neill et al. 2010
[13] Chorney et al. 2011

model to estimate the distance to the 120-dB threshold for the vibracorer increases the calculated distance 13-fold from 2.24 km to 29.30 km. Based the previous acoustical research cited above, the practical spreading model therefore should not be assumed to represent typical transmission loss conditions in Cook Inlet. In particular, Level B exposure estimates based on the practical spreading model are probably significantly overestimated given that the numbers are not supported by actual observations from past marine mammal monitoring programs in Cook Inlet.

Estimated Safety (Level A) Zone radii using both spreading models are found in Table 2. EMALL plans to monitor the Level A Zone radii which were calculated based upon the spherical spreading model, which is consistent with previous acoustical studies in Cook Inlet, and is similar to the distances monitored by PSOs during EMALL's 2015 G&G Program in Cook Inlet.

Table 2. Safety (Level A) Zone Radii for Equipment Types Generating Sound at Frequencies <200 kHz

Survey Equipment	Safety (Level A) Zone Radii			
	Pinnipeds 190 dB radius m (ft)		Cetaceans 180 dB radius m (ft)	
	20 Log r	15 Log r	20 Log r	15 Log r
Sub-bottom profiler - chirp	4 (13)	7 (23)	13 (43)	30 (98)
Sub-bottom profiler – boomer	6 (21)	10 (33)	18 (59)	47 (154)
Air gun	7 (23)	12 (39)	20 (66)	55 (180)
Vibracore	0	0	3 (10)	3 (10)

When the chirp sub-bottom profiler and boomer sub-bottom profiler are operating simultaneously, the loudest sound source (within marine mammal hearing range, <200 kHz) will be the boomer sub-bottom profiler, which is expected to generate received sound levels exceeding 180 dB outward to a radius of approximately 47 m (154 ft) based on the practical spreading model and 18 m (59 ft) based on the spherical spreading model.

When the chirp sub-bottom profiler and air gun are operating simultaneously, the air gun will generate the greatest sound energy levels and is predicted to generate received sound levels of 180 dB outward to a distance of approximately 55 m (180 ft) based on the practical spreading model, but only 20 m (66 ft) based on the spherical spreading model.

Qualified protected species observers (PSOs) will be stationed onboard the survey source vessels to monitor Level A (and Level B) zones to advise vessel operators of operational mitigations at the approach of a marine mammal to these zones. The *Marine Mammal Monitoring and Mitigation Plan* (Appendix A) describes the monitoring and mitigation procedures to be implemented.

2.0 DATES, DURATION, AND SPECIFIED GEOGRAPHIC REGION

2.1 SURVEY TIMING

Surveys using the chirp and boomer sub-bottom profiler and air gun would occur for approximately 102 days during the 2016 open-water season between March 2016 and November 2016. Operations in the pipeline survey area would occur for approximately 46 days, and operations in the marine facilities survey area and LNG carrier (LNGC) approach survey area would occur for a total of approximately 56 days. Approximately 100 km (62 mi) of transect line (the linear distance traveled by the survey vessel) would be surveyed on an average day. The use of an air gun from a stationary platform would occur over an estimated 24 days in the marine facilities survey area. Vibracoring would occur approximately 120 times (estimated 60 days) during the 2016 open-water season between March 2016 and November 2016. It is expected that on average, two vibracores would be conducted each day depending on tides and currents, with the sound source operating for a few minutes each time the equipment is deployed.

The survey days may not be consecutive, given operational limitations including but not limited to tides, currents, hours of daylight, vessel resupply, personnel fatigue days, weather, and simultaneous operations. The activities would be scheduled in such a manner as to minimize potential effects to marine mammals, subsistence activities, and other users of the Cook Inlet. EMALL will engage with NMFS should the program require additional time to complete.

A portion of the planned G&G program area is located within 10 miles (16 km) of the mean lower low water (MLLW) line of the Susitna Delta (Beluga River to the Little Susitna River). NMFS has noted this area to be of high importance to the Cook Inlet beluga whale population, with highest concentrations of beluga whales observed to be present through the months of May to September (NMFS, 2015). NMFS has previously required that work conducted under Incidental Harassment Authorizations in that area be undertaken only prior to April 15 or after October 15 to avoid and reduce potential interactions between work programs and beluga whales. EMALL will conduct work which is authorized under an IHA and located in the Susitna Delta prior to April 15 or after October 15 to avoid and reduce potential effects to the Cook Inlet beluga whale.

2.2 SURVEY AREAS

Three separate areas will be surveyed in Cook Inlet. The survey areas are shown in Figure 1. The survey areas were sized to provide siting flexibility for future infrastructure to avoid existing hazards.

The pipeline survey area (Figure 2) extends in the marine waters of Cook Inlet from the northwest shoreline of Upper Cook Inlet near the communities of Tyonek and Beluga to the southeast shoreline of Upper Cook Inlet near Boulder Point on the Kenai Peninsula. This survey area is approximately 47 km (29 mi) in length and averages approximately 16 km (10 mi) wide. The pipeline survey area is 795 km^2 (307 mi^2).

The marine facilities survey area and LNGC approach survey areas (Figure 3) are located in the marine waters of Cook Inlet near the eastern shoreline of what is defined as the northern region of Lower Cook Inlet, south of the Forelands and adjacent to Nikiski on the Kenai Peninsula. The marine facilities survey area encompasses 109 km^2 (42 mi^2) and the LNGC approach survey area encompasses 79 km^2 (30 mi^2).

In the LNGC approach survey area, the chirp and boomer sub-bottom profilers will be operated simultaneously. The marine facilities survey area will be surveyed twice: once with the chirp and boomer sub-bottom profilers operated simultaneously, and once with the air gun and chirp sub-bottom profiler operated simultaneously. The pipeline survey area will also be surveyed twice:

once with the chirp and boomer sub-bottom profilers operated simultaneously and once with the boomer sub-bottom profiler and air gun operated simultaneously. Use of an air gun from a stationary platform will be conducted only in the marine facilities survey area. Vibracoring may be conducted throughout all of the survey areas.

Figure 2 illustrates that a portion of the pipeline survey area extends into the Susitna Delta Exclusion Area, a region which was identified by NMFS as an area of particular importance to the Cook Inlet beluga whale population (further described in Section 9.2). Approximately 192 km^2 (74 mi^2) of the pipeline survey area are within the Susitna Delta Exclusion Area.

Figure 1. 2016 G&G Program Survey Areas

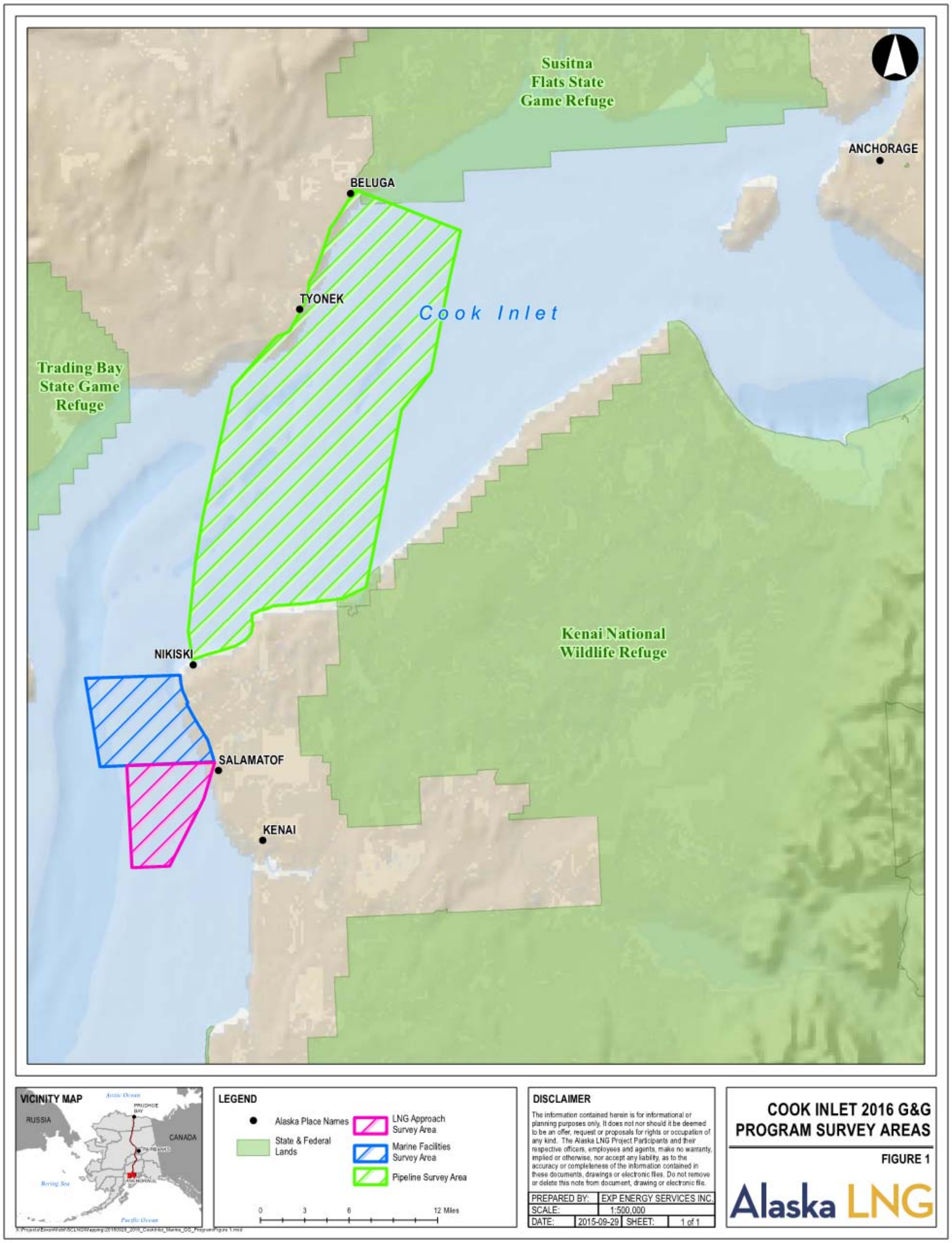


Figure 2. 2016 G&G Program Pipeline Survey Area

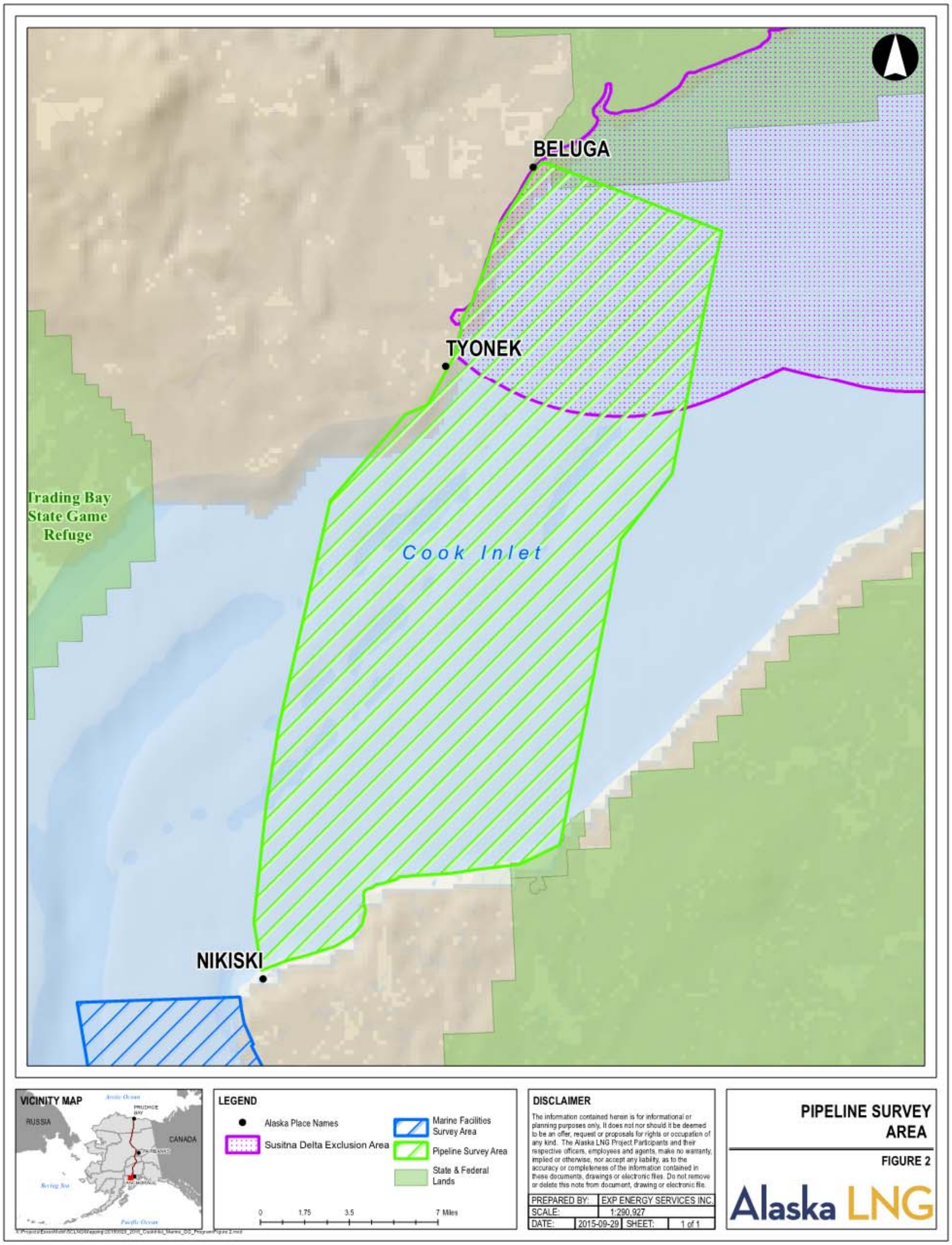
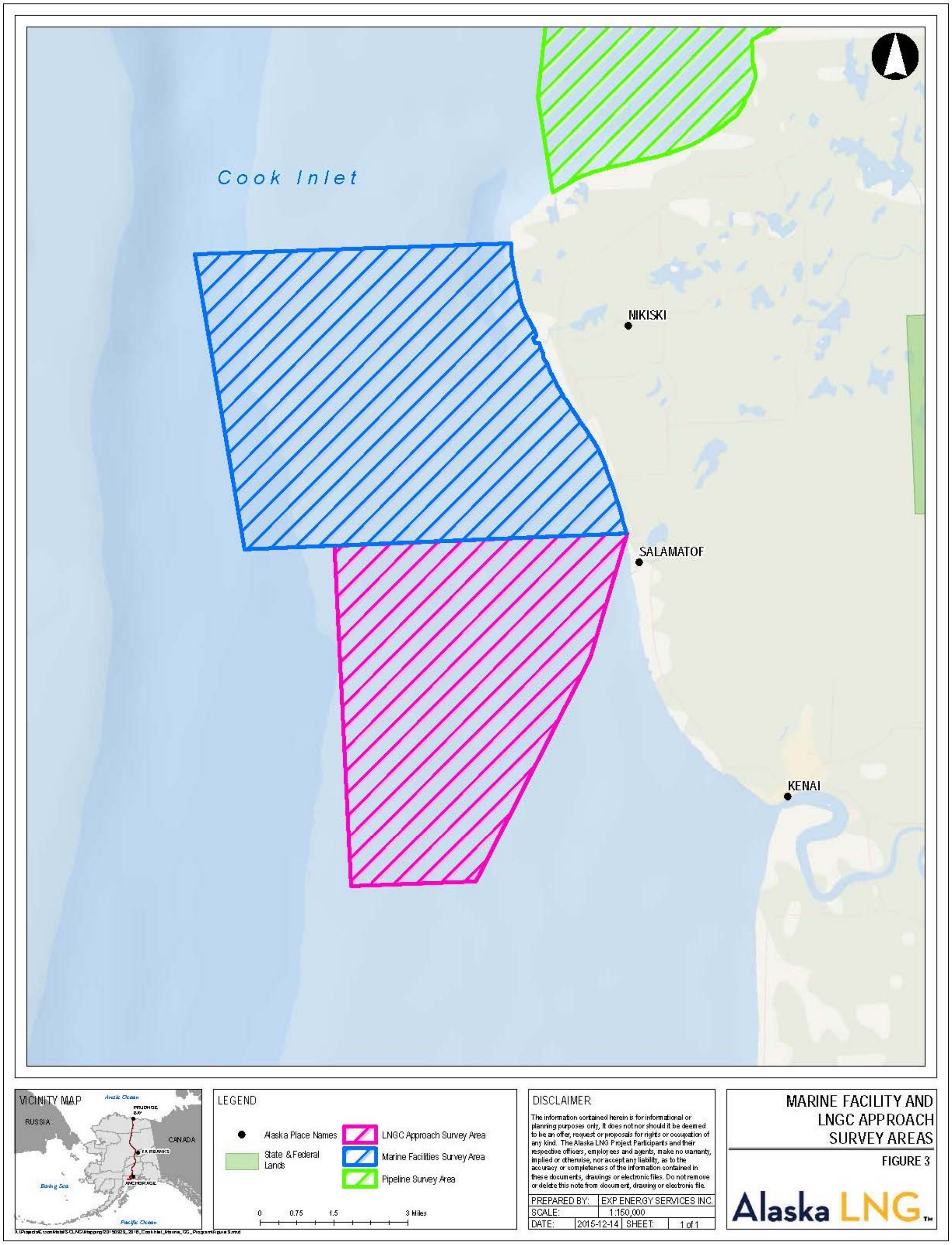


Figure 3. 2016 G&G Program Marine Facilities and LNGC Approach Survey Areas



3.0 SPECIES AND NUMBERS OF MARINE MAMMALS

Marine mammals that regularly inhabit Upper Cook Inlet are the beluga whale (*Delphinapterus leucas*), harbor porpoise (*Phocoena phocoena*), and harbor seal (*Phoca vitulina*). These species are found there in relatively low numbers, and generally only during the summer fish runs (Nemeth et al. 2007, Boveng et al. 2012). Killer whales (*Orcinus orca*) are occasionally observed in Upper Cook Inlet where they have been observed attempting to prey on beluga whales (Shelden et al. 2003). Based on a number of factors, Shelden et al. (2003) concluded that the killer whales found in Upper Cook Inlet to date are the transient type, while resident types occasionally enter Lower Cook Inlet. Table 3 presents the stock estimates for the beluga whale, killer whale, harbor porpoise, and harbor seal.

Marine mammals occasionally found in the southern regions of Lower Cook Inlet include humpback whales (*Megaptera novaeangliae*), gray whales (*Eschrichtius robustus*), minke whales (*Balaenoptera acutorostrata*), Pacific white-sided dolphins (*Lagenorhynchus obliquidens*), Dall's porpoises (*Phocoena dalli*), Steller sea lions (*Eumetopias jubatus*), and sea otters (*Enhydra lutris*; USFWS jurisdiction species). Because these species are not regular inhabitants of the survey areas, it is therefore unlikely that the 2016 G&G program has the potential to expose these species to acoustic harassment, and EMALL has therefore not requested authorization for these species. Mitigation measures that would be undertaken in the event of an observation of any of these species are described in the *Marine Mammal Monitoring and Mitigation Plan (*Appendix A).

Table 3. Marine Mammals Inhabiting the Survey Areas

Species	Stock Estimate [14]	Stock
Beluga Whale	340	Cook Inlet Stock, ESA-listed as Endangered
Killer Whale	587	Alaska Transient Stock
Harbor Porpoise	31,046	Gulf of Alaska Stock
Harbor Seal	22,900	Cook Inlet/Shelikof Stock

[14] Allen and Angliss (2015)

4.0 AFFECTED SPECIES STATUS AND DISTRIBUTION

Beluga whales concentrate in Upper Cook Inlet during the summer, especially in the Susitna Delta, and then move south to the waters of the middle inlet for winter. Both harbor seals and harbor porpoise concentrate around the mouths of the Upper Cook Inlet rivers during the summer, where, like beluga whales, they feed on migrating eulachon (*Thaleichthys pacificus*) and salmon (*Onchorhynchus* spp.). Harbor porpoise and harbor seals can also be found throughout Cook Inlet during the summer and winter south of the annual ice cover. Only a few hundred of any of these three species seasonally inhabit the survey areas. Only 340 beluga whales inhabit Cook Inlet (Allen and Angliss 2015), the Cook Inlet-wide estimate for harbor porpoise is only 136 animals (Dahlheim et al. 2000), and no more than 380 hauled out harbor seals were recorded in Upper Cook Inlet on any given survey during NMFS aerial surveys conducted annually between 1993 and 2012 (Shelden et al. 2013). Killer whale presence in Upper and Lower Cook Inlet is more sporadic and consists of the occasional small group of transient killer whales in search of mammalian prey. Each species of marine mammal is discussed in greater detail below.

4.1 BELUGA WHALE (*DELPHINAPTERUS LEUCAS*)

The Cook Inlet beluga whale Distinct Population Stock (DPS) is a small geographically isolated population that is separated from other beluga populations by the Alaska Peninsula. The population is genetically (mtDNA) distinct from other Alaska populations suggesting that these whales may have been separated from other stocks at least since the last ice age (O'Corry-Crowe et al. 1997). Laidre et al. (2000) examined data from more than 20 marine mammal surveys conducted in the northern Gulf of Alaska and found that sightings of belugas outside Cook Inlet were exceedingly rare, and these were composed of a few stragglers from the Cook Inlet DPS observed at Kodiak Island, Prince William Sound, and Yakutat Bay. Several marine mammal surveys specific to Cook Inlet (Laidre et al. 2000, Speckman and Piatt 2000), including those that concentrated on beluga whales (Rugh et al. 2000, 2005a), clearly indicate that this stock largely confines itself to Cook Inlet. There is no indication that these whales make forays into the Bering Sea where they might intermix with other Alaskan stocks.

The Cook Inlet beluga DPS was originally estimated at 1,300 whales in 1979 (Calkins 1989) and has been the focus of management concerns since experiencing a dramatic decline in the 1990s. Between 1994 and 1998 the stock declined 47%, which has been attributed to overharvesting by subsistence hunting. Subsistence hunting was estimated to then have annually removed 10–15% of the population. Only five belugas have been harvested since 1999, yet the population has continued to decline (Allen and Angliss 2014), with the most recent estimate at only 340 animals (Allen and Angliss 2015). The NMFS listed the population as "depleted" in 2000 as a consequence of the decline, and as "endangered" under the Endangered Species Act (ESA) in 2008 when the population failed to recover following a moratorium on subsistence harvest. In April 2011, the NMFS designated critical habitat (Critical Habitat Areas 1 and 2) for the Cook Inlet beluga whale under the ESA. Critical Habitat Areas are shown in Figure 4.

Prior to the decline, this DPS was believed to range throughout Cook Inlet and occasionally into Prince William Sound and Yakutat (Nemeth et al. 2007). However, the range has contracted coincident with the population reduction (Speckman and Piatt 2000). During the summer and fall, beluga whales are concentrated near the Susitna River mouth, Knik Arm, Turnagain Arm, and Chickaloon Bay (Nemeth et al. 2007) where they feed on migrating eulachon and salmon (Moore et al. 2000). The limits of Critical Habitat Area 1 reflect the summer distribution (Figure 3). During the winter, beluga whales concentrate in deeper waters in the mid-inlet to Kalgin Island, and in the shallow waters along the west shore of Cook Inlet to Kamishak Bay. The limits of Critical

Habitat Area 2 reflect the winter distribution. Some whales may also winter in and near Kachemak Bay.

Goetz et al. (2012) modeled beluga use in Cook Inlet based on the NMFS aerial surveys conducted between 1994 and 2008. The combined model results shown in Figure 5 indicate a very clumped distribution of summering beluga whales, and that lower densities of belugas are expected to occur throughout most of the survey area. Beluga whales begin moving into Knik Arm around August 15 where they spend about a month feeding on Eagle River salmon. The area between Nikiski, Kenai, and Kalgin Island is thought to provide wintering habitat for Cook Inlet beluga whales. Use of this area would be expected between fall and spring, with animals largely absent during the summer months when the G&G program is planned (Goetz et al. 2012).

Figure 4. Cook Inlet Beluga Whale Critical Habitat Areas 1 and 2

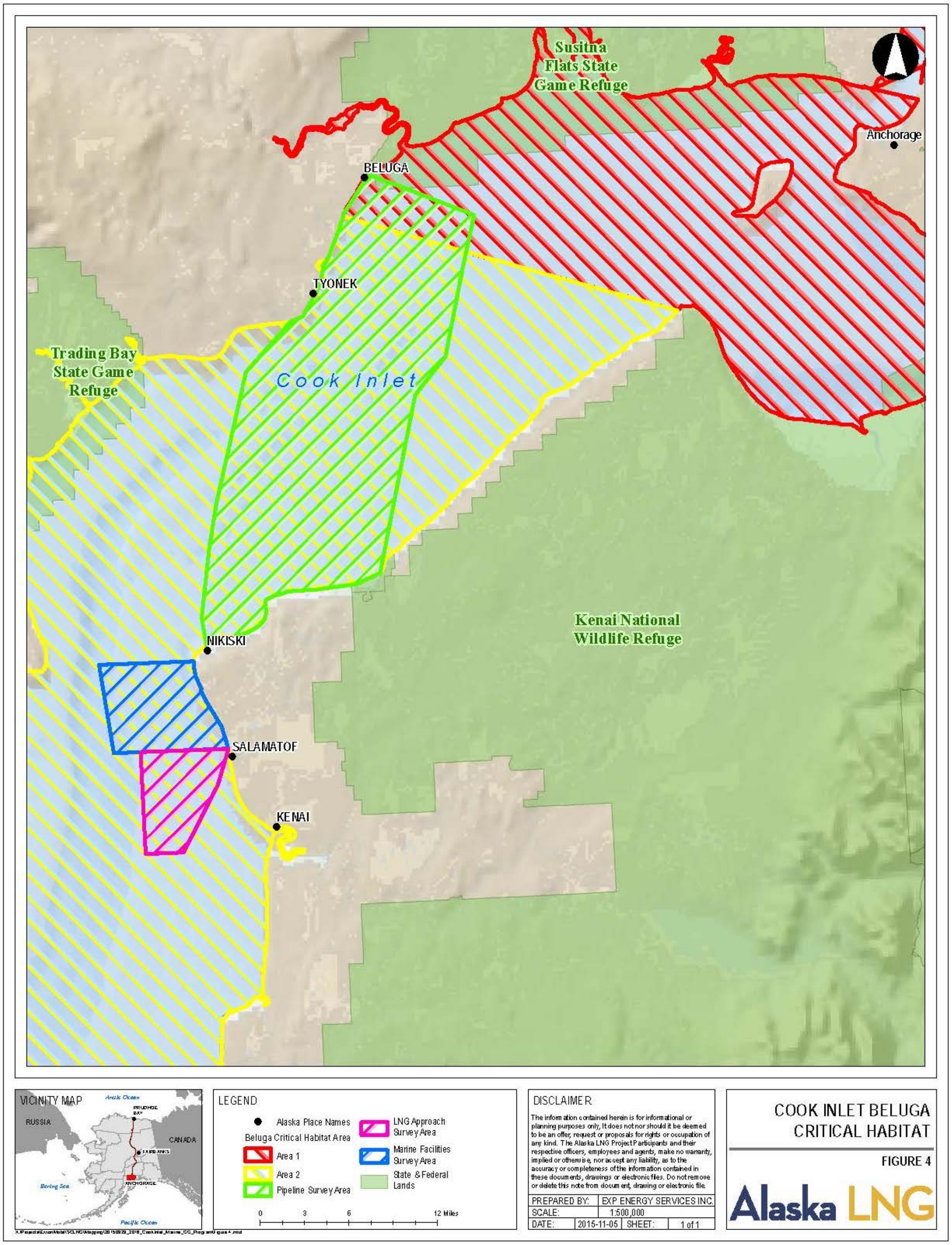
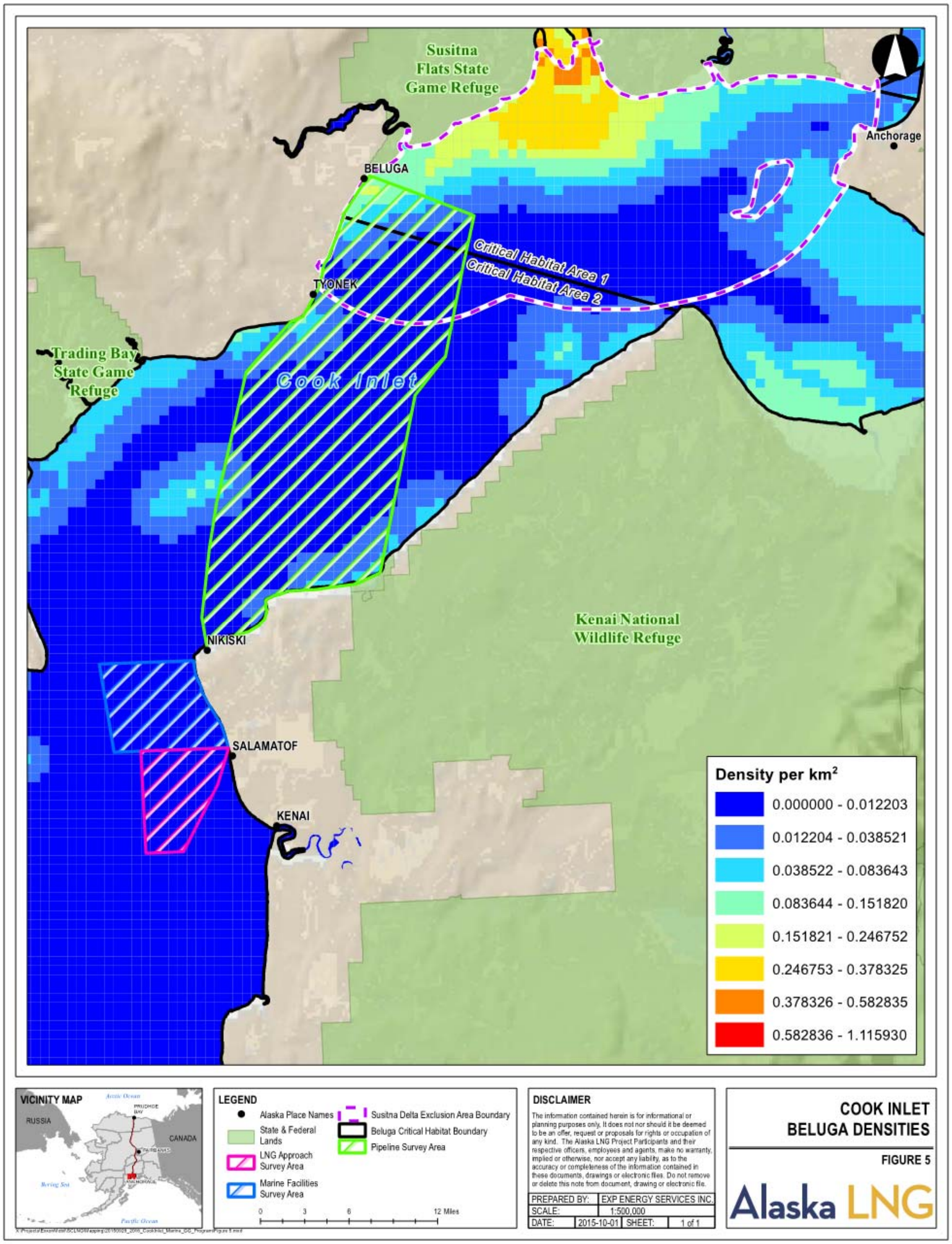


Figure 5. Cook Inlet Beluga Whale Population Summer Densities (Goetz et al. (2012))



4.2 KILLER WHALE (*ORCINUS ORCA*)

Two different stocks of killer whales inhabit the Cook Inlet region of Alaska: the Alaska Resident Stock and the Gulf of Alaska, Aleutian Islands, Bering Sea Transient stock (Allen and Angliss 2014). The Alaska Resident stock is estimated at 2,347 animals and occurs from Southeast Alaska to the Bering Sea (Allen and Angliss 2014). Resident whales feed exclusively on fish and are genetically distinct from transient whales (Saulitis et al. 2000).

The transient whales feed primarily on marine mammals (Saulitis et al. 2000). The transient population inhabiting the Gulf of Alaska shares mitochondrial DNA haplotypes with whales found along the Aleutian Islands and the Bering Sea, suggesting a common stock, although there appears to be some subpopulation genetic structuring occurring to suggest the gene flow between groups is limited (see Allen and Angliss 2014). For the three regions combined, the transient population has been estimated at 587 animals (Allen and Angliss 2014).

Killer whales are occasionally observed in Lower Cook Inlet, especially near Homer and Port Graham (Shelden et al. 2003, Rugh et al. 2005a). The few whales that have been photographically identified in Lower Cook Inlet belong to resident groups more commonly found in nearby Kenai Fjords and Prince William Sound (Shelden et al. 2003). Prior to the 1980s, killer whale sightings in Upper Cook Inlet were very rare. During aerial surveys conducted between 1993 and 2004, killer whales were observed on only three flights, all in the Kachemak and English Bay area (Rugh et al. 2005a). However, anecdotal reports of killer whales feeding on belugas in Upper Cook Inlet began increasing in the 1990s, possibly in response to declines in sea lion and harbor seal prey elsewhere (Shelden et al. 2003). These sporadic ventures of transient killer whales into beluga summering grounds have been implicated as a possible contributor to the decline of Cook Inlet belugas in the 1990s, although the number of confirmed mortalities from killer whales is small (Shelden et al. 2003). If killer whales were to venture into Upper Cook Inlet in 2016, they may be encountered during the G&G program.

4.3 HARBOR PORPOISE (*PHOCOENA PHOCOENA*)

Harbor porpoise are small (approximately 1.2 m {4 ft} in length), relatively inconspicuous toothed whales. The Gulf of Alaska Stock is distributed from Cape Suckling to Unimak Pass and was most recently estimated at 31,046 animals (Allen and Angliss 2014). They are found primarily in coastal waters less than 100 m (328 ft) deep (Hobbs and Waite 2010) where they feed on Pacific herring (*Clupea pallasii*), other schooling fishes, and cephalopods.

Although they have been frequently observed during aerial surveys in Cook Inlet, most sightings of harbor porpoise are of single animals, and are concentrated at Chinitna and Tuxedni bays on the west side of Lower Cook Inlet (Rugh et al. 2005a). Dahlheim et al. (2000) estimated the 1991 Cook Inlet-wide population at only 136 animals. Also, during marine mammal monitoring efforts conducted in Upper Cook Inlet by Apache from 2012 to 2014, harbor porpoise represented fewer than 2% of all marine mammal sightings. However, they are one of the three marine mammals (besides belugas and harbor seals) regularly seen in Upper Cook Inlet (Nemeth et al. 2007), especially during spring eulachon and summer salmon runs. Because harbor porpoise have been observed throughout Cook Inlet during the summer months, including mid-inlet waters, they are a species that might be encountered during the 2016 G&G program.

4.4 HARBOR SEAL (*PHOCA VITULINA*)

At more than 150,000 animals statewide (Allen and Angliss 2015), harbor seals are one of the more common marine mammal species in Alaskan waters. They are most commonly seen hauled out at tidal flats and rocky areas. Harbor seals feed largely on schooling fish such as Alaska pollock (*Theragra chalcogramma*), Pacific cod (*Gadus macrocephalus*), salmon, Pacific herring, eulachon, and squid. Although harbor seals may make seasonal movements in response to prey, they are resident to Alaska and do not migrate.

The Cook Inlet/Shelikof Stock, ranging from approximately Anchorage down along the south side of the Alaska Peninsula to Unimak Pass, has been recently estimated at a stable 22,900 (Allen and Angliss 2015). Large numbers concentrate at the river mouths and embayments of Lower Cook Inlet, including the Fox River mouth in Kachemak Bay (Rugh et al. 2005a). Montgomery et al. (2007) recorded more than 200 haulout sites in Lower Cook Inlet alone. However, only a few dozens to a few hundred seals seasonally occur in Upper Cook Inlet (Rugh et al. 2005a), mostly at the mouth of the Susitna River where their numbers vary with the spring eulachon and summer salmon runs (Nemeth et al. 2007, Boveng et al. 2012). Review of NMFS aerial survey data collected from 1993–2012 (Shelden et al. 2013) finds that the annual high counts of seals hauled out in Cook Inlet ranged from about 100–380, with most of these animals hauling out at the mouths of the Theodore and Lewis Rivers. Although there are thousands of harbor seals occurring in Lower Cook Inlet, no references have been found showing more than about 400 harbor seals occurring seasonally in Upper Cook Inlet. In 2012, up to 100 harbor seals were observed hauled out at the mouths of the Theodore and Lewis rivers (located about 16 km {10 mi} northeast of the pipeline survey area) during monitoring activity associated with Apache's 2012 Cook Inlet seismic program, and harbor seals constituted 60 percent of all marine mammal sightings by Apache observers during 2012 to 2014 survey and monitoring efforts (L. Parker, Apache, pers. comm.). Montgomery et al. (2007) also found that seals elsewhere in Cook Inlet move in response to local steelhead (*Onchorhynchus mykiss*) and salmon runs. Harbor seals may be encountered during the 2016 G&G program.

5.0 TYPE OF INCIDENTAL HARASSMENT AUTHORIZATION REQUESTED

An IHA is requested for Level B harassment from impulsive sound pressure levels exceeding 160 dB re 1 μPa rms and continuous sound pressure levels exceeding 120 dB re 1 μPa [rms] associated with the 2016 G&G program. Actual Level B exposures will depend upon numbers of marine mammals occurring within relevant 120 or 160 dB zones of influence (ZOI) at the time of activity as well as the effectiveness of mitigations. No Level A injury exposures (exposure to sound energy greater than 180 dB re 1 μPa rms for cetaceans and greater than 190 dB re 1 μPa rms for pinnipeds) are expected with the planned mitigation measures in place (see Appendix A).

6.0 HARASSMENT ESTIMATES FOR MARINE MAMMALS

6.1 BACKGROUND

Exposure to impulsive sound levels greater than 160 dB re 1 µPa (rms) or continuous sound pressure level exceeding 120 dB re 1 µPa (rms) are the thresholds for non-lethal, incidental Level B harassment of marine mammals pursuant to Section 101(a)(5)(D) of the MMPA. Level B harassment is defined under the MMPA as “any act of pursuit, torment, or annoyance which has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering but which does not have the potential to injure a marine mammal or marine mammal stock in the wild.” The following sections present the calculations used to estimate the numbers of marine mammals that might be exposed to Level B thresholds. The numbers of marine mammals that could be exposed to Level A thresholds in the absence of proposed mitigation measures are also presented below, and have been included at the request of NMFS; however, with the implementation of the proposed mitigation measures the occurrence of Level A exposures is unlikely and, accordingly, authorization for Level A harassment is not being requested.

6.2 BASIS FOR ESTIMATING POTENTIAL EXPOSURES OF MARINE MAMMALS

The estimates of the numbers of each species of marine mammal that could potentially be exposed to sound from the G&G program sound sources were determined by using a method specifically advised by NMFS. Level B exposures were estimated by multiplying the calculated density of each species by the area estimated to be ensonified to levels exceeding 120 dB re 1 µPa (rms) for continuous sound (i.e. vibracore) and 160 dB re 1 µPa (rms) for impulsive sound (i.e. chirp and boomer sub-bottom profiler and air gun) within an average day of activity. Level A exposures were estimated by multiplying the calculated density of each species by the area that estimated to be ensonified to levels exceeding 190 dB re 1 µPa (rms) for cetaceans (except for vibracore) and 180 dB re 1 µPa (rms) for pinnipeds. These results were then multiplied by the number of days of survey activity to estimate the total number of exposures that might occur during the G&G program. This method is an over-estimate because it includes multiple exposures of the same animal, since it assumes that any animal which is exposed does not change its behavior and is just as likely to be exposed again.

6.2.1 Ensonified Area

The daily ZOI is the area ensonified by a particular sound source to levels exceeding NMFS threshold levels during an average day of operation.

As discussed in Section 1.3, the distance to a sound threshold for equipment was determined by applying the source sound pressure levels described in Table 1 to both the spherical (20 Log r) and practical (15 log r) spreading models to provide ZOI estimates based on the spreading model most aligned with previous acoustical research in Cook Inlet (the spherical spreading model) and the more conservative spreading model (practical) requested by NMFS.

The following assumptions about the 2016 G&G program were used in calculating ensonified area:

- Survey equipment addressed in this IHA application will be operated from the survey vessels that will either be moving steadily across the ocean surface (chirp and boomer sub-bottom profiler and air gun), or moored at a station (vibracoring and air gun).

- In the LNGC approach survey area, the chirp and boomer sub-bottom profiler will be operated simultaneously.
- The pipeline survey area and marine facilities survey area will each be surveyed twice, once with the chirp and boomer sub-bottom profiler operated simultaneously, and once with the boomer sub-bottom profiler and air gun operated simultaneously.
- Approximately 100 km of transect line (applicable to chirp and boomer sub-bottom profiler and air gun) will be surveyed in an average day.
- Vibracoring will occur approximately twice per day.
- Use of an air gun from a stationary source will occur at up to approximately 24 locations in the marine facilities survey area, and each occurrence would last fewer than 24 hours.

The daily ZOI for the sub-bottom profilers and air gun was calculated by multiplying the distance traveled per day by double (2x) the radius and adding the radius on each end of the survey area distance. The daily ZOI for the vibracore was calculated to be equivalent to the area within the radius to the 120 dB isopleth. The vibracore daily ZOI was doubled since it is planned that up to two vibracores would be conducted per day. The daily ZOI for the air gun when operated from a stationary platform was calculated to be the area within the radius.

Tables 4 and 5 summarize the distances to NMFS Level A and Level B thresholds and the associated daily ZOIs for the survey equipment based on the spherical spreading model, while Tables 6 and 7 summarize the distances and ZOIs based on the practical spreading model. This comparison illustrates a significant difference in the daily ZOI calculated when using the spherical versus the practical spreading model, especially for the vibracorer (170-fold difference).

The distances to NMFS Level A and Level B thresholds for the spherical spreading model and the Collins et al. (2007) model (which was used in exposure estimations for EMALL's 2015 G&G Program in Cook Inlet) are similar. Since both the practical spreading and spherical spreading models are theoretical models, EMALL is referencing the spherical spreading model and the associated Level A and Level B distances in this 2016 G&G Program application rather than the Collins model or any other site-specific acoustical studies for the purpose of comparison to the practical spreading model.

Table 4. Summary of Distances to the NMFS Level A Thresholds and Associated Daily ZOIs Applying the Spherical Spreading Model (20 Log r)

Survey Equipment	Distance to 190 dB Isopleth for Pinnipeds m (ft)	Distance to 180 dB Isopleth for Cetaceans m (ft)	190 dB Daily ZOI km^2 (mi^2)	180 dB Daily ZOI km^2 (mi^2)
Sub-bottom profiler – chirp	4 (13)	13 (43)	0.8 (0.3)	2.6 (1.0)
Sub-bottom profiler – boomer	6 (21)	18 (59)	1.2 (0.5)	3.6 (1.4)
Air gun	7 (23)	20 (66)	1.4 (0.5)	4.0 (1.5)
Vibracore	0	3 (10)	0	0.00003 (0.00001)
Air gun (stationary)	7 (23)	20 (66)	0.00015 (0.00005)	0.00126 (0.0005)

Table 5. Summary of Distances to the NMFS Level A Thresholds and Associated Daily ZOIs Applying the Practical Spreading Model (15 Log r)

Survey Equipment	Distance to 190 dB Isopleth for Pinnipeds m (ft)	Distance to 180 dB Isopleth for Cetaceans m (ft)	190 dB Daily ZOI km² (mi²)	180 dB Daily ZOI km² (mi²)
Sub-bottom profiler – chirp	7 (23)	30 (98)	1.4 (0.5)	6.0 (2.3)
Sub-bottom profiler – boomer	10 (33)	47 (154)	2.0 (0.8)	9.4 (3.6)
Air gun	12 (39)	55 (180)	2.4 (0.9)	11.0 (4.2)
Vibracore	0	3 (10)	0	0.00003 (0.00001)
Air gun (stationary)	12 (39)	55 (180)	0.00045 (0.0002)	0.0095 (0.0037)

Table 6. Summary of Distances to the NMFS Level B Thresholds and Associated Daily ZOIs Applying the Spherical Spreading Model (20 Log r)

Survey Equipment	Distance to 160 dB Isopleth m (ft)	Distance to 120 dB Isopleth km (mi)	160 dB Daily ZOI km² (mi²)	120 dB Daily ZOI km² (mi²)
Sub-bottom profiler – chirp	126 (413)	N/A	25.2 (9.7)	N/A
Sub-bottom profiler – boomer	178 (584)	N/A	35.6 (13.7)	N/A
Air gun	200 (656)	N/A	40 (15.4)	N/A
Vibracore	N/A	2.24 (1.39)	N/A	15.8 (6.1)
Air gun (stationary)	200 (656)	N/A	0.126 (0.049)	N/A

Table 7. Summary of Distances to the NMFS Level B Thresholds and Associated Daily ZOIs Applying the Practical Spreading Model (15 Log r)

Survey Equipment	Distance to 160 dB Isopleth m (ft)	Distance to 120 dB Isopleth km (mi)	160 dB Daily ZOI km² (mi²)	120 dB Daily ZOI km² (mi²)
Sub-bottom profiler – chirp	631 (2,070)	N/A	126.2 (48.7)	N/A
Sub-bottom profiler – boomer	1,000 (3,281)	N/A	200 (77.2)	N/A
Air gun	1,170 (3,839)	N/A	234 (90.3)	N/A
Vibracore	N/A	29.3 (18.2)	N/A	2,696 (1,041)
Air gun (stationary)	1,170 (3,839)	N/A	4.3 (1.7)	N/A

6.2.2 Marine Mammal Densities

6.2.2.1 Harbor Porpoise, Killer Whale, Harbor Seal

Density estimates were calculated for harbor porpoise, killer whale, and harbor seal using aerial survey data collected by NMFS in Cook Inlet between 2002 and 2012 (Rugh et al. 2005, Shelden et al. 2013).

To estimate the average raw densities of harbor porpoise and killer whales, the total number of animals for each species observed over the 11-year survey period was divided by the total area of 65,889 km^2 (25,540 mi^2) surveyed over the 11 years. The aerial survey marine mammal sightings, survey effort (area), and derived average raw densities for harbor porpoise and killer whales are provided in Table 8. These raw densities were not corrected for animals missed during the aerial surveys as no accurate correction factors are currently available for these species; however, observer error may be limited as the NMFS surveyors often circled marine mammal groups to get an accurate count of group size.

Table 8. Raw Density Estimates for Cook Inlet Marine Mammals Based on NMFS Aerial Surveys

Species	No. of Animals Recorded	NMFS Survey Area km^2 (mi^2)	Mean Raw Density animals/km^2 (animals / mi^2)
Harbor Porpoise	249	65,889 (25,440)	0.0038 (0.0098)
Killer Whale [15]	42	65,889 (25,440)	0.0006 (0.0017)

The average raw density for harbor seals was also originally calculated in the same manner as harbor porpoise and killer whales (16,117 animals/ 65,889 km^2), but resulted in an unrealistically inflated density of 0.2446 seals/km^2. This inflated density is due to the bias created by the large number of hauled out harbor seals in the NMFS aerial survey database relative to the pattern of nearshore survey transect lines. The original estimate would presume that approximately 60 seals would be exposed during each day of G&G activity, which is in great contrast to the approximate 2.2 seals observed per 24-hour period by Lomac-MacNair et al. (2013, 2014) during similar seismic surveys in previous years in Upper Cook Inlet.

An alternative harbor seal density estimate was therefore developed by taking the highest number of hauled out seals recorded during the NMFS aerial survey (650 seals) and dividing it by the area of Upper Cook Inlet (3,835 km^2) resulting in a density of 0.1695 seals/km^2. This represents the density for the month of June when the aerial surveys were conducted, the period during which the harbor seal presence (and eulachon run) in Upper Cook Inlet is at its peak. NMFS is aware of the bias associated with the harbor seal density based solely on the beluga aerial surveys, and is in the process of developing more realistic density estimates (Sara Young, pers. comm.). As these new densities are not yet available, the 0.1695 seals/km^2 is used in this application.

6.2.2.2 Beluga Whale

Goetz et al. (2012) modeled aerial survey data collected by NMFS between 1993 and 2008 and developed specific beluga whale summer densities for each 1-km^2 cell of Cook Inlet. Given the clumped and distinct distribution of beluga whales in Cook Inlet during the summer months, these results provide a more precise estimate of beluga whale density at a given location than multiplying all aerial observations by the total survey effort.

To develop a density estimate associated with planned survey areas, the ensonified area associated with each activity was overlain on a map of the 1-km density cells. The cells falling within each ensonified area were quantified, and an average cell density was calculated. These densities are presented in Table 9.

[15] Density is for both transient and resident killer whales, although the killer whales in the Upper Cook Inlet are thought to be transient

Table 9. Mean Raw Densities of Beluga Whales within the Survey Areas Based on Goetz et al. (2012) Cook Inlet Beluga Whale Distribution Modeling

Survey Area	Number of Cells	Mean Density (animals/km^2)	Density Range (animals/km^2)
Marine Facilities	141	0.00014	0.00002-0.00069
LNGC Approach	95	0.00016	0.00003-0.00052
Pipeline	880	0.01319	0.00028-0.15672

6.2.3 Activity Duration

The following assumptions about the G&G program which were used in the exposure calculations:

- Surveys using the chirp and boomer sub-bottom profiler and air gun would occur over approximately 102 operational days during the 2016 open water season between March and November 2016.
- Survey days for the pipeline area, marine facilities area, and LNGC approach area (Table 10) are estimated to be 46, 42, and 14 respectively (not including vibracore survey days or air gun use when deployed from a stationary platform).
- Chirp sub-bottom profiler in combination with boomer sub-bottom profiler would be used for an estimated 30 survey days in the pipeline survey area, 14 days in the LNGC approach survey area and 28 days in the marine facilities area.
- Chirp sub-bottom profiler in combination with the air gun would be used for the remaining 16 of the 46 survey days in the pipeline area and 14 of the 42 days in the marine facilities area.
- Vibracoring would occur approximately 120 times (estimated 60 days) during the 2016 open water season between March and November 2016. Several vibracores could be conducted each day (but would average approximately two per day) depending on tides and currents, with the sound source operating for a few minutes each time the equipment is deployed. Vibracores are planned at approximately 40 locations (20 days) in the pipeline survey area, approximately 60 locations (30 days) in the marine facilities survey area, and approximately 20 locations (10 days) in the LNGC approach survey area.
- Use of an air gun from a stationary platform would occur over an estimated 24 days in the marine facilities survey area.

Table 10. Estimated Activity Durations for 2016 G&G Program

		Survey Area			
Survey Equipment	**Unit**	**Marine Facilities**	**LNGC Approach**	**Pipeline**	**Total**
Sub-bottom profiler – boomer [16]	Days	28	14	30	72
Air gun[16]	Days	14	0	16	30
Subtotal	**Days**	**42**	**14**	**46**	**102**
Vibracore [17]	Days	30	10	20	60
Air gun (stationary)	Days	24	0	0	24

6.3 EXPOSURE CALCULATIONS

The number of potential exposures of marine mammals to sound pressure levels exceeding NMFS Level A and Level B harassment threshold levels during the 2016 G&G program, without mitigation, were calculated by multiplying the average raw density for each species by the applicable daily ZOI and then multiplying by the number of days of survey. The results of the exposure calculations for harbor seals, harbor porpoise, and killer whales, based on the spherical spreading model, are found in Section 6.3.1. Results using the practical spreading model are found in Section 6.3.2. Exposure calculations for beluga whales used densities specific to each survey area.

6.3.1 Spherical Spreading Model

The results of the exposure calculations, based on the spherical spreading model, are shown in Table 11 (chirp and boomer sub-bottom profiler) and Table 12 (chirp sub-bottom profiler and air gun) for harbor porpoise, killer whales, and harbor seals, and Table 13 (chirp and boomer sub-bottom profiler) and 14 (chirp sub-bottom profiler and air gun) for beluga whales. Potential exposures of marine mammals due to vibracoring operations are shown in Table 15. Table 16 displays potential exposures of marine mammals due to use of the air gun from a stationary platform. Tables 17 and 18 summarize the estimated Level A and Level B exposures for each species for each type of survey equipment configuration.

Table 11. Calculated Number of Potential Marine Mammal Exposures to Received Sound Levels Exceeding Level A and Level B Thresholds (using Spherical Spreading Model) when Chirp and Boomer Sub-bottom Profiler are Operated Simultaneously Without Mitigations.

Species	Mean Density (no./km^2)	Days	Level A ZOI (km^2)	Level B ZOI (km^2)	Calculated Exposures Level A [18]	Calculated Exposures Level B [18]
Harbor Porpoise	0.0038	72	3.6	35.6	1	10
Killer Whale	0.0006	72	3.6	35.6	<1	2
Harbor Seal	0.1695	72	1.2	35.6	15	434

[16] Chirp sub-bottom profiler will be operated simultaneously with boomer sub-bottom profiler and separately with air gun.
[17] Vibracore activity is represented here as days, but each vibracore event is short duration. An estimated two vibracores would occur per day.
[18] Calculation does not account for implementation of mitigation measures, which would reduce potential for exposure.

Table 12. Calculated Number of Potential Marine Mammal Exposures to Received Sound Levels Exceeding Level A and Level B Thresholds (using Spherical Spreading Model) when Chirp Sub-bottom Profiler and Air Gun are Operated Simultaneously Without Mitigations.

Species	Mean Density (no./km^2)	Days	Level A ZOI (km^2)	Level B ZOI (km^2)	Calculated Exposures Level A [18]	Calculated Exposures Level B [18]
Harbor Porpoise	0.0038	30	4.0	40	<1	10
Killer Whale	0.0006	30	4.0	40	<1	1
Harbor Seal	0.1695	30	1.4	40	7	203

Table 13. Calculated Number of Potential Beluga Whale Exposures to Received Sound Levels Exceeding Level A and Level B Thresholds (using Spherical Spreading Model) when Chirp and Boomer Sub-bottom Profiler are Operated Simultaneously Without Mitigations.

Survey Area	Mean Density (no./km^2)	Days	Level A ZOI (km^2)	Level B ZOI (km^2)	Calculated Exposures Level A [18]	Calculated Exposures Level B [18]
LNGC Approach	0.0002	14	3.6	35.6	<1	<1
Marine Facilities	0.0001	28	3.6	35.6	<1	<1
Pipeline	0.0132	30	3.6	35.6	1	14
Total	not applicable	72	not applicable	not applicable	1	14

Table 14. Calculated Number of Potential Beluga Whale Exposures to Received Sound Levels Exceeding Level A and Level B Thresholds (using Spherical Spreading Model) when Chirp Sub-bottom Profiler and Air Gun are Operated Simultaneously Without Mitigations.

Survey Area	Mean Density (no./km^2)	Days	Level A ZOI (km^2)	Level B ZOI (km^2)	Calculated Exposures Level A [18]	Calculated Exposures Level B [18]
LNGC Approach	0.0002	0	4.0	40	0	0
Marine Facilities	0.0001	14	4.0	40	<1	<1
Pipeline	0.0132	16	4.0	40	1	8
Total	not applicable	30	not applicable	not applicable	1	8

Table 15. Calculated Number of Potential Marine Mammal Exposures to Received Sound Levels Exceeding Level A and Level B Thresholds (using Spherical Spreading Model) during Vibracoring Without Mitigations.

Species	Mean Density (no./km^2)	Days	Level A ZOI (km^2)	Level B ZOI (km^2)	Calculated Exposures Level A [18]	Calculated Exposures Level B [18]
Beluga Whale (Marine Facilities and LNGC Approach)	0.0002	40	0.00003	15.8	<1	<1
Beluga Whale (Pipeline)	0.0132	20	0.00003	15.8	<1	4
Harbor Porpoise	0.0038	60	0.00003	15.8	0	4
Killer Whale	0.0006	60	0.00003	15.8	<1	6
Harbor Seal	0.1695	60	0	15.8	0	161

Table 16. Calculated Number of Potential Marine Mammal Exposures to Received Sound Levels Exceeding Level A and Level B Thresholds (using Spherical Spreading Model) with Air Gun Operated from a Stationary Platform.

Species	Mean Density (no./km^2)	Days	Level A ZOI (km^2)	Level B ZOI (km^2)	Calculated Exposures Level A [18]	Calculated Exposures Level B [18]
Beluga Whale (Marine Facilities and LNGC Approach)	0.0002	24	0.00126	0.125	<1	<1
Beluga Whale (Pipeline)	0.0132	0	0.00126	0.125	0	0
Harbor Porpoise	0.0038	24	0.00126	0.125	<1	<1
Killer Whale	0.0006	24	0.00126	0.125	<1	<1
Harbor Seal	0.1695	24	0.00015	0.125	<1	1

Table 17. Summary of Calculated Exposures of Marine Mammals to Received Sound Levels Exceeding Level A Thresholds Without Mitigations (using Spherical Spreading Model).

Species	Chirp and Boomer Sub-bottom Profiler [18]	Chirp Sub-Bottom Profiler and Air Gun [18]	Vibracore [18]	Air Gun from a Stationary Platform	Total [18]
Beluga Whale	1	1	<1	<1	2
Killer Whale	<1	<1	<1	<1	<1
Harbor Porpoise	1	<1	<1	<1	1
Harbor Seal	15	7	0	<1	22

Table 18. Summary of Calculated Exposures of Marine Mammals to Received Sound Levels Exceeding Level B Thresholds Without Mitigations (using Spherical Spreading Model).

Species	Chirp and Boomer Sub-bottom Profiler [18]	Chirp Sub-Bottom Profiler and Air Gun [18]	Vibracore [18]	Air Gun from a Stationary Platform	Total [18]
Beluga Whale	14	8	4	<1	26
Killer Whale	2	1	6	<1	9
Harbor Porpoise	10	10	4	<1	24
Harbor Seal	434	203	161	1	799

6.3.2 Practical Spreading Model

Exposure calculations, based on the practical spreading model (15 Log r), are shown in Table 19 (chirp and boomer sub-bottom profiler) and Table 20 (chirp sub-bottom profiler and air gun) for harbor porpoise, killer whales, and harbor seals, and Table 21 (chirp and boomer sub-bottom profiler) and Table 22 (chirp sub-bottom profiler and air gun) for beluga whales. Potential exposures of marine mammals due to vibracoring operations are shown in Table 23. Table 24 displays potential exposures of marine mammals due to use of the air gun from a stationary platform. Tables 25 and 26 summarize the estimated Level A and Level B exposures for each species for each type of survey equipment configuration.

Table 19. Calculated Number of Potential Marine Mammal Exposures to Received Sound Levels Exceeding Level A and Level B Thresholds (using Practical Spreading Model) when Chirp and Boomer Sub-bottom Profiler are Operated Simultaneously Without Mitigations.

Species	Mean Density (no./km^2)	Days	Level A ZOI (km^2)	Level B ZOI (km^2)	Calculated Exposures Level A [18]	Calculated Exposures Level B [18]
Harbor Porpoise	0.0038	72	9.4	200	3	55
Killer Whale	0.0006	72	9.4	200	<1	9
Harbor Seal	0.1695	72	2.0	200	24	2,441

Table 20. Calculated Number of Potential Marine Mammal Exposures to Received Sound Levels Exceeding Level A and Level B Thresholds (using Practical Spreading Model) when Chirp Sub-bottom Profiler and Air Gun are Operated Simultaneously Without Mitigations.

Species	Mean Density (no./km^2)	Days	Level A ZOI (km^2)	Level B ZOI (km^2)	Calculated Exposures Level A [18]	Calculated Exposures Level B [18]
Harbor Porpoise	0.0038	30	11	234	1	27
Killer Whale	0.0006	30	11	234	<1	4
Harbor Seal	0.1695	30	2.4	234	12	1,190

Table 21. Calculated Number of Potential Beluga Whale Exposures to Received Sound Levels Exceeding Level A and Level B Thresholds (using Practical Spreading Model) when Chirp and Boomer Sub-bottom Profiler are Operated Simultaneously Without Mitigations.

Survey Area	Mean Density (no./km^2)	Days	Level A ZOI (km^2)	Level B ZOI (km^2)	Calculated Exposures Level A [18]	Calculated Exposures Level B [18]
LNGC Approach	0.0002	14	9.4	200	<1	1
Marine Facilities	0.0001	28	9.4	200	<1	1
Pipeline	0.0132	30	9.4	200	4	79
Total	not applicable	72	not applicable	not applicable	4	81

Table 22. Calculated Number of Potential Beluga Whale Exposures to Received Sound Levels Exceeding Level A and Level B Thresholds (using Practical Spreading Model) when Chirp Sub-bottom Profiler and Air Gun are Operated Simultaneously Without Mitigations.

Survey Area	Mean Density (no./km^2)	Days	Level A ZOI (km^2)	Level B ZOI (km^2)	Calculated Exposures Level A [18]	Calculated Exposures Level B [18]
LNGC Approach	0.0002	0	11	234	0	0
Marine Facilities	0.0001	14	11	234	<1	<1
Pipeline	0.0132	16	11	234	2	49
Total	not applicable	30	not applicable	not applicable	2	49

Table 23. Calculated Number of Potential Marine Mammal Exposures to Received Sound Levels Exceeding Level A and Level B Thresholds (using Practical Spreading Model) during Vibracoring Without Mitigations.

Species	Mean Density (no./km^2)	Days	Level A ZOI (km^2)	Level B ZOI (km^2)	Calculated Exposures Level A [18]	Calculated Exposures Level B [18]
Beluga Whale (Marine Facilities and LNGC Approach)	0.0002	40	0.00003	2,696	<1	22
Beluga Whale (Pipeline)	0.0132	20	0.00003	2,696	<1	712
Harbor Porpoise	0.0038	60	0.00003	2,696	<1	615
Killer Whale	0.0006	60	0.00003	2,696	<1	97
Harbor Seal	0.1695	60	0	2,696	0	27,434

Table 24. Calculated Number of Potential Marine Mammal Exposures to Received Sound Levels Exceeding Level A and Level B Thresholds (using Practical Spreading Model) with Air Gun Operated from a Stationary Platform.

Species	Mean Density (no./km^2)	Days	Level A ZOI (km^2)	Level B ZOI (km^2)	Calculated Exposures Level A [18]	Calculated Exposures Level B [18]
Beluga Whale (Marine Facilities and LNGC Approach)	0.0002	24	0.00126	4.3	<1	<1
Beluga Whale (Pipeline)	0.0132	0	0.00126	4.3	0	0
Harbor Porpoise	0.0038	24	0.00126	4.3	<1	<1
Killer Whale	0.0006	24	0.00126	4.3	<1	<1
Harbor Seal	0.1695	24	0.00015	4.3	<1	17

Table 25. Summary of Calculated Exposures of Marine Mammals to Received Sound Levels Exceeding Level A Thresholds Without Mitigations (using Practical Spreading Model).

Species	Chirp and Boomer Sub-bottom Profiler [18]	Chirp Sub-Bottom Profiler and Air Gun [18]	Vibracore [18]	Air Gun from a Stationary Platform	Total [18]
Beluga Whale	4	2	<1	<1	6
Killer Whale	<1	<1	<1	<1	<1
Harbor Porpoise	3	1	<1	<1	4
Harbor Seal	24	12	0	<1	36

Table 26. Summary of Calculated Exposures of Marine Mammals to Received Sound Levels Exceeding Level B Thresholds Without Mitigations (using Practical Spreading Model).

Species	Chirp and Boomer Sub-bottom Profiler [18]	Chirp Sub-Bottom Profiler and Air Gun [18]	Vibracore [18]	Air Gun from a Stationary Platform	Total [18]
Beluga Whale	81	49	734	<1	864
Killer Whale	9	4	97	<1	110
Harbor Porpoise	55	27	615	<1	697
Harbor Seal	2,441	1,190	27,434	17	31,082

Use of the practical spreading model to estimate radii and ZOIs results in very high exposure estimates compared to using the spherical spreading model (Section 6.3.1).

6.4 INCIDENTAL HARASSMENT AUTHORIZATIONS REQUESTED

As a result of the previously presented exposure calculations, and incorporating other considerations which are subsequently described, EMALL is requesting authorization for incidental, non-lethal harassment (Level B) of 34 beluga whales, 9 killer whales, 24 harbor porpoises, and 799 harbor seals (Table 27). The request is based on the estimated number of exposures using the spherical spreading model as the basis for estimating the equipment ZOIs.

The requested authorization for beluga whale was increased to 10% of the population given the larger average group size which may be encountered for this species. Exposure estimates based on the practical spreading model provide more exaggerated estimates, which do not reflect what is known about marine mammal distribution and stock size in Cook Inlet or the results from previous monitoring programs in the area. This is especially true for the proposed vibracore activity, where the conservatism of the practical spreading model is compounded due to the farther distance to the 120-dB isopleth, and for harbor seals, where the inflated density estimate further exaggerates the exposure estimates. The calculations conducted using the spherical model provide a more realistic estimate of potential exposures.

Table 27. Calculated Exposures and Requested Non-lethal, Incidental Level B "Harassment" of Marine Mammals.

Species	Calculated Exposures without Mitigation using Spherical Spreading Model	Calculated Exposures without Mitigation using Practical Spreading Model	Level B Harassment Authorization Requested
Beluga Whale [19]	26	864	34
Killer Whale [20]	9	110	9
Harbor Porpoise [20]	24	697	24
Harbor Seal [21]	799	31,082	799

The calculated Level A exposures, which are presented in Tables 17 and 25 at the request of NMFS, are not likely to occur, based on the implementation of mitigation measures such as vessel-based monitoring and shut-down procedures which would preclude a marine mammal from exposure to Level A sound. Since no Level A injury exposures are expected, EMALL is not asking for Level A authorizations.

The calculated Level B exposures using the spherical spreading model are also an over-estimate of likely exposures since they do not take into account the implementation of mitigation measures, which will reduce the potential for exposure of marine mammals to sound from planned activities. The methodology presented here to calculate potential exposures (commonly referred to as the 'daily method'), which was used at the request of NMFS, includes the potential for repeated exposures to the same animal. The circumstance of repeated exposures to the same animal is unlikely given the small area of the survey operations when compared to the habitat available in Cook Inlet, and the slow speed of vessel transit during surveying. There is additional uncertainty in calculating potential future exposures using historical densities given the variability in marine mammal behavior and the uncertainty regarding factors which influence behavior. Taking into account both the exposure calculations as well as quantitative and qualitative considerations, EMALL is requesting the authorizations shown in Table 27.

6.5 SMALL NUMBERS ANALYSIS

The requested authorizations represent small numbers of exposures relative to the applicable species or stock sizes, as shown in Table 28.

The requested authorization for beluga whales (which represents the number of potential exposures and not number of animals) is calculated to be 10% of the estimated stock (animals). The requested authorization accounts for mitigation measures which EMALL is confident will limit

[19] Based on 1-km cell densities in Goetz et al. (2012) model
[20] Based on average raw densities
[21] Exposures based on average raw densities with correction factor to reflect previously reported observations in survey area

the actual number of exposures. Most notable is the mitigation measure that the sub-bottom profilers and air gun will be shut-down at the approach of an ESA-listed species (such as the beluga whale) to the Level B zone. During 2012 and 2014, Lomac-MacNair et al. (2013, 2014) initiated the same mitigation measures planned by EMALL during Apache seismic activities in Upper Cook Inlet. Over the two seasons, observations of nearly 300 belugas were recorded from the seismic vessels and 25 delays or shutdowns were initiated. Only 12 beluga whales were observed within the Level B zone before a shutdown could be initiated (well below their authorized take of 30), and all of these were over 4 km (2.5 mi) from the vessel. EMALL is confident that the exposures to beluga whales can be minimized, and that the requested authorization represents small numbers relative to the stock.

The requested authorization for killer whale is an estimated 1.5% of the Alaska transient population or an estimated 0.4% of the Alaska resident population. The requested authorization is conservative given that killer whales are known to only occasionally visit Upper Cook Inlet.

The requested authorization for harbor porpoise of 24 exposures is similar to the number of animals expected to be seen based on similar previous geophysical surveys in Upper Cook Inlet (Lomac-MacNair et al. 2013, 2014).

The harassment authorization requested for harbor seals, at 3.4% of the population without mitigation, is conservative when compared to actual observations during similar G&G surveys which were conducted in the project area. A request for 799 seal exposures over 182 days of G&G activity (assuming for the purpose of calculation that each vibracore event is equivalent to one day), results in about 4.4 seals observed per day, or twice the 2.2 per day average that Lomac-MacNair et al. (2013, 2014) reported.

Table 28. Requested Non-lethal, Incidental Level B Harassments as Percentage of the Stock

Species	Abundance [22]	Requested Level B Harrassments	Percent Population
Beluga Whale	340	34	10.0%
Killer Whale (Alaska Transient)	587	9	1.5%
Killer Whale (Alaska Resident)	2,347	9	0.4%
Harbor Porpoise	31,046	24	0.1%
Harbor Seal	22,900	799	3.4%

[22] Allen and Angliss (2014, 2015)

7.0 ANTICIPATED IMPACT OF THE ACTIVITY

7.1 INTRODUCTION

This section summarizes the potential impacts of sounds generated by the 2016 G&G program. Potential impacts are reported based upon available literature. The 2016 G&G program is not expected to cause ship strike, entanglement, temporary or permanent threshold shift, non-auditory physical or physiological effects, injury, or mortality to any species.

The primary potential impact from the planned survey activities to local marine mammals is acoustical harassment from operation of the sub-bottom profilers, air gun, and vibracore. Sound pressure levels generated from these survey activities might disrupt normal behaviors of marine mammals when received levels exceed 120 dB re 1 μPa (vibracore) or 160 dB re 1 μPa (air gun and sub-bottom profilers).

The potential effects of the air gun, sub-bottom profilers, and the vibracore could include masking, behavioral responses, and temporary hearing impairment of marine mammals.

Masking occurs when loud sounds interfere with marine mammal vocalizations or the ability to hear natural sounds in their environment (Richardson et al. 1995), which limit their ability to communicate or avoid predation or other natural hazards. Masking is most evident when the dominant frequencies of industrial sound overlaps that of vocalization and hearing ranges of local marine mammals, and when the duration of the sound is prolonged.

Behavioral responses can include tolerance to industrial sound, or disturbance leading to behavioral modifications including diving patterns, habitat abandonment to avoid acoustical sound, and cessation of feeding or social interactions. Disturbance reactions, however, are dependent upon the behavioral state of the animal at the time of exposure (e.g., motivation, experience, activity such as feeding versus resting), which is difficult to predict (Richardson et al. 1995).

Sound has the potential to impair hearing in marine mammals by inducing temporary threshold shift (TTS) or permanent threshold shift (PTS) hearing loss (Weilgart 2007) if the sound is within the animal's hearing range, is loud enough, and the animal is exposed to the sound for a sufficient period of time. The level of temporary hearing loss is therefore dependent on sound frequency, intensity, and duration. Similar to masking, hearing loss reduces the ability for marine mammals to forage efficiently, maintain social cohesion, and avoid predators (Weilgart 2007). TTS is a mild, short-term hearing impairment than can occur due to exposure to loud sound levels (Kryter 1985). It is not physically damaging, and recovery is rapid, but the onset of TTS does indicate exposure levels are beginning to approach those that are damaging (Southall et al. 2007). TTS is possible from the survey activities if a marine mammal were very close to a sound source.

PTS occurs when sound exposure causes hairs within the inner ear system to die. This can occur due to moderate durations of very loud sound pressure levels, or long-term continuous exposure of moderate sound pressure levels. However, PTS is not an issue with the planned survey activities. The operation of the air gun and sub-bottom profilers will occur from moving vessels, which will limit marine mammal exposure to the few minutes during which the vessel passes. Vibracoring is a more fixed activity, but its operation lasts for only several minutes.

Further discussion on masking, behavioral responses, and temporary hearing impairment for applicable equipment is provided below.

7.2 EFFECTS OF A SMALL AIR GUN OR ARRAY

7.2.1 Masking

Marine mammal communication is not expected to be disrupted except when industrial sound frequencies overlap frequencies used by marine mammals in communication. A small air gun or air gun, such as that which is planned for use in 2016, typically produce sound at frequencies less than 1 kHz (Richardson et al. 1995, Zykov and Carr 2012).

Beluga whales have a well-developed and well-documented sense of hearing. White et al. (1978) measured the hearing of two belugas whales and described hearing sensitivity between 1 kHz and 130 kHz, with best hearing between 30 kHz to 50 kHz. Awbrey et al. (1988) examined their hearing in octave steps between 125 Hz and 8 kHz, with average hearing thresholds of 121 dB re1 µPa at 125 Hz and 65 dB re 1 µPa at 8 kHz. Johnson et al. (1989) further examined beluga hearing at low frequencies, establishing that the beluga whale hearing threshold at 40 Hz was 140 dB re 1 µPa. Ridgway et al (2001) measured hearing thresholds at various depths down to 984 ft (298 m) at frequencies between 500 Hz and 100 kHz. Beluga whales showed unchanged hearing sensitivity at this depth. Lastly, Finneran et al. (2005) measured the hearing of two belugas, describing their auditory thresholds between 2 kHz and 130 kHz. In summary, these studies indicate that beluga whales hear from approximately 40 Hz to 130 kHz, with maximum sensitivity from approximately 10 to 70 kHz (Wartzok and Ketten 1999). It is important to note that these audiograms represent the best hearing of beluga whales, measured in very quiet conditions. These quiet conditions are rarely present in the wild, where high levels of ambient sound may exist, especially in Cook Inlet where strong tidal currents can produce ambient sound levels well above 100 dB (Lammers et al. 2013).

Kastelein et al. (2002) measured the hearing range of the harbor porpoise and reported the full hearing range to be 0.25 to 180 kHz, the most sensitive range 16 to 140 kHz, and the maximum sensitivity hearing range to be 100 to 140 kHz. The frequency content of harbor porpoise echolocation clicks overlaps the above maximum sensitivity hearing range, and has been reported as 120 to 130 kHz (Verboom and Kastelein 1995) and 125 to 148 kHz (Mohl and Anderson 1973).

Beluga and killer whales are Type II vocalizers in that they tend to occur in social groups and much of the purpose of their vocalizations is to communicate with other group members. Both species communicate with a variety of sounds, but most especially with whistles in the 0.1 to 35 kHz range. Their vocalizations generally occur at frequencies at the lower end of their maximum sensitivity hearing range, but given that the communication is probably with nearby group members, maximum hearing sensitivity is unnecessary. In contrast, harbor porpoises are less social and inhabit complex nearshore environments (Type I vocalizers). Their vocalizations include low frequency (2 kHz) clicks and high frequency (100 to 160 kHz) pulses more designed to detect prey and hazards than to communicate (Schevill et al. 1969, Mohl and Anderson 1973, Kamminga 1988,).

Harbor seals, much like killer whales, have maximum hearing sensitivity in the 10 to 30 kHz range (Wartzok and Ketten 1999), but like harbor porpoise, they vocalize low frequency (100 to 400 Hz) grunts and high frequency (8 to 150 kHz) clicks. Underwater vocal communication is probably limited to very close range.

In summary, all four marine mammals likely to be encountered during the 2016 G&G program have maximum hearing sensitivity well above the low frequency sound levels expected to be generated by the small air gun. Except for low frequency grunts by harbor porpoise, these species also vocalize at frequencies well above that of air guns. Operation of the air gun is unlikely to mask local marine mammal communication.

7.2.2 Behavioral Response

Researchers have noted behavioral changes in captive beluga whales and other odontocetes when exposed to very loud impulsive sound similar to air guns (Finneran *et al.* 2000, 2002), and field observations in the Beaufort Sea reported evidence of belugas avoiding large array seismic operations (Miller *et al.* 2005). Further, Romano *et al.* (2004) exposed a captive beluga whale to air gun sound levels and found that the whale produced stress-level hormones with increasing sound pressure levels, and some hormone levels remained high as long as an hour after exposure (but these hormone levels were far less than those produced during beluga whale chase and capture events). Although the above observations occurred during beluga exposure to larger air gun than that which is planned to be used in the 2016 survey, they do demonstrate that beluga are susceptible to sound-induced stress and may avoid high sound levels as a result, leading to limited use of the available habitat.

There is little information on harbor porpoise reaction to survey activities, but they probably show a tolerance to sound levels similar to other odontocetes given their most sensitive hearing is largely above frequencies characterizing the survey equipment. However, Lucke et al. (2009) recently exposed harbor porpoise to high impulsive sound levels and found a behavioral aversion to impulsive sounds as low as 174 dB re 1 µPa (peak-peak), indicating a greater sensitivity to impulsive sound than beluga whales. Other studies (Stone 2003, MacLean and Koski 2005, Bain and Williams 2006, Stone and Tasker, 2006) have also observed harbor seal avoidance to air gun operations. Harbor porpoise are likely to avoid the planned survey activities.

Pinnipeds in general appear somewhat tolerant of underwater industrial sounds, partially because they can escape underwater pressure levels by exposing their head above the water surface, and they are less sensitive to lower frequency sound pressure levels. In her review of the known effects of sound on marine mammals, Weilgart (2007) largely confined her discussion on cetaceans and only once mentioned a possible negative effect on pinnipeds. Richardson et al. (1995) were not aware of any detailed data on reactions of seals to, for example, seismic sound energy, and expected them to tolerate or habituate to underwater seismic sound energy, especially if food sources were present. However, Calambokidis and Osmek (1998) did find harbor seal and California sea lion sighting distances to be longer in the presence of seismic activity in Puget Sound. Most information on the reaction of pinnipeds to vessels relate to disturbance of hauled out animals. There is little information on the reaction of these pinnipeds to ships while in the water other than some anecdotal information that sea lions are often attracted to boats (Richardson et al. 1995).

7.2.3 Hearing Impairment

Finneran et al. (2002) exposed a single beluga whale to single impulsive sound at a received level equivalent to 228 dB re 1 µPa (peak-peak), which resulted in a 6 dB TTS at 30 kHz. Within four minutes, the threshold returned to near the pre-exposure level. Later, Finneran et al. (2005) suggested that a sound exposure level of 195 dB is the likely threshold for onset of TTS.

Lucke et al. (2009) exposed harbor porpoise to high impulsive sound levels and found that TTS was induced at received sound pressure levels of approximately 200 dB re 1 µPa (peak-peak) with behavioral aversion to impulsive sounds as low as 174 dB re 1 µPa (peak-peak), indicating a greater sensitivity to impulsive sound than beluga whales.

There are no specific data on TTS thresholds for killer whales or harbor seals, although there is indirect evidence that thresholds for harbor seals may be less than odontocetes, although seals are generally less reactive (NMFS 2010). Recent information (Wood et al. 2012) suggests that for harbor seals and harbor porpoise, TTS may occur upon exposure to air gun pulses with received levels of 190 dB re 1 µPa (rms). Given the mitigation measures planned for the 2016

G&G program, it is unlikely that TTS onset due to exposure from the planned equipment would occur.

7.3 EFFECTS OF SUB-BOTTOM PROFILERS

7.3.1 Masking

Both the chirp and boomer sub-bottom profilers produce impulsive sound exceeding 160 dB re 1 µPa-m (rms). The boomer operates at a source value of 205 dB re 1 µPa-m (rms), but with a frequency between 0.5 and 6 kHz, which is lower than the maximum sensitivity hearing range of any the local species (belugas – 40-130 kHz;, killer whales – 18-42 kHz; harbor porpoise – 100-140 kHz; and harbor seals – 10-30 kHz; Szymanski et al. 1999, Wartzok and Ketten 1999, Kastelein et al. 2002). While the chirp sub-bottom profiler is not as loud (202 dB re 1 µPa-m [rms]), it does operate at a higher frequency range (2-16 kHz), and within the maximum sensitive range of all of the local marine mammal species except beluga whales. The ability for the chirp sub-bottom profiler to mask marine mammal communication is limited to the immediate vicinity of the survey vessel. Thus, as with the air gun, the sub-bottom profilers are not likely to interfere with the communication of local marine mammals.

7.3.2 Behavioral Response

The behavioral response of local marine mammals to the operation of the sub-bottom profilers is expected to be similar to that of the air gun. The odontocetes are likely to avoid the sub-bottom profiler activity, especially the naturally shy harbor porpoise, while the harbor seals might be attracted to them out of curiosity. However, because the sub-bottom profilers operate from a moving vessel, the area and time that this equipment would be affecting a given location is very small.

7.3.3 Hearing Impairment

It is unlikely that the sub-bottom profilers produce sound levels strong enough to cause hearing impairment or other physical injuries even in an animal that is (briefly) in a position near the source (Wood et al. 2012). The likelihood of marine mammals moving away from the source make if further unlikely that a marine mammal would be approach close enough to cause hearing impairment.

7.4 EFFECTS OF VIBRACORING

7.4.1 Masking

Chorney et al. (2011) conducted sound measurements on an operating vibracore in Alaska and found that it emitted a sound pressure level at 1-m source of 188 dB re 1 µPa-m (rms), with a frequency range of between 10 Hz and 20 kHz. While the frequency range overlaps the lower ends of the maximum sensitivity hearing ranges of harbor porpoises, killer whales, and harbor seals, and the continuous sound extends 2.54 km (1.6 mi) to the 120 dB threshold, the vibracore will operate the few minutes it takes to drive the core pipe 7 m (20 ft) into the sediment. Therefore, there is very little opportunity for this activity to mask the communication of local marine mammals.

7.4.2 Behavioral Response

There are no data on the behavioral response to vibracore activity. The closest analog to vibracoring might be exploratory drilling, although there is a notable difference in magnitude between an oil and gas drilling operation and collecting sediment samples with a vibracore. Regardless, Thomas et al. (1990) played back drilling sound to four captive beluga whales and found no statistical difference in swim patterns, social groups, respiration and dive rates, or stress hormone levels before and during playbacks. There is no reason to believe that beluga whales or any other marine mammal exposed to vibracoring sound would behave any differently, especially since vibracoring occurs for only one or two minutes.

7.4.3 Hearing Impairment

The vibracore operates for only one or two minutes at a time with a 1-m source of 187.4 dB re 1 μPa-m (rms). It is neither loud enough nor operates for a long enough duration to induce either TTS or PTS.

G&G program sound is not expected to cause resonate effects to gas-filled spaces or airspaces in marine mammals based on the research of Finneran (2003) on beluga whales showing that the tissue and other body masses dampen any potential effects of resonance on ear cavities, lungs, and intestines. Chronic exposure to sound could lead to physiological stress eventually causing hormonal imbalances (NRC 2005). If survival demands are already high, and/or additional stressors are present, the ability of the animal to cope decreases, leading to pathological conditions or death (NRC 2005). Potential effects may be greatest where sound disturbance can disrupt feeding patterns including displacement from critical feeding grounds. However, all potential exposures to marine mammals from G&G program would be of durations measured in minutes.

Specific sound-related processes that lead to strandings and mortality are not well documented, but may include (1) swimming in avoidance of a sound into shallow water; (2) a change in behavior (such as a change in diving behavior) that might contribute to tissue damage, gas bubble formation, hypoxia, cardiac arrhythmia, hypertensive hemorrhage, or other forms of trauma; (3) a physiological change such as a vestibular response leading to a behavioral change or stress-induced hemorrhagic diathesis, leading in turn to tissue damage; and, (4) tissue damage directly from sound exposure, such as through acoustically mediated bubble formation and growth or acoustic resonance of tissues (Wood et al. 2012). Some of these mechanisms are unlikely to apply in the case of impulse G&G program sounds, especially since air guns and sub-bottom profilers produce broadband sound with low pressure rise. Strandings to date that have been attributed to sound exposure related to date from military exercises using narrowband mid-frequency sonar with a much greater likelihood to cause physical damage (Balcomb and Claridge 2001, NOAA and USN, 2001, Hildebrand 2005).

The low-intensity, low-frequency, broadband sound associated with air gun and sub-bottom profilers, combined with the mitigation measures described in Appendix A would prevent physical injury to marine mammals. Sound generated by vibracoring would also be unlikely to have the capability of causing physical damage to marine mammals because of its low intensity and short duration. Strandings and mortality are not anticipated due to use of the planned equipment.

8.0 ANTICIPATED IMPACTS ON SUBSISTENCE USES

Tyonek is the only tribal village in the Upper Cook Inlet area with a tradition of hunting marine mammals (beluga whales and harbor seals). The Cook Inlet area villages of Kenai and Salamatof have traditionally hunted seals. Some Native subsistence hunters do reside in Nikiski, although Nikiski is not a traditional Native village. Tyonek is the village in the Cook Inlet area that is most associated with traditionally hunting beluga whales. However, a series of moratoriums have been placed on the Cook Inlet beluga subsistence harvest beginning in 1999, following significant harvest pressure in the mid-1990s that saw annual removals of 10 to 15 percent of the population (Mahoney and Shelden 2000) and resulted in a population decline from an estimated 1,300 whales in 1979 (Calkins 1989) to a recent estimate of 340 animals (Allen and Angliss 2015). Tyonek subsistence hunters were not involved with the high harvest activity in the 1990s (this was largely conducted by Anchorage-based hunters), and their harvest numbers remained low (Stephen R. Braund & Associates and Huntington Consulting {SRBA and HC} 2011). Village harvests between 1980 and 2000 generally averaged fewer than one beluga whale (Fall et al. 1984, SRBA and HC 2011). Although only five beluga whales have been harvested since 1999 (Hobbs et al. 2008, Allen and Angliss 2014), the population has continued to decline. No future subsistence harvest is planned until after the five-year population average has grown to at least 350 beluga whales. No beluga harvest is authorized for 2016 when the G&G program would occur.

Tyonek's annual recorded seal harvest since the 1980s has averaged approximately one animal (Fall et al. 1984, Wolfe et al. 2009). Many of the seals that are harvested are taken incidentally to salmon fishing or moose hunting (Fall et al. 1984, Merrill and Orpheim 2013), often near the mouths of the Susitna Delta rivers (Fall et al. 1984) north of the pipeline survey area. Kenai and Salamatof hunters more commonly harvest harbor seals, with Kenai reporting an average of about 13 per year between 1992 and 2008 (Wolfe et al. 2009). (Salamatof's harvest was not reported.) According to Fall et al. (1984), many of the seals harvested by hunters from these villages were taken on the west side of Cook Inlet (outside the survey areas) during hunting excursions for moose and black bears. Because of the position of Kenai and Salamatof in the upper reaches of Lower Cook Inlet, sea otters and Steller sea lions are rarely harvested.

Although marine mammals remain an important subsistence resource in Cook Inlet, the actual numbers of animals harvested annually by hunters from these villages are low, and are primarily limited to harbor seals. Much of the harbor seal harvest occurs incidental to other fishing and hunting activities, and at areas outside of the planned survey areas such as the Susitna Delta or the west side of Lower Cook Inlet. Thus, the 2016 G&G program will not affect local populations of harbor seals such that they would be unavailable for subsistence harvest in 2016.

EMALL has previously engaged with the Tyonek, Kenai, and Nikiski communities and will continue to do so. EMALL plans to meet with leadership at the Native Village of Tyonek, the Village of Salamatof and the Kenaitze Indian Tribe, all federally recognized tribes, prior to commencement of the 2016 survey activities. The purpose of these meetings is to convey Project plans (activities, timing) and to solicit additional information on subsistence use and community concerns. If a conflict with subsistence use is identified, the Project will meet with the affected party and develop a course of resolution. Based on subsistence information collected up to 2008, and the general tolerance of pinnipeds to industrial sounds, the G&G program will not affect harbor seal populations sufficient to render them less available for subsistence harvest in the future, especially because the village closest to the planned survey activities, Tyonek, has recently harvested on average only approximately one seal per year.

Since the survey area is not frequently used for native subsistence, the historical harvest numbers of marine mammals are extremely low, the G&G program is short-term with negligible impacts on the stock or species, and EMALL plans to communicate with local subsistence groups to avoid any conflicts, the 2016 G&G program will therefore not result in an unmitigatable adverse impact on the availability of the species or stock for subsistence uses.

9.0 ANTICIPATED IMPACTS ON HABITAT

The 2016 G&G program survey areas are primarily within Upper Cook Inlet, although the marine facilities survey area is located near Nikiski just south of the East Foreland (technically Lower Cook Inlet). Cook Inlet is a large subarctic estuary roughly 299 km (186 mi) in length and averaging 96 km (60 mi) in width. It extends from the city of Anchorage at its northern end and flows into the Gulf of Alaska at its southernmost end. For descriptive purposes, Cook Inlet is separated into unique upper and lower sections, divided at the East and West Forelands, where the opposing peninsulas create a natural waistline in the length of the waterway, measuring approximately 16 km (10 mi) across (Mulherin et al. 2001).

Upper Cook Inlet consists of the area between Point Campbell (Anchorage) down to the Forelands, and is roughly 95 km (59 mi) in length and 24.9 km (15.5 mi) in width (Mulherin et al. 2001). Five major rivers (Knik, Matanuska, Susitna, Little Susitna, and Beluga) deliver freshwater to Upper Cook Inlet, carrying a heavy annual sediment load of more than 40 million tons of eroded materials and glacial silt (Brabets 1999). As a result, Upper Cook Inlet is relatively shallow, averaging 18.3 m (60 ft) in depth. It is characterized by shoals, mudflats, and a wide coastal shelf, less than 17.9 m (59 ft) deep, extending from the eastern shore. A deep trough exists between Trading Bay and the Middle Ground Shoal, ranging from 35 to 77 m (114-253 ft) deep (NOAA Nautical Chart 16660). The substrate consists of a mixture of coarse gravels, cobbles, pebbles, sand, clay, and silt (Bouma et al. 1978, Rappeport 1982).

Upper Cook Inlet experiences some of the most extreme tides in the world, demonstrated by a mean tidal range from 4.0 m (13 ft) at the Gulf of Alaska end to 8.8 m (29 ft) near Anchorage (U.S. Army Corps of Engineers 2013). Tidal currents reach 3.9 kts (Mulherin et al. 2001) in Upper Cook Inlet, increasing to 5.7–7.7 kts near the Forelands where the Inlet is constricted. Each tidal cycle creates significant turbulence and vertical mixing of the water column in the Upper Cook Inlet (U.S. Army Corps of Engineers 2013), and are reversing, meaning that they are marked by a period of slack tide followed an acceleration in the opposite direction (Mulherin et al. 2001).

Because of scouring, mixing, and sediment transport from these currents, the marine invertebrate community is very limited (Pentec 2005). Of the 50 stations sampled by Saupe et al. 2005 for marine invertebrates in Southcentral Alaska, the Upper Cook Inlet station had by far the lowest abundance and diversity. Further, the fish community of Upper Cook Inlet is characterized largely by migratory fish—eulachon and Pacific salmon—returning to spawning rivers, or outmigrating salmon smolts. Moulton (1997) documented only 18 fish species in Upper Cook Inlet compared to at least 50 species found in Lower Cook Inlet (Robards et al. 1999).

Lower Cook Inlet extends from the Forelands southwest to the inlet mouth demarked by an approximate line between Cape Douglas and English Bay. Water circulation in Lower Cook Inlet is dominated by the Alaska Coastal Current (ACC) that flows northward along the shores of the Kenai Peninsula until it turns westward and is mixed by the combined influences of freshwater input from Upper Cook Inlet, wind, topography, tidal surges, and the coriolis effect (Field and Walker 2003, MMS 1996). Upwelling by the ACC brings nutrient-rich waters to Lower Cook Inlet and contributes to a biologically rich and productive ecology (Sambrotto and Lorenzen 1986). Tidal currents average 2–3 kts and are rotary in that they do not completely go slack before rotating around into an opposite direction (Gatto 1976, Mulherin et al. 2001). Depths in the central portion of Lower Cook Inlet are 60–80 m (197–262 ft) and decrease steadily toward the shores (Muench 1981). Bottom sediments in the Lower Inlet are coarse gravel and sand that grade to finer sand and mud toward the south (Bouma 1978).

Coarser substrate support a wide variety of invertebrates and fish including Pacific halibut, Dungeness crab (*Metacarcinus magister*), tanner crab (*Chionoecetes bairdi*), pandalid shrimp

(*Pandalus* spp.), Pacific cod, and rock sole (*Lepidopsetta bilineata*), while the soft-bottom sand and silt communities are dominated by polychaetes, bivalves and other flatfish (Field and Walker 2003). Razor clams (*Siliqua patula*) are found all along the beaches of the Kenai Peninsula. In general, the Lower Cook Inlet marine invertebrate community is of low abundance, dominated by polychaetes, until reaching the mouth of the inlet (Saupe et al. 2005). Overall, the Lower Cook Inlet marine ecosystem is fed by midwater communities of phytoplankton and zooplankton, with the latter composed mostly of copepods and barnacle and crab larvae (Damkaer 1977, English 1980).

Acoustical effects to prey resources are limited. Christian et al. (2004) studied seismic energy impacts on male snow crabs (*Chionoecetes* sp.) and found no significant increases in physiological stress due to exposure to high sound pressure levels. No acoustical impact studies have been conducted to date on the above fish species, but studies have been conducted on Atlantic cod (*Gadus morhua*) and sardine (*Clupea* sp). Davis et al. (1998) cited various studies which found no effects to Atlantic cod eggs, larvae, and fry when received levels were 222 dB. Effects found were to larval fish within about 5.0 m (16 ft), and from air guns with volumes between 49,661 and 65,548 cm^3 (3,000 and 4,000 in^3). Similarly, effects to sardine were greatest on eggs and two-day larvae, but these effects were greatest at 0.5 m (1.6 ft), and again confined to 5.0 m (16 ft). Further, Greenlaw et al. (1988) found no evidence of gross histological damage to eggs and larvae of northern anchovy (*Engraulis mordax*) exposed to seismic air guns, and concluded that noticeable effects would result only from multiple, close exposures. Based on these results, much lower energy impulsive equipment planned for this program would not damage larval fish or any other marine mammal prey resource.

Sediment sampling activities such as vibracore will temporarily disturb the seafloor and therefore habitat for benthic organisms. However, there are few benthic resources in the survey area that could be impacted by collection of the small samples (Saupe et al. 2005). A number of minor discharges to Cook Inlet from vessels associated with the G&G program will have a negligible impact to marine mammal habitat. These discharges are those associated with the normal operation of vessels in transit including deck drainage, ballast water, bilge water, non-contact cooling water, and gray water.

9.1 EFFECTS ON BELUGA WHALE CRITICAL HABITAT

Potential effects on beluga whale habitat would be limited to effects of sound on prey and direct impact to benthic habitat from sediment sampling. ESA section 3(5)(A)(i) defines critical habitat to include those “specific areas within the geographical area occupied by the species at the time it is listed…on which are found those physical or biological features…(I) essential to the conservation of the species and (II) which may require special management considerations or protection.” Joint NMFS/FWS regulations for listing endangered and threatened species and designating critical habitat at section 50 CFR 424.12(b) state that the agency ‘‘shall consider those physical and biological features that are essential to the conservation of a given species and that may require special management considerations or protection’’ also referred to as ‘‘Essential Features’’ or ‘‘Primary Constituent Elements.’’

When establishing critical habitat for the Cook Inlet beluga whale, NMFS identified the following as the Primary Constituent Elements. An analysis of the potential effects of the G&G program on these Primary Constituent Elements follows.

1. Intertidal and subtidal waters of Cook Inlet with depths <30 ft (9.1 m) (MLLW) and within five mi (8.0 km) of high and medium flow accumulation anadromous fish streams.

   Portions of the survey areas include waters of Cook Inlet that are <9.1 m (30 ft) in depth and within 8.0 km (5.0 mi) of anadromous streams. The G&G program will not prevent beluga access to the mouths of these streams and will result in no short-term or long-

term loss of intertidal or subtidal waters that are <9.1 m (30 ft) in depth and within 8.0 km (5.0 mi) of anadromous streams. There will be no residual effect on the area as beluga habitat once the survey is completed. Therefore, the 2016 G&G program will have no effect on this Primary Constituent Element.

2. Primary prey species consisting of four species of Pacific salmon (Chinook, sockeye, chum, and coho), Pacific eulachon, Pacific cod, walleye pollock, saffron cod, and yellowfin sole.

   The beluga prey species could potentially be affected by: the sound generated by G&G equipment, physical disturbance of the fish habitat, and discharges associated with the 2016 G&G program.

   As discussed previously in Section 9, acoustical effects to marine mammals prey resources, including Pacific salmon, Pacific eulachon, Pacific cod, saffron cod, yellowfin sole are limited and would be negligible, if they were to occur. The effects of larger seismic air guns on fish, fish larvae and eggs, and benthic invertebrates have been studied and have been found to be minimal. Based on these results, the much lower-energy impulsive equipment planned for the 2016 G&G program would not damage eggs or larval fish of these primary prey species or any other marine mammal prey resource.

   Direct physical disturbance of the benthic habitats will be limited. Physical evidence of the direct and indirect benthic impacts would be expected to be ameliorated naturally in a relatively short time in the high energy environment of the Cook Inlet. The survey areas are not known to contain any especially important spawning areas for these species. Salmon and eulachon are anadromous and spawn in freshwater; only adult Pacific cod are found in the Upper Cook Inlet. Given the small area affected, the temporary nature of the effects, and the high energy environment of Cook Inlet, the 2016 G&G program will have no noticeable effect on this Primary Constituent Element.

3. The absence of toxins or other agents of a type or amount harmful to beluga whales.

   No toxins will be discharged or otherwise introduced into waters of the Cook Inlet by the activities proposed in this IHA application. The program will have no effect on this Primary Constituent Element.

4. Unrestricted passage within or between the critical habitat areas.

   Belugas may avoid areas ensonified by the survey activities that generate sound with frequencies within the beluga hearing range and at levels above threshold values. This includes the chirp sub-bottom profiler, the boomer sub-bottom profiler, the air gun and the vibracores. The sub-bottom profilers and the air gun will be operated from a vessel moving at speeds of approximately 4 kts. The operation of a vibracore has a duration of approximately several minutes. All of these activities will be conducted in relatively open areas of the Cook Inlet within Critical Habitat Area 2 and a small area within Critical Habitat Area 1. Given the small area and mobile/temporary nature of the zones of ensonification with respect to the larger size of Cook Inlet, the generation of sound by the survey activities is not expected to result in any restriction of passage of belugas within or between critical habitat areas. The program will have no effect on this Primary Constituent Element.

5. The absence of in-water noise at levels resulting in the abandonment of habitat by Cook Inlet beluga whales.

   Operation of the survey equipment generates sound with frequencies within the beluga hearing range and at levels above threshold values. However, displacement of belugas due to these activities would be unlikely, since the sound sources are either mobile or very brief in duration. No abandonment of the habitat by belugas would be expected. The 2016 G&G program will have no effect on this Primary Constituent Element.

9.2 EFFECTS ON SUSITNA DELTA EXCLUSION AREA

Some of the 2016 G&G program is planned to occur within 10 miles (16 km) of the mean lower low water (MLLW) line of the Susitna Delta (Beluga River to the Little Susitna River), which is an area of importance for feeding and breeding for Cook Inlet beluga whales, particularly during the summer months of May through September when the highest concentrations of beluga whales are found there (NMFS 2015).

The pipeline survey area itself represents a maximum area within which G&G program activities could be conducted. The variability in tides and currents as well as the success of data acquisition will dictate the location of vessel transit within the pipeline survey area; these decisions will be made in the field. The pattern and timing of the G&G program activities within the pipeline survey area will therefore determine the actual area ensonified within the Susitna Delta Exclusion Area.

Since the G&G program activities have the potential to result in ensonification of a small percentage of the total area of the Susitna Delta, are proposed to occur during the months of March and April (before the summer salmon runs and prior to the highest concentrations of Cook Inlet beluga whale), and would be accompanied by the implementation of mitigation measures to avoid or minimize exposure of Cook Inlet beluga whales to sound generated from the activities, the effects from the G&G program to the Susitna Delta Exclusion Area will be minimal.

10.0 ANTICIPATED EFFECTS OF HABITAT IMPACTS ON MARINE MAMMALS

Based on the conclusions of Section 9, no loss or direct modification of marine mammal habitat is expected. Potential impacts to prey resources are considered minor or negligible, and no long-term effects would occur. The acoustic environment created by the survey could potentially result in the temporary displacement of any marine mammal that chose to avoid sound levels above ambient, but this is unlikely to occur because sound source is either constantly moving (sub-bottom profilers or air gun) or momentary in duration (vibracores). Additionally, the maximum area that could be ensonified to Level B thresholds at any given time would be equivalent to approximately 49 km^2 (19 mi^2), which represents only about 0.2% of the 20,943 km^2 (8,086 mi^2) Cook Inlet. Thus, while the G&G program has the potential to result in temporary displacement of marine mammals and minor and temporary disturbance of the seafloor, any such effects would be negligible given the ephemeral nature of these effects, the amount of habitat available, and the summer distribution of local marine mammals.

11.0 MITIGATION MEASURES

The planned mitigation measures which are fully described in the *Marine Mammal Monitoring and Mitigation Plan* (Appendix A) will minimize the probability of acoustic exposures to marine mammals and result in the least practicable adverse impact to marine mammals while carrying out the objectives of the 2016 G&G program.

Vessel-based visual observation using experienced PSOs as well as trained vessel captains and crew provides the most practicable and proven means for avoiding exposures through proactive observations as well as clear procedures for survey adaption to respond to marine mammal observations. Vessel-based visual observation is fit for purpose for the 2016 G&G program given the limited number of survey source vessels, the targeted geographic area of survey, the distinctive summer population distribution of the Cook Inlet beluga whale, and the relatively small sizes of the Level A and Level B zones. In circumstances where conditions are conducive to conduct vibracoring during periods of darkness, EMALL will utilize vessel-based passive acoustic monitoring (instead of visual monitoring) as the means to monitor for marine mammal presence in the vicinity of operations before and during vibracoring. Communication with NMFS through protected species observation reporting will further support avoidance or minimization of the potential for acoustic exposures to marine mammals.

12.0 PLAN OF COOPERATION

Given that Cook Inlet is not considered a traditional Arctic subsistence area, EMALL will not be preparing a formal Plan of Cooperation. EMALL will engage with applicable communities and local tribes near Cook Inlet to avoid adverse impacts to subsistence hunting and fishing activities by identifying and mitigating potential conflicts during the 2016 G&G program. Subsistence community engagement is discussed in greater detail in Section 8.

13.0 MONITORING AND REPORTING

Procedures for monitoring and reporting of potential acoustical exposures to local marine mammals are addressed in the *Marine Mammal Monitoring and Mitigation Plan* attached as Appendix A.

14.0 SUGGESTED MEANS OF COORDINATION

Observations of marine mammals recorded by the PSOs will be reported to NMFS (PR1 and AKR), following protocols described in the *Marine Mammal Monitoring and Mitigation Plan.* EMALL will coordinate with applicable agencies and community stakeholders to reduce potential impacts from planned activities. Given the targeted survey area, time constraints related to obtaining the data to meet program objectives, and limited survey duration, it is not practical to develop a specific research program in association with the 2016 G&G program. EMALL will continue dialogue with NMFS regarding the possible future implementation of passive acoustic monitoring near Nikiski.

15.0 ACRONYMS AND TERMS

Term or Abbreviation	Definition
Abbreviations for Units of Measurements	
cm	Centimeters
cm^3	cubic centimeters
dB	Decibels
ft	Feet
Hz	Hertz
in^3	cubic inches
kHz	Kilohertz
km	Kilometer
km^2	square kilometer
kts	Knots
mi	Mile
mi^2	square mile
rms	root mean square
μPa	Micropascals
Other Abbreviations	
§	section or paragraph
4MP	marine mammal monitoring and mitigation plan
ACC	Alaska Coastal Current
ADEC	Alaska Department of Environmental Conservation
CFR	Code of Federal Regulations
DPS	Distinct Population Stocks
EMALL	ExxonMobil Alaska LNG LLC
ESA	Endangered Species Act
G&G	geotechnical and geophysical
IHA	Incidental Harassment Authorization
LLC	Limited Liability Company
LNG	liquefied natural gas
Mainline	An approximately 800-mile-long, large-diameter gas pipeline
MLLW	Mean lower low water
MMPA	Marine Mammal Protection Act
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration

Term or Abbreviation	Definition
North Slope	Alaska North Slope
PBU	Prudhoe Bay Unit
PSO	Protected Species Observer
PTS	permanent threshold shift
PTU	Point Thomson Unit
TTS	temporary threshold shift
USFWS	U.S. Fish and Wildlife Service
ZOI	Zone of Influence

16.0 REFERENCES

Allen, B.M., and R.P. Angliss. Alaska marine mammal stock assessments, 2014. U.S. Dep. Commer., NOAA Tech. Memo. NMFSAFSC-277, 294.

Allen, B.M. and R.P. Angliss. 2015. Alaska marine mammal stock assessments. 2014. NOAA Technical Memorandum NMFS-AFSC-301. National Marine Fisheries Service. Seattle, Washington. 304 pp.

Austin, M.A., and G. Warner. 2013. Sound Source Acoustic Measurements for Apache's 2012 Cook Inlet Seismic Survey. Technical report for Fairweather LLC and Apache Corporation by JASCO Applied Sciences. 65 pp.

Awbrey, F.T., J.A. Thomas, and R.A. Kastelein. 1988. Low-frequency underwater hearing sensitivity in belugas*, (Delphinapterus leucas)*. Journal of the Acoustical Society of America 8:2273–2275.

Bain, D.E. and R. Williams. 2006. Long-range effects of air gun noise on marine mammals: responses as a function of received sound level and distance. Working Paper. SC/58/E35. International Whaling Commission. Cambridge, U.K. 13 p.

Balcomb, K.C. and D.E. Claridge. 2001. A mass stranding of cetaceans caused by naval sonar in the Bahamas. Bahamas J. Sci. 8(2):2-12.

Blackwell, S. B. 2005. Underwater measurements of pile-driving sounds during the Port MacKenzie dock modifications, 13-16 August 2004. Prepared for Knik Arm Bridge and Toll Authority by Greeneridge Sciences, Inc. and LGL Alaska Research Associates, Inc., at the request of HDR Alaska, Inc. Goleta, CA.

Blackwell, S.B. and C.R. Greene, Jr., 2002. Acoustic measurements in Cook Inlet, Alaska, during August 2001. Greeneridge Rep. 271-2. Prepared by Greeneridge Sciences, Inc., Santa Barbara, Calif., for National Marine Fisheries Service, Anchorage.

Bouma, A.H., M.A. Hampton, J.W. Whitney, and W.G. Noonan. 1978. Physiography of Lower Cook Inlet, Alaska. U.S. Geological Survey Open-File Report 78-728.

Boveng, P.L., J.M. London, and J.M. VerHoef. 2012. Distribution and abundance of harbor seals in Cook Inlet, Alaska. Task III: Movements, marine habitat use, diving behavior, and population structure, 2004-2006. Final Report. BOEM Report 2012-065. Bureau of Ocean Energy Management, Alaska Outer Continental Shelf Region, Anchorage, Alaska, USA. 58 pp.

Brabets et al. 1999. Water-quality assessment of the Cook Inlet Basin, Alaska – environmental setting. U.S. Geological Survey Water-Resources Investigations Report 99-4025.

Calambokidis, J. and S.D. Osmek. 1998. Marine mammal research and mitigation in conjunction with air gun operation for the USGS 'SHIPS' seismic surveys in 1998. Report by Cascadia Research, Olympia, WA, for U.S. Geological Survey and Minerals Management Service.

Calkins D.G. 1989. Status of belukha whales in Cook Inlet. In: Jarvela L.E., Thorsteinson L.K. (eds) Proceedings of the Gulf of Alaska, Cook Inlet, and North Aleutian Basin Information Update Meeting, Anchorage, AK, Feb. 7-8. U.S. Dept. Commerce, NOAA, OCSEAP, Anchorage, AK, pg. 109-112.

Carretta, J.V., E. Oleson, D.W. Weller, A.R. Lang, K.A. Forney, J. Baker, M.M. Muto, B. Hanson, A.J. Orr, H. Huber, M.S. Lowry, J. Barlow, J.E. Moore, D. Lynch, L. Carswell, and R. L. Brownell Jr. 2015. U.S. Pacific marine mammal stock assessments: 2014. NOAA Technical Memorandum, NMFS-SWFSC-549. U.S. Department of Commerce, 414 pp.

Castellote, M., T. A. Mooney, L. Quakenbush, R. Hobbs, C. Goetz, and E. Gaglione. 2014. Baseline hearing abilities and variability in wild beluga whales (*Delphinapterus leucas*). Journal of Experimental Biology 217:1682-1691.

Christian, J.R., A. Mathieu, and R.A. Buchanan. 2004. Chronic effects of seismic energy on snow crab (*Chionoecetes opilio*). Environmental Studies Research Funds Report No. 158, Calgary, AB.

Chorney, N.E., G. Warner, J. MacDonnell, A. McCrodan, T. Deveau, C. McPherson, C. O'Neill, D. Hannay, and B. Rideout. 2011. Underwater sound measurements. Chapter 3 In Reiser, C.M, D.W. Funk, R. Rodrigues, and D. Hannay. (eds.) 2011. Marine mammal monitoring and mitigation during marine geophysical surveys by Shell Offshore, Inc. *in* the Alaskan Chukchi and Beaufort seas, July–October 2010: 90-day report. LGL Rep. P1171E–1. Rep. from LGL Alaska Research Associates Inc., Anchorage, AK, and JASCO Applied Sciences, Victoria, BC for Shell Offshore Inc, Houston, TX, Nat. Mar. Fish. Serv., Silver Spring, MD, and U.S. Fish and Wild. Serv., Anchorage, AK.

Collins, K. A. MacGillivray, and S. Turner. 2007. Underwater source level measurements of air gun sources from ConocoPhillips' 2007 Beluga 3D seismic survey, Cook Inlet, Alaska. Unpublished report prepared by JASCO Research Ltd., for Veritas DGC. 27 pp.

Dahlheim, M., A. York, R. Towell, J. Waite, and J. Breiwick. 2000. Harbor porpoise (*Phocoena phocoena*) abundance in Alaska: Bristol Bay to Southeast Alaska, 1991-1993. Marine Mammal Science 16:28-45.

Damkaer, D. 1977. Initial zooplankton investigations in Prince William Sound, Gulf of Alaska and Lower Cook Inlet. In Outer Continental Shelf Environmental Assessment Program. Boulder, CO. pp. 137-274.

Davis, R.A., D. Thomson, and C.I. Malme. 1998. Environmental assessment of seismic exploration of the Scotian Shelf. Unpublished Report by LGL Ltd., environmental research associates, King City, ON and Charles I. Malme, Engineering and Science Services, Hingham, MA for Mobil Oil Canada Properties Ltd, Shell Canada Ltd., and Imperial Oil Ltd.

English, S.T. 1980. Lower Cook Inlet meroplankton. University of Washington. Seattle, WA. 57 pp. .

Fall, J.A., D.J. Foster, and R.T. Stanek. 1984. The use of fish and wildlife resources in Tyonek, Alaska. Alaska Department of Fish and Game, Division of Subsistence Technical Paper No. 104. Juneau, AK.

Field, C. and C. Walker. 2003. A site profile of the Kachemak Bay Research Reserve: A Unit of the National Estuarine Research Reserve System. Kachemak Bay Research Reserve, Homer, AK. 147 pp.

Finneran, J.J. 2003. Whole-lung resonance in bottlenose dolphin (*Tursiops truncatus*) and white whale (*Delphinapterus leucas*). Journal of the Acoustical Society of America. 114:529-535.

Finneran, J.J., C.E. Schlundt, R. Dear, D.A. Carder, and S.H. Ridgway. 2002. Temporary shift in masked hearing thresholds in odontocetes after exposure to single underwater impulses from a seismic watergun. Journal of the Acoustical Society of America. 111:2929-2940.

Finneran, J.J., D. A. Carder, R. Dear, T. Belting, J. McBain, L. Dalton, and S. H. Ridgway. 2005. Pure tone audiograms and possible aminoglycoside-induced hearing loss in belugas (*Delphinapterus leucas*). Journal of the Acoustical Society of America. 117:3936-3943.

Finneran, J. J., Schlundt, C. E., Carder, D. A., Clark, J. A., Young, J. A., Gaspin, J. B., et al. (2000). Auditory and behavioral responses of bottlenose dolphins (*Tursiops truncatus*) and white whales (*Delphinapterus leucas*) to impulsive sounds resembling distant signatures of underwater explosions. Journal of the Acoustical Society of America, 108, 417-431.

Gatto, L.W. 1976. Baseline data on the oceanography of Cook Inlet, Alaska. Cold Regions Research and Engineering Laboratory, U.S. Army Corps of Engineers, Hanover, NH. CRREL Report 76-2E, 92 pp.

Goetz K.T., Montgomery R.A., Ver Hoef J.M., Hobbs R.C., Johnson D.S. 2012. Identifying essential summer habitat of the endangered beluga whale *Delphinapterus leucas* in Cook Inlet, Alaska. Endangered Species Research 16:135-147

Greenlaw, C.F., D.V. Holliday, R.E. Pieper, and M.E. Clark. 1988. Effects of air gun energy releases on the northern anchovy. Journal of the Acoustical Society of America.84:S165.

Heath, B., G. Jimenez, and K. Marks. 2014. Sound Source Verification Final Report, Cook Inlet Seismic Survey, SAE, Alaska. 28 pp.

Hildebrand, J.A. 2005. Impacts of anthropogenic sound. p. 101-124 in: J.E. Reynolds, W.F. Perrin, R.R. Reeves, S. Montgomery, and T. Ragen (eds.), Marine Mammal Research: Conservation Beyond Crisis. Johns Hopkins Univ. Press, Baltimore, MD. 223 pp.

Hobbs, R. C., and K. E. W. Shelden. 2008. Supplemental status review and extinction assessment of Cook Inlet belugas (*Delphinapterus leucas*). AFSC Processed Rep. 2008-08, 76 p. Alaska Fish. Sci. Cent., NOAA, National Marine Fisheries Service, 7600 Sand Point Way NE, Seattle WA 98115.

Hobbs, R.C. and J.M. Waite. 2010. Abundance of harbor porpoise (*Phocoena phocoena*) in three Alaskan regions, corrected for observer errors due to perception bias and species misidentification, and corrected for animals submerged from view. Fisheries Bulletin. 108:251-267.

Illingworth & Rodkin, Inc. (I&R). 2014. Cook Inlet Exploratory Drilling Program – Underwater Sound Source Verification Assessment. Report prepared for BlueCrest Energy, Inc. Illingworth & Rodkin, Inc., Petaluma, CA. 20 pp.

Johnson, C.S., M.W. McManus, and D. Skaar. 1989. Masked tonal hearing thresholds in the beluga whale. Journal of the Acoustical Society of America 85:2651–54.

Kamminga, C. 1988. Echolocation signal types of odontocetes, pp. 9-22 in P.E. Natchigall and P.W. Moore (eds.) Animal sonars: processes and performance. Plen, NY.

Kastelein, R. A., Bunskoek, P., Hagedoorn, M., Au, W. W. L., and de Haan, D. (2002). Audiogram of a harbor porpoise (*Phocoena phocoena*) measured with narrow-band frequency-modulated signals," Journal of the Acoustical Society of America.112, 334–344.

Kryter, K.D. 1985. The Effects of Noise on Man, 2nd ed. Academic Press, Orlando, FL. 688 pp.

Laidre, K.L., K.E.W. Shelden, D.J. Rugh, and B.A. Mahoney. 2000. Beluga*, Delphinapterus leucas*, Distribution and Survey Effort in the Gulf of Alaska. Marine Fisheries Review, 62:27-36.

Lammers, M., M. Castellote, R.J. Small, S. Atkinson, J. Jenniges, A. Rosinski, J. Oswald, C. Garner. 2013. Passive acoustic monitoring of belugas (*Delphinapterus leucas*). Journal of the Acoustical Society of America.134 (3), Pt. 2.

Lomac-MacNair, K., M.A. Smultea and G. Campbell. 2014. Draft NMFS 90-Day Report for marine mammal monitoring and mitigation during Apache's Cook Inlet 2014 seismic survey, 2 April – 27 June 2014. Prepared for Apache Alaska Corporation, 510 L Street #310, Anchorage AK 99501. Prepared by Smultea Environmental Sciences (SES), P.O. Box 256, Preston, WA 98050.

Lomac-MacNair, K.S, L.S. Kendall, and S. Wisdom. 2013. Marine mammal monitoring and mitigation, 90-day report, May 6- September 30, 2012, Alaska Apache Corporation 3D Seismic Program, Cook Inlet, Alaska. Prepared by SAExploration 8240 Sandlewood Pl. Suite 102 Anchorage, AK and Fairweather Science 9525 King Street, Anchorage, AK. Prepared for Apache Alaska Corporation and National Marine Fisheries Service. 87 p.

Lucke K., U. Siebert, P. Lepper, and M.A. Blanchet. 2009. Temporary shift in masked hearing thresholds in a harbor porpoise (*Phocoena phocoena*) after exposure to seismic air gun stimuli. Journal of the Acoustical Society of America. 125:4060–4070.

MacLean, S.A. and W.R. Koski. 2005. Marine mammal monitoring during Lamont-Doherty Earth Observatory's seismic program in the Gulf of Alaska, August-September 2004. LGL Rep. TA2822-28. Rep. by LGL Ltd., King City, Ont., for Lamont-Doherty Earth Observatory of Columbia Univ., Palisades, NY, and NMFS, Silver Spring, MD. 102 pp.

Mahoney, B. A. and K. E. W. Shelden. 2000. Harvest history of belugas, *Delphinapterus leucas*, in Cook Inlet, Alaska. Marine Fisheries Review. 62:124-133.

Merrill, T. and Orpheim, M. 2013. Assessment of Cook Inlet Tribes Subsistence Consumption. Prepared for Seldovia Village Tribe (SVT).

Miller, G.W., V.D. Moulton, R.A. Davis, M. Holst, P. Millman, A. MacGillivray, and D. Hannay. 2005. Monitoring seismic effects on marine mammals—southeastern Beaufort Sea, 2001-2002. p. 511-542 In: S.L. Armsworthy, P.J. Cranford, and K. Lee (eds.), Offshore Oil and Gas Environmental Effects Monitoring/Approaches and Technologies. Battelle Press, Columbus, OH.

Minerals Management Service (MMS). 1996. Cook Inlet Planning Area Oil and Gas Lease Sale 149. Final Environmental Impact Statement, Volume 1. OCS EIS/EA MMS 95-0066. Minerals Management Service, Alaska OCS Region. Anchorage, AK.

Mohl, B. and S. Andersen. 1973. Echolocation: high frequency component in the click of the harbor porpoise (*Phocoena phocoena* L.). Journal of the Acoustical Society of America. 54, 1368-1373.

Montgomery, R.A., J.M. Ver Hoef, and P.L. Boveng. 2007. Spatial modeling of haul-out site use by harbor seals in Cook Inlet, Alaska. Marine Ecology Progress Series. 341:257-264.

Moore, S.E., D.P. DeMaster, and P.K. Dayton. 2000. Cetacean habitat selection in the Alaskan Arctic during summer and autumn. Arctic 53:432-447.

Moulton, L.L. 1997. Early marine residence, growth, and feeding by juvenile salmon in northern Cook Inlet, Alaska. Alaska Fisheries Research Bulletin. 4:154-177.

Muench, R.D., J.D. Schumacher, and C.A. Pearson. 1981. Circulation in the Lower Cook Inlet, Alaska. NOAA Technical Memorandum.

Mulherin, N.D., W.B. Tucker III, O.P. Smith, and W.J. Lee. 2001. Marine ice atlas for Cook Inlet, Alaska.

National Marine Fisheries Service (NMFS). 2015. Takes of marine mammals incidental to specified activities; taking marine mammals incidental to geophysical and geotechnical surveys in Cook Inlet, Alaska. Federal Register 80:50990-51018.

National Marine Fisheries Service (NMFS). 2012. Guidance Document: Sound Propagation Modeling ot Characterize Pile Driving Sounds Relevant to Marine Mammals. USDOC, National oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Region. Seattle, WA

National Marine Fisheries Service (NMFS). 2010. Environmental Assessment for the issuance of Incidental Harassment Authorizations to take marine mammals by harassment incidental to conducting open water seismic and marine surveys in the Chukchi and Beaufort Seas. USDOC, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Office of Protected Resources. Silver Spring, MD

National Research Council (NRC). 2003. Ocean noise and marine mammals. National Academies Press, Washington, D.C. 192 pp.

National Research Council (NRC). 2005. Marine mammal populations and ocean noise. National Academies Press, Washington, D.C. 126 pp.

Nemeth, M.J., C.C. Kaplan, A.P. Ramos, G.D. Wade, D.M. Savarese, and C.D. Lyons. 2007. Baseline studies of marine fish and mammals in Upper Cook Inlet, April through October 2006. Final report prepared by LGL Alaska Research Associates, Inc., Anchorage, Alaska for DRven Corporation, Anchorage, Alaska.

NOAA. 2015. Interim Sound Threshold Guidance. Available at http://www.westcoast.fisheries.noaa.gov/protected_species/marine_mammals/threshold_guidance.html

NOAA and USN (National Oceanographic and Atmospheric Administration and U.S. Navy). 2001. Joint interim report: Bahamas marine mammal stranding event of 15-16 March 2000. U.S. Dep. Commerce., NOAA Fisheries., Sec. Navy, Assist. Sec. Navy, Installations and Environ. 51 pp. Available at http://www.nmfs.noaa.gov/ pr/pdfs/health/stranding_ bahamas2000.pdf.

O'Corry-Crowe, G.M., R.S. Suydam, A. Rosenberg, K.J. Frost, and A.E. Dizon. 1997. Phylogeography, population structure and dispersal patterns of the beluga whale *Delphinapterus leucas* in the western Nearctic revealed by mitochondrial DNA. Molecular Ecology 6:955-970.

O'Neill, C., D. Leary, and A. McCrodan. (2010). Sound Source Verification. (Chapter 3) In Blees, M. K., K. G. Hartin, D. S. Ireland, and D. Hannay. (eds.) Marine mammal monitoring and mitigation during open water seismic exploration by Statoil USA E&P Inc. in the Chukchi Sea, August–October 2010: 90-day report. LGL Report P1119. Prepared by LGL Alaska Research Associates Inc., LGL Ltd., and JASCO Applied Sciences Ltd. for Statoil USA E&P Inc., Nat. Mar. Fish. Serv., and U.S. Fish and Wildlife Service. 3-1, 3-34 p.

Parker, L. (personal communication). Unpublished presentation of the results of Apache Alaska Corporation's 2013 3D seismic program in the Cook Inlet.

Pentec. 2005. Marine fish and benthos studies in Knik Arm, Anchorage, Alaska. Prepared for Knik Arm Bridge and Toll Authority and HDR Alaska, Inc. Report 12214-10/12214-12. Prepared by Pentec Environmental, Edmonds, Washington.

Rappeport, M.L. 1982. An analysis of oceanographic and meteorological conditions for central Lower Cook Inlet, Alaska. U.S. Geological Survey Open-File Report 82-128.

Richardson, W.J., C.R. Greene, Jr., C.I. Malme, and D.H. Thomson. 1995. Marine mammals and noise. Academic Press, San Diego. 576 pp.

Ridgway, S. H., D.A. Carder, T. Kamolnick, R.R. Smith, C.E. Schlundt, and W.R. Elsberry. 2001. Hearing and whistling in the deep sea: Depth influences whistle spectra but does not attenuate hearing by white whales (*Delphinapterus leucas*) (Odontoceti, Cetacea). Journal of Experimental Biology 204:3829-3841.

Robards, M.D., J.F. Piatt, A.B. Kettle and A.A. Abookire. 1999. Temporal and geographic variation in fish communities of Lower Cook Inlet, Alaska. Fisheries Bulletin. 97:962–977.

Romano, T. A., Keogh, M. J., Kelly, C., Feng, P., Berk, L., Schlundt, C. E., et al. 2004. Anthropogenic sound and marine mammal health: Measures of the nervous and immune systems before and after intense sound exposure. Canadian Journal of Fisheries and Aquatic Sciences. 61:1124-1134.

Rugh, D.J., K.E.W. Shelden, C.L. Sims, B.A. Mahoney, B.K. Smith, L.K. (Litzky) Hoberecht, and R.C. Hobbs. 2005. Aerial surveys of belugas in Cook Inlet, Alaska, June 2001, 2002, 2003, and 2004. NOAA Technical Memorandum NMFS-AFSC-149. 71 pp.

Sambrotto, R.N. and C.J. Lorenzen. 1986. Phytoplankton and primary productivity. In: The Gulf of Alaska Physical Environment and Biological Resources*.* D.W. Hood and S.T. Zimmerman eds. OCS Study 86-0095 USDOC, NOAA, NOS, and USDOI, MMS, Alaska OCS Region. Anchorage, AK. pp. 249-282.

Saulitis, E., C. Matkin, L. Barrett-Lennard, K. Heise, and G. Ellis. 2000. Foraging strategies of sympatric killer whale (*Orcinus orca*) populations in Prince William Sound, Alaska. Mar. Mammal Sci. 16:94-109.

Saupe, S., J. Gendron, and D. Dasher. 2005. The condition of southcentral Alaska's bays and estuaries. A Statistical Summary for the National Coastal Assessment Program, Alaska Department of Environmental Conservation, March 15, 2006.

Scientific Fishery Systems, Inc. (SFS). 2009. 2008 underwater noise survey during construction pile driving, Port of Anchorage Marine Terminal Development Project, in support of Alaska Native

Technologies, LLC. Prepared for U.S. Department of Transportation Maritime Administration, Port of Anchorage, and Integrated Concepts and Research Corporation.

Schevill, W.E., W.A. Watkins, and C. Ray. 1969. Click structure in the porpoise *Phocoena phocoena*. Journal of Mammalogy 50:721-729.

Shelden, K.E.W., D.J. Rugh, B.A. Mahoney, and M.E. Dahlheim. 2003. Killer whale predation on belugas in Cook Inlet, Alaska: implications for a depleted population. Marine Mammal Science. 19:529-544

Shelden, K. E. W., D.J. Rugh, K.T. Goetz, C.L. Sims, L. Vate Brattström, J.A. Mocklin, B.A. Mahoney, B.K. Smith, and R.C. Hobbs. 2013. Aerial surveys of beluga whales, *Delphinapterus leucas*, in Cook Inlet, Alaska, June 2005 to 2012. U.S. Department of Commerce. NOAA Tech. Memo. NMFS-AFSC-263, 122 p.

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene Jr., D. Kastak, D.K. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas, and P.L. Tyack. 2007. Marine mammal noise exposure criteria: Initial scientific recommendations. Special Issue of Aquatic Mammals 33(4):412-522.

Speckman, S.G. and J.F. Piatt. 2000. Historic and Current Use of Lower Cook Inlet, Alaska, by Belugas, *Delphinapterus leucas*. Marine Fisheries Review 62:22-26.

Stephen R. Braund & Associates and Huntington Consulting (SBRA and HC). 2011. Relationship between the native village of Tyonek, Alaska and beluga whales in Cook Inlet, Alaska. Submitted to NOAA Fisheries, Juneau, AK. 73 pp.

Stone, C.J. 2003. The effects of seismic activity on marine mammals in UK waters 1998-2000. JNCC Report 323. Joint Nature Conservancy, Aberdeen, Scotland. 43 p.

Stone, C.J. and M.L. Tasker. 2006. The effects of seismic air guns on cetaceans in UK waters. Journal of Cetacean Research Management. 8(3): 255-263.

Szymanski, M. D., Bain, D. E., Kiehl, K., Pennington, S., Wong, S., Henry, K.R., 1999. Killer whale (*Orcinus orca*) hearing: Auditory brainstem response and behavioral audiograms. Journal of the Acoustical Society of America. 106: 1134-1141.

Thomas, J. A., R. A. Kastelein, and F. T. Awbrey. 1990. Behavior and blood catecholamines of captive belugas during playbacks of noise from an oil drilling platform. Zoo Biology 9:393–402.

URS. 2007. Port of Anchorage Marine Terminal Development Project underwater noise survey test pile driving program, Anchorage, Alaska. Final underwater noise report. Prepared for Integrated Concepts and Research Corp. Infrastructure Support Services.

U.S. Army Corps of Engineers. 2013. Maintenance Dredging, Cook Inlet Navigation Channel, Alaska. Environmental Assessment and Finding of No Significant Impact. Alaska District. 112 pp.

Verboom, W. C. and R. A. Kastelein. 1995. Acoustic signals by harbor porpoises (*Phocoena phocoena*). pp 1-39 in P. Natchigall, J. Lien, W. Au, and A. Read (editors) Harbour porpoises, laboratory studies to reduce bycatch. De Spil, The Netherlands.

Wartzok, D. and D.R. Ketten. 1999. Marine mammal sensory systems. Pages 117-148 *in* J.E. Reynolds III and S.A. Rommel (eds), Biology of marine mammals. Washington D.C.: Smithsonian Institution Press.

Weilgart, L.S. 2007. The impacts of anthropogenic ocean noise on cetaceans and implications for management. Canadian Journal of Zoology 85:1091-1116.

White, M.J., J. Norris, D.L. Jungblad, K. Baron, and G. Di Sciara. 1978. Auditory thresholds of two beluga whales (*Delphinapterus leucas*). HSWRI Technical Report 78-109. Prepared for Naval Ocean Systems Center, San Diego.

Wolfe, R.J., J.A. Fall, and M. Riedel. 2009. The subsistence harvest of harbor seals and sea lions by Alaska natives in 2008. Alaska Native Harbor Seal Commission and Alaska Department of Fish and Game Division of Subsistence. Technical Paper No. 347, Anchorage. 93 pp.

Wood, J., B.L. Southall, and D.J. Tollit. (2012) PG&E offshore 3-D Seismic Survey Project EIR – Marine Mammal Technical Draft Report. SMRU Ltd.

Zykov, M. and S. Carr. 2012. Acoustic Modelling Report. (Appendix D) In: Atlantic OCS Proposed Geological and Geophysical Activities Mid-Atlantic and South Atlantic Planning Areas Draft Programmatic Environmental Impact Statement. Bureau of Ocean Energy Management, Gulf of Mexico OCS Region. Prepared by JASCO Applied Sciences for Continental Shelf Associates International Inc.

APPENDIX A: MARINE MAMMAL MONITORING AND MITIGATION PLAN

Marine Mammal Monitoring and Mitigation Plan For Alaska LNG Project's Cook Inlet 2016 G&G Program

1.0 INTRODUCTION

This Marine Mammal Monitoring and Mitigation Plan (4MP) was prepared in support of the application for Incidental Harassment Authorization (IHA) from the National Marine Fisheries Service (NMFS) for the Cook Inlet 2016 G&G program. This Plan will be updated to meet requirements established by NMFS in the Incidental Harassment Authorization (IHA).

2.0 MONITORING RADII

The IHA issued by NMFS will establish safety (Level A) and harassment (Level B) zones appropriate for cetaceans and pinnipeds in reference to Zones of Influence (ZOI) surrounding the chirp and boomer sub-bottom profiler, air gun, and vibracore. Applicable equipment will be shut-down at any approach of marine mammals to the Level A zones.

PSOs will record observations of marine mammals not listed on the Endangered Species List (e.g. gray whales {*Eschrichtius robustus*}, minke whales {*Balaenoptera acutorostrata*}, Pacific white-sided dolphins {*Lagenorhynchus obliquidens*}, Dall's porpoise {*Phocoena dalli*}) occurring inside the Level B zones.

PSOs will initiate shut-downs to avoid harassment of beluga whales and any other ESA-listed marine mammals (e.g. humpback whales {*Megaptera novaengliae*}, Steller sea lion {*Eumetopias jubatus*}) observed to be approaching the Level B zone.

3.0 SOUND SOURCE VERIFICATION

As explained in the IHA Application, no sound source verification measurements are planned.

4.0 VESSEL-BASED VISUAL MONITORING

Vessel-based visual monitoring through the involvement of qualified protected species observers (PSOs) stationed onboard the survey vessels from which chirp and boomer sub-bottom profilers, air gun, and vibracoring are operating will support IHA compliance. Specifically, the monitoring provides: the basis for real-time mitigation; data on occurrence, distribution and activities of marine mammals in the survey area and relative to program activities; and information used for NMFS to determine Level B exposures of marine mammals.

PSOs will observe the appropriate Level A and Level B zones for marine mammals, estimate the numbers of marine mammals exposed to sound and their reactions (where applicable), and document those events as required. PSOs will lead mitigation measures, including: clearing and ramp-up measures; observing marine mammals within, or which are about to enter, the applicable Level A and Level B zones; implementing necessary shut-down, power-down, and/or speed/course alteration mitigation procedures when applicable; and advising operational crews of mitigation procedures. The PSOs have stop work authority.

PSOs will conduct monitoring during daylight periods (weather permitting) when equipment is operating, and during most daylight periods when equipment is not operating. PSOs will be stationed at the best available vantage point on the source vessels. PSOs will scan systematically with the unaided eye and 7x50 reticle or 40x80 long-range binoculars. Generally, two PSOs will work on a rotational basis during daylight hours with shifts of 2-4 hours. Work days for an individual PSO will not exceed 12 hours in duration. Sufficient numbers of qualified PSOs will be available and provided to meet requirements. An experienced PSO will be assigned to oversee all 4MP mandates and function as the on-site person-in-charge (PIC) implementing the 4MP.

5.0 VESSEL-BASED PASSIVE ACOUSTIC MONITORING

If conditions are conducive for conducting vibracoring during a period of darkness, real-time passive acoustic monitoring deployed from the source vessel will be used in lieu of visual monitoring to detect the presence of marine mammals. The passive acoustic monitoring will support IHA compliance by providing information on marine mammal presence and vocalizations prior to and during periods of vibracoring activity when visual observation is not possible. PSOs or other qualified personnel will deploy and monitor the passive acoustic monitoring equipment from the same vessel being used to conduct the vibracoring activities. The passive acoustic monitoring equipment will be capable of detecting the range of vocalization frequencies of marine mammals commonly found in EMALL's survey area in Cook Inlet and will be selected and configured to maximize the potential for data collection (given the dynamic tidal and current conditions in Cook Inlet).

6.0 FIELD DATA

All field data collected by the PSOs will be entered by the end of each survey day into a custom database using a notebook computer.

The following information will be recorded when a marine mammal is sighted:

- Species.
- Group size.
- Age/size/sex categories (if determinable).
- Behavior when first sighted and after initial sighting.
- Heading (if consistent).
- Bearing and distance to the sighting.
- Sighting cue (e.g., animal, splash, birds, etc.).
- Apparent reaction to activities – changes in behavior (e.g., none, avoidance, approach, paralleling, etc.).
- Behavioral pace (Direction and speed relative to vessel).
- Orientation when sighted (e.g., toward, away, parallel, etc.).
- Closest point of approach.
- Physical description of features that were observed or determined not to be present in the case of unknown or unidentified animals.
- Time of sighting.
- Location, speed, and activity of the source and mitigation vessels, sea state, ice cover, visibility, and sun glare; and positions of other vessel(s) in the vicinity.
- Mitigation measure taken – if any.

Weather data relative to viewing conditions will be collected hourly, on rotation, and when sightings occur and include the following:

- Sea state.
- Wind speed and direction.
- Sun position.
- Percent glare.

All observations and shut-downs will be recorded in a standardized format and data entered into a custom database using a notebook computer. Accuracy of all data will be verified daily by the PIC or designated PSO by a manual verification. These procedures will reduce errors, allow the preparation of short-term data summaries, and facilitate transfer of the data to statistical, graphical, or other programs for further processing and archiving.

7.0 MITIGATION MEASURES

The following mitigation measures will be implemented to avoid Level A or Level B exposures of marine mammals:

- Visual "clearing" of Level A and Level B zones (applicable to the air gun, chirp and boomer sub-bottom profiler, and vibracore) –
  - PSOs will establish a 160 dB re 1 μPa (rms) Level B ''disturbance zone'' for belugas, and groups of five or more harbor porpoises and killer whales as well as a 180 dB re 1 μPa (rms) and 190 dB re 1 μPa (rms) Level A "exclusion zone" for cetaceans and pinnipeds respectively before equipment is in operation. PSOs will visually observe the entire extent of the Level A zone for at least 30 minutes prior to starting the survey.
  - If the PSO observes a marine mammal within the Level A zone, the start of survey operations will be delayed until the marine mammal(s) leave the area.
  - If the PSO sees a marine mammal that surfaces, then dives below the surface, the PSO will wait 30 min. If the PSO sees no marine mammals during that time, they may assume that the animal has moved beyond the Level A zone.
  - If for any reason the entire radius of the Level A zone cannot be seen for the entire 30 minutes (i.e., rough seas, fog, darkness), or if marine mammals are near, approaching, or in the Level A zone, the sound sources will not be started.
  - If conditions are conducive for conducting vibracoring during a period of darkness, passive acoustic monitoring deployed from the source vessel will be used in lieu of visual monitoring to detect the presence of marine mammals. The aforementioned procedures for visual "clearing" will also apply to passive acoustic monitoring.
- Visual monitoring of Level A and Level B zones (applicable to the air gun, chirp and boomer sub-bottom profiler, and vibracore) –
  - PSOs will continue monitoring applicable Level A and Level B zones during operations, and will monitor the zones for 30 minutes after ending survey operations.
  - Level A and Level B zones must be visible by the PSOs (i.e. not obstructed by fog, heavy rain, or darkness) during the initial clearing before the start of operations. PSOs will also make observations during daytime periods when the sound sources are not operating, when feasible, for comparison of animal abundance and behavior.
  - Work may continue into night and low-light hours if the survey is initiated when the entire relevant Level A and Level B zones can be effectively monitored visually.
  - No initiation of survey operations involving the use of sound sources is permitted from a shutdown position at night or during low-light hours (such as in dense fog or heavy rain).
  - If conditions are conducive for conducting vibracoring during a period of darkness, passive acoustic monitoring deployed from the source vessel will be used in lieu of visual monitoring to detect the presence of marine mammals. The aforementioned procedures for visual monitoring will also apply to passive acoustic monitoring.
- Ramp-up or "soft start" procedure (applicable only to the air gun) –
  - When starting up air gun operations from a shutdown position, the air gun volume will be gradually increased until the full volume is achieved. This will reduce potential alarm or injury to marine mammals in the vicinity.
  - During the ramp-up, PSOs will monitor the full extent of the Level A and Level B zones (as if the air gun were operational at its maximum volume).

- Speed or course alteration (applicable to the air gun and chirp and boomer sub-bottom profilers) –
  - When a marine mammal(s) outside the Level A zone are observed, and there is potential for it to enter the Level A zone (based on position and motion relative to the vessel actions), the PSOs will direct the vessel operator to alter vessel speed or direction.
  - If, after speed or course alteration, the marine mammal(s) still appears likely to enter the Level A zone, then further mitigations actions will be taken, including further speed or course alteration, power-down, or shut-down.
- Power-down (applicable only to the air gun) –
  - When a marine mammal(s) outside the Level A zone are observed, and there is potential for it to enter the Level A zone (based on position and motion relative to the vessel actions), the PSOs will direct the vessel operator to power-down the air gun such that the radius of the Level A zone is decreased to the extent that marine mammals are not in the Level A zone.
  - After a power-down has occurred, operation of the air gun will not resume at full volume/power until the PSO has visually observed the marine mammal(s) exiting the Level A zone and is not likely to return, or has not seen the animal within the Level A zone for 15 minutes for species with shorter dive durations (small odontocetes and pinnipeds) or 30 minutes for species with longer dive durations (large odontocetes, including killer whales and beluga whales).
- Shut-down (applicable to the air gun and chirp and boomer sub-bottom profilers) –
  - If a marine mammal is detected within, approaches, or enters the relevant Level A zone, the sound sources will be shut-down (i.e., turned off).
  - Survey activity will not resume until the PSO has visually observed the marine mammal(s) exiting the Level A zone and is not likely to return, or has not seen the animal within the Level A zone for 15 minutes for species with shorter dive durations (small odontocetes and pinnipeds) or 30 minutes for species with longer dive durations (large odontocetes, including killer whales and beluga whales).

During vessel transits, vessel operators will follow the NMFS Alaska Marine Mammal Viewing Guidelines, including:

- Remaining at least 100 meters (yards) from marine mammals;
- Avoid encircling or trapping marine mammals between the vessel and other vessels, or between the vessel and shore; and
- Putting the engine in neutral (if vessel has a propeller) if the vessel is less than 100 meters (yards) from cetaceans.

Vessel operators and crew onboard the vessels will assist the PSOs in observing for marine mammals and reporting the observations to the PSOs.

8.0 REPORTING

8.1 WEEKLY FIELD REPORTS

A weekly field report will be submitted to NMFS (PR1 and AKR) no later than close of business (Alaska time) each Thursday during the weeks when in-water survey activities take place. The field reports will summarize species detected, in-water activity occurring at the time of the sighting, behavioral reactions to in-water activities, and the number of marine mammals exposed to harassment level sound.

8.2 MONTHLY FIELD REPORTS

Monthly reports will be submitted to NMFS (PR1 and AKR) for all months during which in-water survey activities take place. The reports will be submitted to NMFS no later than the 15th of each month. The monthly report will contain and summarize the following information:

- Dates, times, locations, heading, speed, weather, sea conditions (including Beaufort Sea state and wind force), and associated activities during all operations and marine mammal sightings.
- Species, number, location, distance from the vessel, and behavior of any sighted marine mammals, as well as associated activity (number of shut-downs), observed throughout all monitoring activities (including visual and passive acoustic monitoring).
- An estimate of the number (by species) of: (i) pinnipeds that have been exposed to the activity (based on visual observation) at received levels greater than or equal to relevant 120dB or 160 dB re 1 μPa (rms) and/or 190 dB re 1 μPa (rms) with a discussion of any specific behaviors those individuals exhibited; and (ii) cetaceans that have been exposed to the activity (based on visual observation) at received levels greater than or equal to 120 dB or 160 dB re 1 μPa (rms) and/or 180 dB re 1 μPa (rms) with a discussion of any specific behaviors those individuals exhibited.
- An estimate of the number (by species) of pinnipeds and cetaceans that have been exposed to the geotechnical activity (based on visual observation) at received levels greater than or equal to 120 dB re 1 μPa (rms) with a discussion of any specific behaviors those individuals exhibited.
- A description of the implementation and effectiveness of the: (i) terms and conditions of the Biological Opinion's Incidental Take Statement; and (ii) mitigation measures of the IHA. For the Biological Opinion, the report will confirm the implementation of each Term and Condition, as well as any conservation recommendations, and describe their effectiveness, for minimizing the adverse effects of the action on Endangered Species Act-listed marine mammals.

8.3 TECHNICAL REPORT

A report will be submitted to NMFS (PR1 and AKR) within 90 days after the completion of the survey. The Technical Report will include the following:

- Summaries of monitoring effort (e.g., total hours, total distances, and marine mammal distribution through the study period, accounting 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 (e.g., 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 (if determinable), group sizes, and ice cover.
- Analyses of the effects of survey operations.
- Sighting rates of marine mammals during periods with and without G&G program activities (and other variables that could affect detectability), such as: (i) initial sighting distances versus survey activity state; (ii) closest point of approach versus survey activity state; (iii) observed behaviors and types of movements versus survey activity state; (iv) numbers of sightings/individuals seen versus survey activity state; (v) distribution around the source vessels versus survey activity state; and (vi) estimates of Level B harassment based on presence in the 120 or 160 dB Level B zone.

The draft technical report will include all data and associated metadata and will be submitted to NMFS (PR1 and AKR) in a form that can be directly imported into an Excel spreadsheet template for incorporation into NMFS Cook Inlet Beluga Scientific Sightings Mapper.

8.4 NOTIFICATION OF INJURED OR DEAD MARINE MAMMALS

In the unanticipated event that the specified activity leads to an injury of a marine mammal (Level A harassment) or mortality (*e.g.*, ship-strike, gear interaction, and/or entanglement), EMALL would immediately cease the specified activities and immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, and the Alaska Regional Stranding Coordinators. The report would include the following information:

- Time, date, and location (latitude/longitude) of the incident.
- Name and type of vessel involved.
- Vessel's speed during and leading up to the incident;
- Description of the incident.
- Status of all sound source use in the 24 hours preceding the incident.
- Water depth.
- Environmental conditions (e.g., wind speed and direction, Beaufort sea state, cloud cover, and visibility).
- Description of all marine mammal observations in the 24 hours preceding the incident.
- Species identification or description of the animal(s) involved.
- Fate of the animal(s).
- Photographs or video footage of the animal(s) (if equipment is available).

Activities would not resume until NMFS is able to review the circumstances of the event. EMALL would work with NMFS to minimize reoccurrence of such an event in the future. EMALL would not resume activities until formally notified by NMFS via letter, email, or telephone.

In the event that EMALL discovers an injured or dead marine mammal, and the lead PSO determines that the cause of the injury or death is unknown and the death is relatively recent (*i.e.*, in less than a moderate state of decomposition as described in the next paragraph), EMALL would immediately report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, and the NMFS Alaska Stranding Hotline and/or by email to the Alaska Regional Stranding Coordinators. The report would include the same information identified above. Activities would be able to continue while NMFS reviews the circumstances of the incident. NMFS would work with EMALL to determine if modifications in the activities are appropriate.

In the event that EMALL discovers an injured or dead marine mammal, and the lead PSO determines that the injury or death is not associated with or related to the activities authorized in the IHA (*e.g.*, previously wounded animal, carcass with moderate to advanced decomposition, or scavenger damage), EMALL would report the incident to the Chief of the Permits and Conservation Division, Office of Protected Resources, NMFS, and the NMFS Alaska Stranding Hotline and/or by email to the Alaska Regional Stranding Coordinators, within 24 hours of the discovery. EMALL would provide photographs or video footage (if available) or other documentation of the stranded animal sighting to NMFS and the Marine Mammal Stranding Network.