90-Day Report of the Marine Mammal Monitoring Program for the ConocoPhillips Alaska Shallow Hazards Survey Operations during the 2008 Open Water Season in the Chukchi Sea

Prepared for

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Table of Contents

List of Tables

List of Figures

Summary

ConocoPhillips Alaska, Inc. (CPAI) conducted a shallow hazards survey program in the Chukchi Sea between September 7 and October 31, 2008. The program involved operations at the Klondike and Burger Prospects, potential pipeline routes, and adjacent areas between the coast and the prospects. Shallow hazards surveys were only conducted at the Klondike Prospect. Bathymetric data and core samples were collected along potential pipeline routes connecting the prospects to the coast near the village of Wainwright. The configuration of the seismic profiler used during the shallow hazards survey was a single 6 kj sparker. A field validation test was completed to determine the distances where received levels decreased below 190, 180, and 160 dB re 1 µPa (rms) for the sparker as required by the National Marine Fisheries Service. The results of the validation test established the boundaries for the 190 and 180 dB safety radii for pinnipeds and whales, respectively, and the 160 dB behavioral disturbance zone for all marine mammals. The resulting distances from the test were 13 m for the 190 dB level, 41 m for the 180 dB level, and 368 m for the 160 dB level. These distances are magnitudes lower than those produced by multiple airgun configurations used during deep seismic surveys for oil and gas exploration.

Professional biologists monitored marine mammals throughout the daylight hours and nighttime startups of the sparker from the shallow hazards survey vessel. There was a total of 467 hr of marine mammal monitoring effort covering a distance of 3,452 km. The majority (67%) of the effort occurred at the Klondike prospect. Approximately 75% of the monitoring effort occurred while shallow hazards surveys were being conducted and 25% when there was no-sparker tool in use at Klondike. The remainder (33%) of the total monitoring effort was distributed while moving through the Burger prospect area, the pipeline route, transits to the coast to resupply the vessel, and transiting between the site and Nome at the start and end of the program.

A total of 222 sightings of 279 marine mammals representing 8 species were recorded during the shallow hazards survey program. Seals comprised the highest proportion (78%) followed by walrus (18%), cetaceans (4%), and one polar bear (<1%). Of the seals, ringed and spotted seals together were most common (41%), ribbon seals least common (<1%), and bearded seals intermediate (18%); unidentified seals and pinnipeds (40%, most of the three unidentified pinnipeds were likely seals) made up the remaining sightings. Of the 11 cetaceans recorded, all were gray whales except for 1 minke whale and 1 unidentified whale. There were a total of 11 juvenile/subadult animals including 5 bearded seals, 3 ringed/spotted seals, 2 unidentified seals, and 1 gray whale. There were no observations of some of the more common Arctic species including beluga and bowhead whales or harbor porpoises during the shallow hazards survey program.

A total of 79 (28%) marine mammal sightings were recorded at Klondike. Ringed, spotted (including one juvenile), and bearded seals, and walrus were observed at Klondike. The majority (86%) of the walrus recorded during the program were at Klondike. Most (72%) of the marine mammals including all 9 gray whales recorded during the program were observed outside of Klondike with few marine mammals observed along the pipeline route (5 seals) and none at Burger. Some seals (14) and the only minke whale were recorded during the transit between Nome and the program area. Distribution of marine mammals was generally consistent with that reported in the literature including seals occurring throughout the program areas, gray whales closer to shore, and the one polar bear associated with sea ice. Most walrus were likely north of the shallow hazards survey program area in the pack ice except for the few encountered in open water during the program.

More marine mammal sightings were recorded during no-seismic than seismic activity at Klondike. Twenty-eight percent of all seal sightings were recorded during seismic activity which represented 73% of the total survey effort at Klondike. While sample size for walrus was too small (14 groups) at Klondike to provide a meaningful comparison, it is noteworthy that only 1 of 14 walrus sightings were recorded during seismic activity. No comparison could be made for cetaceans or polar bears, since none were recorded at Klondike.

Seal density was correspondingly lower during seismic than no-seismic activity for seals at Klondike which was also below the density for all other survey areas. Estimated density during no-seismic activity was over 7 times higher than during seismic activity (0.0.284 vs 0.038 seals/km^2). Seal density in Klondike during no-seismic activity was about two thirds less (0.284 vs 0.920 seals/km^2) than the density for all other survey areas, suggesting seals unequally used the two areas during periods of no-seismic activity. There were too few sightings of walrus (16), cetaceans (7), and polar bears (1) to calculate a meaningful density. Other measures (behavior, distance from vessel) used to assess effects were not substantially different between seismic and no-seismic conditions or comparing Klondike to the other survey areas, suggesting other environmental and operational factors (prey abundance and distribution, habitat quality, location relative to the coast, operation configuration, etc.) may have contributed to the observed disparity in seal numbers.

There were no shutdowns of seismic operations, since no pinnipeds or cetaceans were observed in their respective safety radii. The marine mammals observed within the 160 dB behavioral disturbance radii during seismic activity included ten seals and one walrus. Seal species included one bearded seal, three ringed/spotted seals, and six unidentified seal species.

Take was presented as a range but the upper boundary was calculated two ways because of sample size limitations for most species. The lower boundary for all species was the actual number observed in the behavioral disturbance zone. The upper boundary for seals was an estimated number determined by multiplying the density times the area ensonified within the 160 dB level at Klondike during seismic activity. The upper boundary for all other marine mammals was the total number recorded in the program area, since too few animals were observed to estimate a number from density. It is unlikely that the take would have exceeded the total number of cetaceans, walrus or polar bears observed in the program area. Using these approaches, the estimated take ranged from 10 to 42 seals, 0 to 10 cetaceans, 1 to 50 walrus, and 0 to1 polar bears. Species-specific take of seals can be estimated from the total take by allocating the take by the proportion of each species observed during seismic activity. This would include 30% (3-13) for ringed/spotted seals, 10% (1-4) for bearded seals, and 60% (6-25) for unidentified seals. The take is most likely toward the lower end of the range given the small number of marine mammals observed during seismic operations.

The overall effect of the shallow hazards survey activity on marine mammals was no more than negligible on the individuals and there was no effect on the populations. This is reflected by the small numbers of animals exposed to seismic activity within the behavioral disturbance zone, which represent considerably less than one percent of the populations.

1.0 Introduction

Marine mammals were monitored during a shallow hazards survey program for potential exploratory drilling in the Chukchi Sea between September 7 and October 31, 2008 by ConocoPhillips Alaska Inc. (CPAI); monitoring also occurred during a sound source verification test by JASCO Research on September 7-8, 2008. Marine mammal surveys occurred over 100 km west of the Alaska coast at the Klondike and Burger Prospects and also along a potential pipeline route connecting the prospects to the coast north and south of Wainwright, Alaska. Monitoring was conducted from the sound source vessel, Norseman-1, as required by the National Marine Fisheries Service (NMFS) in the Incidental Harassment Permit (IHA) issued for the shallow hazards survey program. Key marine mammal species monitored in the program area included bowhead, gray, minke, beluga, and killer whales; harbor porpoise; and ringed, bearded, spotted, and ribbon seals, which are all managed by the NMFS. Other species monitored included the Pacific walrus and polar bear, which are managed by the U.S. Fish and Wildlife Service (USFWS).

The purpose of the monitoring program was to collect data on each marine mammal species observed during the shallow hazards survey program. The permit required collecting specific data on behavior, overall numbers of individuals observed, frequency of observations, and any behavioral changes due to the shallow hazards survey operations. More specifically the monitoring program was to determine the following:

(1) Species and number of marine mammals within the safety zone (> 180 dB),
(2) Number of seismic survey shutdowns due to marine mammals approaching or within the safety zones, and
(3) Number and species of marine mammals within the 160 dB disturbance zone for calculating incidental take.

The following sections describe marine mammal use of the project vicinity, the area of the shallow hazards survey program and the results of the monitoring program including a validation test required by NMFS to determine safety radii.

2.0 Literature Review of Marine Mammal Use of Project Vicinity

A total of seven cetacean, one porpoise, and four pinniped species potentially occur in the vicinity of the program area. The bowhead whale is listed as endangered under the Endangered Species Act (ESA) and depleted under the Marine Mammal Protection Act (MMPA). The other marine mammal species have no special designation under the ESA or the MMPA. However, NMFS has been petitioned to list the ringed, bearded, spotted, and ribbon seals and the USFWS to list the Pacific walrus under the ESA, but the only decisions made on the potential listings has been to not list the ribbon seal. A few humpback and fin whales have recently been observed in the Chukchi Sea, but it would be rare to encounter either species during the shallow hazards survey program, since their normal geographic range is south of the Chukchi Sea (Angliss and Outlaw 2008). Both species are listed as endangered under the ESA and depleted under the MMPA. Brief descriptions of the most common species are provided below.

Bowhead whale: The Bering-Chukchi-Beaufort (BCB) stock of bowhead whales was estimated at 10,400 to 23,000 animals in 1848, before commercial whaling decreased the stock to between 1,000 and 3,000 animals by 1914 (Woodby and Botkin,1993). This stock has slowly increased since 1921 when commercial whaling ended, and now numbers at least 10,545 whales with an estimated 3.4 to 3.5% (>350 animals/year) annual rate of increase (Brandon and Wade 2004, George et al. 2004a,b, Zeh and Punt 2004, and Angliss and Outlaw 2008). The most recent published count of 121 calves during the 2001 census was the highest recorded for the population (George et al. 2004a). The high calf count is reflected in a high pregnancy rate and low length at sexual maturity, which is characteristic of an increasing and healthy population (George et al. 2004b). The actual population size is likely higher, since the most recent estimate was derived from data collected in 2001. The current population could be over 12,000 bowheads given an annual growth rate (3.4 - 3.5%). Shelden et al. (2001) suggested that the BCB stock should be delisted under the ESA, since its population is within the range of its pre-commercial exploitation size. George et al. (2004a) concluded that the recovery of the BCB bowhead whale population is likely attributable to low anthropogenic mortality, relatively pristine habitat, and well-managed subsistence harvest.

The BCB stock winters in the central and western Bering Sea and largely summers in the Canadian Beaufort Sea (Moore and Reeves 1993, Brueggeman 1982). Calving occurs in the Bering Sea and during the spring migration (Braham et al. 1984). Spring migration from the Bering Sea follows the eastern coast of the Chukchi Sea to Point Barrow in nearshore leads from mid-March to mid-June before continuing through the Western Beaufort Sea through offshore ice leads (Braham et al. 1984; Moore and Reeves 1993). Some bowheads arrive in coastal areas of the eastern Canadian Beaufort Sea and

Amundsen Gulf in late May and June but most may remain among the offshore pack ice of the Beaufort Sea until mid-summer. After leaving the Canadian Beaufort Sea, bowheads migrate westward from late August or September through mid- or late October. Recently (2008) satellite-tagged whale left Canadian waters in early October to begin the fall migration (ADFG, Lori Quackenbush). Fall migration into Alaskan waters is primarily during September and October. However, in recent years a small number of bowheads has been seen or heard offshore from the Prudhoe Bay region during the last week of August (Treacy 1993; LGL and Greeneridge 1996; Greene 1997; Greene et al. 1999; Blackwell et al. 2004). Consistent with this, Nuiqsut whalers have stated that a small number of the earliest arriving bowheads have apparently reached the Cross Island area earlier (late August) than in past years (C. George, personal communication, 2006).

The Minerals Management Service (MMS) has conducted or funded late-summer/autumn aerial surveys for bowhead whales in the Alaska Beaufort Sea since 1979 (e.g., Ljungblad et al. 1986, 1987; Moore et al. 1989; Treacy 1988-1998, 2000, 2002a,b). Bowheads tend to migrate west in deeper water (farther offshore) during years with higher than average ice coverage than in years with less ice (Moore 2000, Treacy et al. 2006). In addition, the sighting rate tends to be lower in heavy ice years and more widespread in light ice years (Treacy 1997:67; Treacy et al. 2006). During fall migration, most bowheads migrate west in waters ranging from 15 to 200 m deep (Miller et al. 2002 in Richardson and Thomson 2002); some individuals enter shallower water, particularly in light ice years, but very few whales are ever seen shoreward of the barrier islands. Survey coverage far offshore in deep water is usually limited, and offshore movements may have been underestimated. However, the main migration corridor is over the continental shelf.

Bowhead whales typically reach the Pt. Barrow area during their westward migration from the feeding grounds in the Canadian Beaufort Sea in mid-September to late October. Recent studies conducted in conjunction with the 2006 and 2007 seismic programs operated by Shell and CPAI reported no bowhead whales in the Chukchi Sea until after September 2007 and a few in September 2006 (Ireland et al. 2008). Over the years, local residents report having seen small numbers of bowhead whales feeding off Barrow or in the pack ice off Barrow during summer (C. George, personal communication, 2007). A few bowheads were reported in the Chukchi Sea during July 2006 during the Shell and CPAI surveys, but it was unclear if these animals were summering or late migrants traveling to the Beaufort Sea feeding ground (Ireland et al. 2008). Bowhead whales may feed opportunistically where food is available as they migrate through the Alaskan Beaufort Sea. Recent carbon-isotope analysis of bowhead whale baleen suggests the Chukchi and Bering Seas may be the predominant feeding areas for adult and juvenile bowhead whales (Schell et al. 1987; Schell and Saupe 1993, Lee et al. 2005), but this suggestion has been questioned by the scientific community. Examination of stomach contents from whales taken in the Iñupiat subsistence harvest indicates that bowhead whales feed on a variety of invertebrates and small fishes (Lowry 1993). Bowhead whales complete their annual cycle by migrating across the Chukchi Sea in a westerly direction past Wrangel Island and then down the western coast of the Chukchi Sea to the Bering Sea (Miller et al., 1985). This westerly pattern and also a southwesterly pattern were recently confirmed by observed movements of satellite-tagged bowhead whales tracked from the summering grounds in the Beaufort Sea to or towards the wintering grounds in the Bering Sea (see maps below). Another but less clear potential migration pattern was demonstrated by one tagged whale which deviated from a westerly track off Pt. Barrow to travel down the Alaska coast but offshore until reaching about Point Lay and then reversing course to head north back up the coast (ttp://www.wc.adfg.state.ak.us/index.cfm?adfg=marinemammals.bowheadMate).

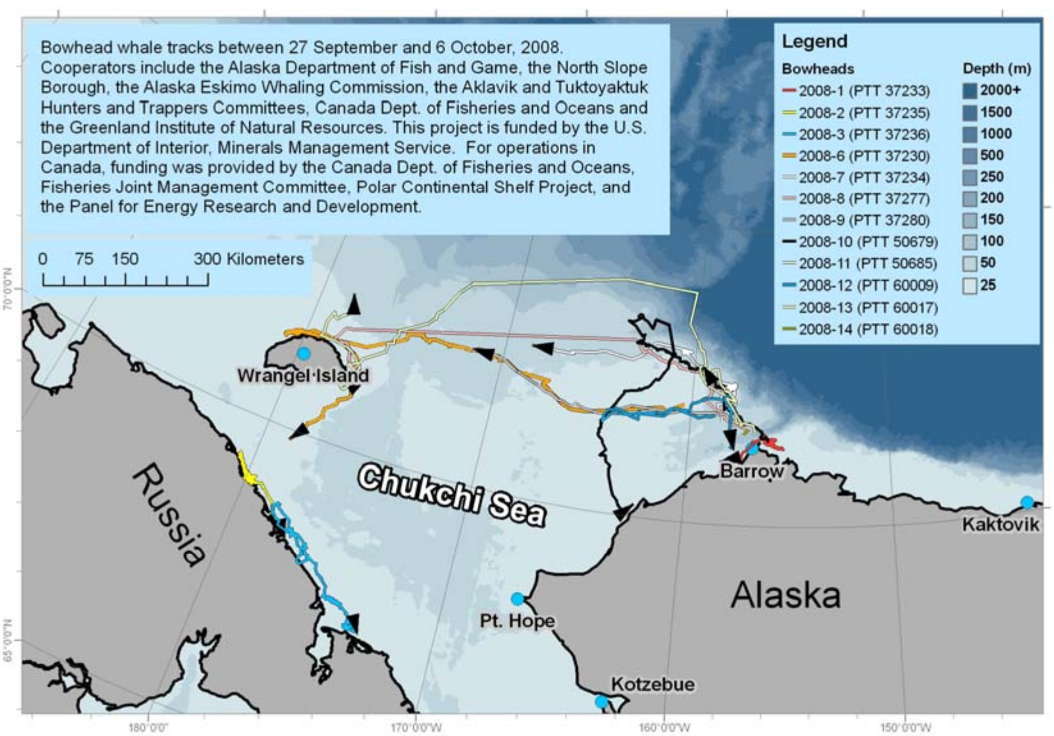

Figure 1 Map of satellite-tagged bowhead whale during fall migration in Chukchi Sea (courtesy Alaska Department of Fish and Game Marine Mammal Division website)

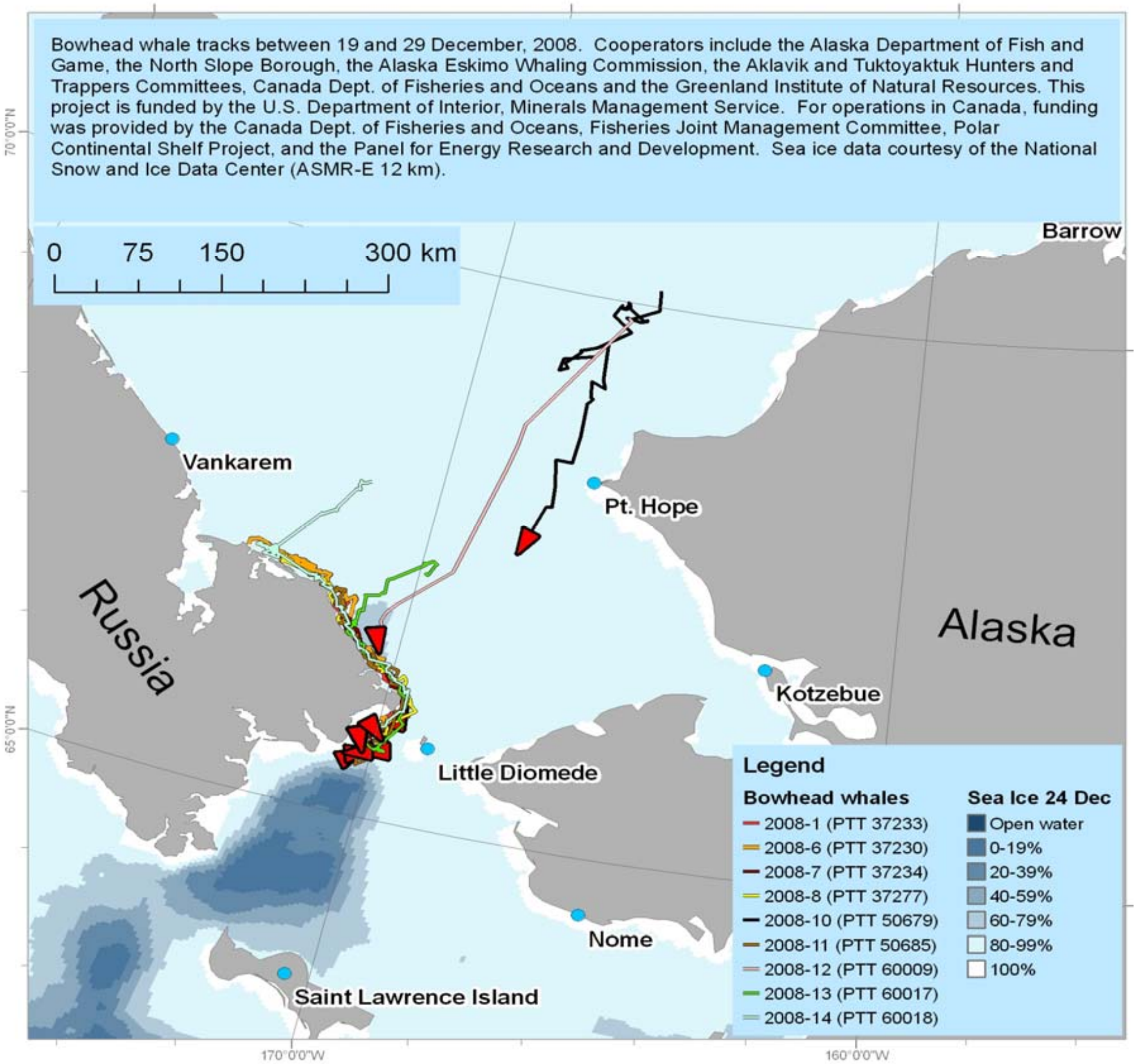

Figure 1 (continued) Maps of satellite-tagged bowhead whales during fall migration in Chukchi Sea

Beluga Whale: In Alaska, beluga whales comprise five distinct stocks: Beaufort Sea, eastern Chukchi Sea, eastern Bering Sea, Bristol Bay, and Cook Inlet (O'Corry-Crowe et al. 1997). For the proposed project, only the Beaufort Sea stock and eastern Chukchi Sea stock occur in the area of the shallow hazards survey program. Some eastern Chukchi Sea animals enter the Beaufort Sea in late summer (Suydam et al. 2001). Beluga whales from the eastern Chukchi Sea stock are an important subsistence resource for residents of the village of Point Lay, adjacent to Kasegaluk Lagoon, and other villages in Arctic Alaska.

The Beaufort Sea population is estimated to exceed 39,258 whales (Angliss and Outlaw, 2008). An estimated 2,500-3,000 beluga whales summer in the northwestern Beaufort and Chukchi Seas, with some using coastal areas such as Peard Bay and Kasegaluk Lagoon (Frost et al. 1988, 1993 *cited in* USDI MMS 2003). This eastern Chukchi Sea stock is estimated at a minimum of about 3,710 whales (Angliss and Outlaw 2008). The current population trend of the Beaufort Sea population is unknown, and there is no evidence of the eastern Chukchi Sea population declining (Angliss and Outlaw, 2008).

The Beaufort stock of beluga whales winter in the Bering Sea, summer in the eastern Beaufort Sea, and migrate around western and northern Alaska (Angliss and Outlaw 2008). Most of these belugas migrate into the Beaufort Sea in April or May, although some whales may pass Point Barrow as early as late March and as late as July (Braham et al. 1984; Ljungblad et al. 1984; Richardson et al. 1995). Much of this stock enters the Mackenzie River estuary during July–August to molt, but they spend most of the summer in offshore waters of the eastern Beaufort Sea and Amundsen Gulf (Davis and Evans 1982; Harwood et al. 1996; Richard et al. 2001). During late summer and autumn, most belugas migrate far offshore near the pack ice front (Frost et al. 1988; Hazard 1988). However, during the westward migration in late summer and autumn, small numbers of belugas are sometimes seen near the north coast of Alaska (e.g., Johnson 1979). Nonetheless, the main fall migration corridor of beluga whales is ~100+ km north of the coast. Satellite-linked telemetry data show that some belugas migrate west considerably farther offshore, as far north as 76ºN to 78ºN latitude (Richard et al. 1997, 2001).

The eastern Chukchi Sea stock seasonally inhabits the coastal areas off Alaska. Belugas have been predictably sighted near the Kasegaluk Lagoon from late June through mid to late July, after which they move north and east before returning to the Chukchi Sea in fall and then to the Bering Sea to winter (Lowry et al. 1999 in Lowry 2001; Suydam et al. 2001, Suydam et al. 2005, Ireland et al. 2008). Suydam et al. (2005) satellite-tagged 23 belugas in Kasegaluk Lagoon in June/July 1998-2002, and found they moved north and east into the northern Chukchi Sea and western Beaufort Sea during July to September. Male belugas moved north of 75º N, with adult males moving farther north (beyond 79º N or > 1100 km north of the Alaska coast), using deeper water, and remaining there for the summer. Early in the northward migration adult males traveled in heavy ice (>90 % ice cover in pack ice) to reach 79-80º N by late July/early August. Belugas of all ages and both sexes most often occurred in water deeper than 200m along and beyond the continental shelf break, but some adult and immature females remained at or near the shelf break throughout summer and early fall. Brueggeman et al. (1990, 1991, 1992) recorded as many as 1,276 sightings of beluga whales west and southwest of Point Barrow during more than 1173 hr of vessel survey and over 40 flights in summer to early fall (July to October) of five oil and gas prospects in the Chukchi Sea; over 90% of the belugas were in a single group at Kasegaluk Lagoon on July 1. These data suggest the eastern Chukchi stock ranges over a broad area during summer and fall, primarily near and considerably beyond the continental shelf break regardless of ice cover.

Gray Whale: The eastern North Pacific Ocean population summers in the Bering, Chukchi, and western extreme of the Beaufort Seas and largely winters in the lagoons off Mexico. The population is currently estimated at 18,813 whales based on the mean of the 2000/01 and 2001/02 estimates derived by Rugh et al. (2005). Based on the current population trend and estimates, Rugh et al. (2005) and Wade and Perryman (2002) stated that the population is near or at carrying capacity.

A relatively small proportion of gray whales arrive in the Chukchi Sea to feed in mid-June and remain until Sept-Oct (Braham 1984, Moore 2000). Most gray whales summer in the northern Bering Sea, particularly off St. Lawrence Island and in the Chirikov Basin (Moore et al. 2000), and in the southern Chukchi Sea. More recently, Moore et al. (2003) suggested that gray whale use of Chirikov Basin has decreased, likely from the combined effects of changing currents resulting in altered secondary productivity dominated by lower quality food. The northeastern-most of the recurring feeding areas is in the northeastern Chukchi Sea southwest and west of Pt. Barrow (Clarke et al. 1989, Brueggeman et al. 1992). Brueggeman et al. (1992) reported 258 gray whale sightings within the pack ice west and southwest of Barrow in the Chukchi Sea during aerial and vessel surveys in 1991. More recently, gray whales were encountered both inshore from Point Lay to Point Barrow and offshore during aerial and vessel surveys conducted in conjunction with the 2006 and 2007 seismic programs operated by Shell and CPAI (Ireland et al. 2008). Variation in gray whale distribution was likely influenced by prey distributions (Ireland et al. 2008). The increased frequency of gray whale sightings in this region is likely a reflection of recovery of the population to pre-exploitation level and the need to exploit more distant summer feeding areas.

Only a small number of gray whales enter the Beaufort Sea east of Pt Barrow from the Chukchi Sea (Angliss and Outlaw 2008). In the springs of 2003 and 2004, a few tens of gray whales were seen near Barrow by early-to-mid June (LGL Ltd and NSBDWM, unpubl. data). In addition, four gray whales were encountered each year during aerial and vessel surveys associated with Shell's 2006 and 2007 seismic program in the Beaufort Sea (Ireland et al 2008). Recent acoustic monitoring detected gray whales off Barrow during winter (Moore et al. 2006). Consequently, the northeastern Chukchi Sea is a feeding area, a transition area for small number of gray whales inhabiting the Beaufort Sea in summer of which some may overwinter.

Killer Whale: Small numbers of killer whales are known to inhabit almost all coastal waters of Alaska, extending from the Bering Sea into the Chukchi and Beaufort Seas. Killer whales appear to prefer coastal areas, but are also known to occur in deep water (Dahlheim and Heyning 1999). Killer whales are very uncommon in the Chukchi and Beaufort Seas based on the paucity of sightings by researchers. Brueggeman et al. (1992) reported a pod of 12 killer whales southwest of Barrow in Peard Bay during aerial surveys conducted in 1991. There have been a few sightings of killer whales off Point Barrow, Point Lay, Peard Bay, and Point Hope by natives but none in the last ten years, suggesting they are occasionally present but uncommon in the program area (George and Suydam 1998). More recently, one to seven killer whales were recorded in the Chukchi Sea during the Shell and CPAI seismic programs in 2006 and 2007 (Ireland et al. 2008). While there is no current population estimate for the program area, Alaska Department of Fish and Game (1994) provided an estimate of about 100 killer whales in the Bering Sea in the early 1990s.

Minke Whales: Very little is known about minke whale use of the Chukchi Sea, and they would not be expected to occur in the Beaufort Sea. Sightings have been infrequently reported during the open water season in the Chukchi Sea. Brueggeman et al. (1990) reported one minke whale in the northeastern Chukchi Sea during extensive vessel and aerial surveys from 1989 through 1991. More recently, vessel surveys conducted by Shell and CPAI in 2006 and 2007 encountered a few minke whales (about 3 whales/year) in the Chukchi Sea (Ireland et al. 2008). There are no estimates for minke whales in the Chukchi Sea, but numbers are clearly very low because it is the northern extreme of their range.

Other Cetaceans: Very small numbers of other cetaceans may occur in the program area including fin and humpback whales and harbor porpoise. Several fin and humpback whales have been recently reported in the Chukchi Sea (Ireland et al. 2008). The Chukchi Sea is the northern most extreme of their range and no more than a few whales would be expected in the central to northern Chukchi Sea during summer (Angliss and Outlaw 2008, Ireland et al. 2008). Small numbers of harbor porpoise have been observed in the Chukchi Sea during summer, but it is unclear if these were nearshore or offshore (Ireland et al. 2008). Harbor porpoise typically occur nearshore in bays and inlets where they travel as single animals (Angliss and Outlaw 2008). There are no population estimates for harbor porpoise in Alaska, and the estimate for fin whales (5,703 whales) and humpback whales (961) are for northeast and central Pacific Ocean, respectively (Angliss and Outlaw 2008).

Ringed Seals: Ringed seals have a circumpolar distribution, which is closely associated with sea ice. Ringed seals are found throughout the Bering, Chukchi, and Beaufort Seas (Angliss and Outlaw 2008). They are the most abundant and widely distributed seal in the Chukchi Sea (King 1983).

Although there are no recent population estimates for the Alaska Arctic, Bengtson et al. (2005) estimated ringed seal abundance from Barrow south to Shismaref in the Chukchi Sea to be 252,488 (SE=47,204) for 1999 and 208,857 (SE=25,502) in 2000 for an average of 230,673 seals. Frost et al. (2002, 2004) estimated a density of 0.98 km^2 seals for 18,000 km^2 surveyed in the Beaufort Sea, which Angliss and Outlaw (2008) combined with the average estimate from Bengston et al. (in review) for a total minimum estimate of 249,000 ringed seals in the Beaufort and Chukchi Seas. This is a minimum estimate, since Frost et al. (2002) and Bengston et al. (2005) surveyed a small part of the ringed seal habitat in the Beaufort and Chukchi Seas, and Frost et al. (2002) did not correct for missed seals. Consequently, estimates are likely much higher than reported, and they could be as high or approach past estimates of 1-3.6 million ringed seals in the Alaska stock (Frost 1985; Frost and Lowry 1988; Frost et al. 1988).

Ringed seal use is widespread in the sea ice during spring after which they use ice remnants and open water during summer and fall (Bengston et al. 2005; Frost et al. 2004; Wiig et al. 1999). During summer, high densities of ringed seals are associated with ice remnants (Burns et al. 1980 *cited in* USDI MMS 2003). Brueggeman et al. (1990, 1991, 1992) recorded as many as 668 sightings of ringed seals on ice remnants and open water west and southwest of Point Barrow during more than 1173 hr of vessel survey and over 40 flights in summer to early fall (July to October) of five oil and gas prospects in the Chukchi Sea; ringed seals were over three times more often sighted than bearded seals, the next most common seal. Apparently ringed seals were also found in open water during 2006 and 2007 vessel surveys in the northeastern Chukchi Sea, but the actual number was unknown since ringed seal sightings were combined with those of spotted seals (Ireland et al. 2008).

Ringed seals pup on sea ice in late March and April in lairs constructed by excavating snowdrifts and pressure ridges. Pups nurse for about 4-6 weeks. They are abandoned after weaning, when capable of foraging for themselves. The primary prey of ringed seals is Arctic cod, saffron cod, shrimps, amphipods, and euphausiids (Kelly 1988; Reeves et al. 1992 *cited in* USDI MMS 2003). Ringed seals are a major resource that subsistence hunters harvest in Alaska (USDI MMS 2003).

Bearded Seals: Bearded seals, the second most common seal in the Arctic, are associated with sea ice and have a circumpolar distribution (Burns 1981). Bearded seals occur over the continental shelves of the Bering, Chukchi, and to a lesser extend the Beaufort Seas (Burns 1981).

Reliable estimates of bearded seal abundance in Alaska waters are unavailable (Angliss and Outlaw 2008). However, Bengtson et al. (2005) estimated the average density for the eastern Chukchi Sea to be 0.07-0.14 seals/km² between Barrow and Shismaref from surveys conducted in 1999 and 2000. While he did not adjust the density for haul-out behavior to estimate abundance, he did state that actual densities could be of a magnitude 12.5 times higher or 0.87-1.75 seals/km². Extrapolating these densities to abundance would put the number below but close to the estimate of ringed seals (230,000) in the Chukchi Sea. While there are no current estimates for bearded seals in the rest of their range off Alaska, early estimates of the entire Alaska stock ranged from 250,000-300,000 seals (Angliss and Outlaw 2008; Popov 1976; Burns 1981), which may be reasonable if not low given the estimate suggested by Bengtson et al. (2005) for a small part of their range.

Seasonal movements of bearded seals are directly related to the advance and retreat of sea ice and to water depth (Kelly 1988). During winter, most bearded seals are in the Bering Sea. From mid-April to June, as the ice recedes, some of the bearded seals over-wintering in the Bering Sea migrate northward through the Bering Strait into the Chukchi Sea. During the open-water period, bearded seals occur mainly along the margin of the pack ice over the relatively shallow Outer Continental Shelf, because they are predominantly benthic feeders (Burns 1981). They prefer areas no deeper than 200 m (e.g., Harwood et al. 2005). If the pack ice retreats beyond the outer continental shelf (> 200m), they usually move into open water areas. Brueggeman et al. (1990, 1991, 1992) recorded as many as 258 sightings of bearded seals west and southwest of Point Barrow in fragmented ice during over 1173 hr of vessel survey and more than 40 flights in July to October of five oil and gas prospects in the Chukchi Sea. Bearded seals were also reported during vessel surveys in northeastern Chukchi Sea during summer and fall 2006 and 2007, primarily near areas of sea ice (LGL 2008). Most bearded seals return to the Bering Sea to winter with the advance of the pack ice in the fall.

Pupping takes place on top of the ice less than 1 meter from open water from late March through May mainly in the Bering and Chukchi Seas, although some takes place in the Beaufort Sea (Kovacs et al. 1996 *cited in* USDI MMS 2003). Pups are abandoned after weaning when they are capable of swimming and feeding on their own. These seals tend to be solitary but sometimes form loose groups. Bearded seals feed on a variety of primarily benthic prey, decapod crustaceans (crabs and shrimp) and mollusks (clams), and other food organisms, including Arctic and saffron cod, flounders, sculpins, and octopuses (Kelly 1988; and Reeves et al. 1992 *cited in* USDI MMS 2003).

Spotted Seal: Spotted seals (also known as largha seals) seasonally occur in the Beaufort, Chukchi, and Bering Seas (Shaughnessy and Fay 1977). Spotted seals occur in large numbers along the Chukchi Sea coast from June to October (USDI MMS 1990; Ireland et al. 2008) and in lower numbers along the Beaufort coast, hauling out on beaches, barrier islands, and remote sandbars on the river deltas (USDI MMS 2003). Haulouts within Kasegaluk Lagoon in the Chukchi Sea contain among the largest spotted seal concentrations in Alaska (Frost et al. 1993). Spotted seals migrate from the Chukchi or Beaufort Seas in the fall to the Bering Sea where they winter.

A reliable estimate of spotted seals is currently not available. However, surveys conducted by Rugh et al. (1993) in the Bering Sea and at known haul-out sites resulted in maximum counts of 4,145 in 1992 and 2,591 in 1993. Using the maximum count with a correction factor for missed seals, Angliss and Outlaw (2008) developed an estimate of 59,214 spotted seals. This represents a minimum estimate, since a substantial portion of their range was not included in the survey.

During spring when pupping, breeding, and molting occur, spotted seals are along the southern edge of the sea ice in the Bering Sea (Quakenbush 1988; Rugh et al. 1997). In late April and early May, adult spotted seals are often seen on the ice in female-pup or male-female pairs, or in male-female-pup triads. Subadults may be seen in larger groups of up to 200 animals. During summer, spotted seals are primarily in the Bering and Chukchi seas, but some range into the Beaufort Sea (Rugh et al. 1997; Lowry et al. 1998) from July until September. At this time of year, spotted seals haul out on land part of the time, but also spend extended periods at sea. The seals are commonly seen in bays, lagoons and estuaries, but also range far offshore as far north as 69–72ºN. In summer, they are rarely seen on the pack ice, except when the ice is very near to shore. Brueggeman et al. (1990, 1991, 1992) recorded 50 or fewer sightings of spotted seals west and southwest of Point Barrow during over 1173 hr of vessel survey and more than 40 flights in summer to early fall (July to October) of five oil and gas prospects in the Chukchi Sea; considerably fewer spotted seals were observed than ringed or bearded seals. Spotted seals leave the Chukchi and Beaufort Seas as ice cover thickens with the onset of winter and move into the Bering Sea (Lowry et al. 1998). Important prey includes pelagic fishes, octopus, and crustaceans.

3.0 Program Area

Shallow hazards survey operations were originally planned to occur in two rectangular areas spaced about 60 km apart and also along a potential pipeline route (Figure 2). Each rectangular area is about 2,000 km² with dimensions about 72 km by 62 km. The two areas are over 111 km (60 nmi) off the Alaska coast, generally west from the village of

Wainwright. The more southern area overlaps the Klondike Prospect and the other area overlaps the Burger Prospect. Data (bathymetry, substrate sampling) on the pipeline route were incidentally collected during transits to and from the mainland to change out crews and resupply the vessel. The vessel also traveled a less defined route between the coast and the survey area when it did not follow the pipeline route. Shallow hazards surveys only occurred at the Klondike Prospect. Shallow hazards survey operations occurred in open water away from the main pack ice, except in a few instances where ice floes were encountered in the Klondike prospect.

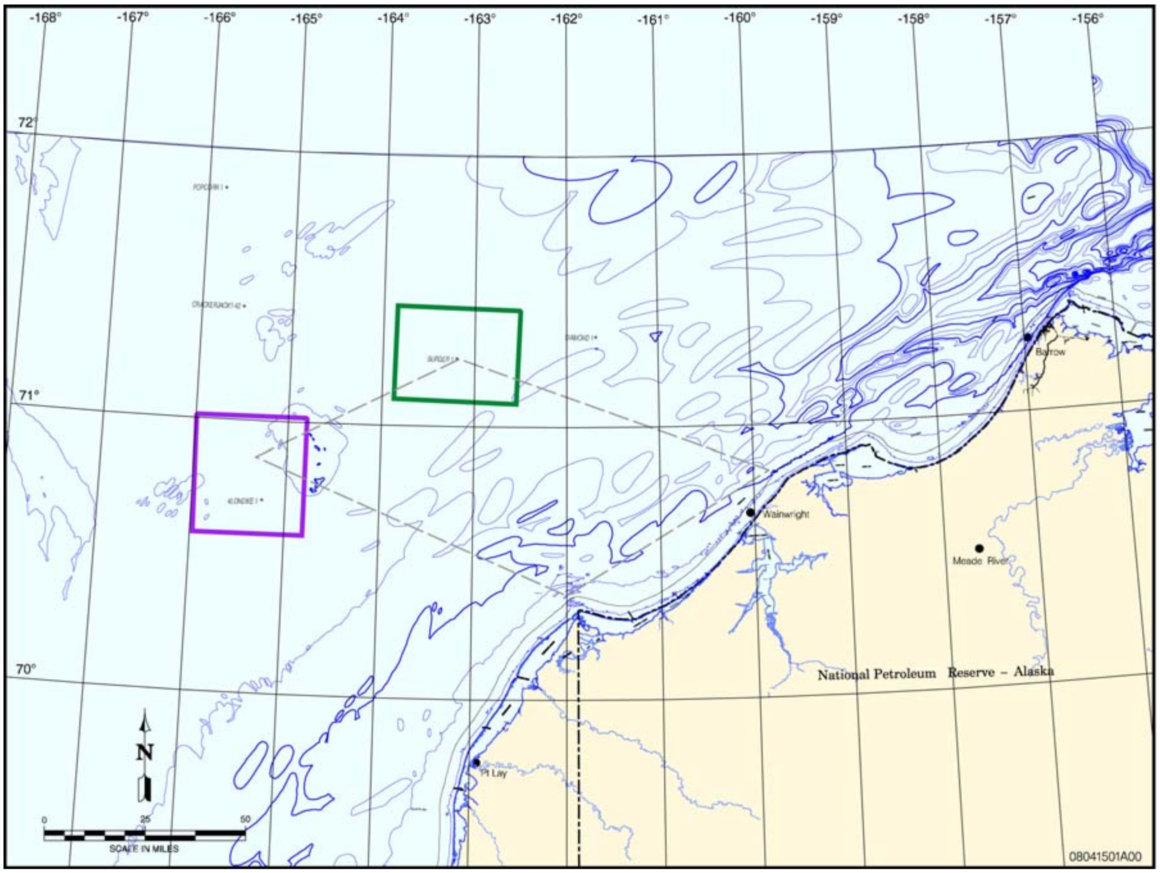

Figure 2 Program area showing two planned shallow hazards survey areas (green and purple) and the potential pipeline route (--- lines).

4.0 Shallow Hazards Survey Program

Shallow hazards surveys were completed to confirm the seafloor has soil and surface characteristics that will support the safe set-down of a drill rig, long-term occupation of the site by such a vessel, and no shallow drilling hazards are present. Acoustic instrumentation used for the survey was designed to characterize the seabed topography, bathymetry, potential shallow drilling hazards, and other seafloor features (e.g., boulders) using seafloor imaging, water depth measurements, and high-resolution seismic profiling. The locations and dates of the surveys did not conflict with the subsistence hunts conducted by Barrow, Wainwright, Point Lay, or Point Hope.

Furthermore, the sound characteristics of the instrumentation had no more than a negligible effect on marine mammals as discussed later in the report. Descriptions of the functions and features of the possible acoustic instrumentation for the project are provided below.

Seafloor Imagery

- Sidescan uses a sonar transducer that emits fan-shaped pulses down toward the seafloor across a wide angle perpendicular to the path of the sensor through the water.
- The intensity of the acoustic reflections from the seafloor of this fan-shaped beam is recorded in a series of cross track slices.
- When stitched together along the direction of motion, these slices form an image of the sea bottom within the swath (coverage width) of the beam.
- The sidescan sonar was a Marine Sonic Technology Sidescan Sonar System using a stainless steel towfish with150 kHz transducers.

Bathymetry

Echosounders measure the time it takes for sound to travel from a transducer, to the seafloor, back to a receiver. The travel time can be converted to a depth value by multiplying it with the sound velocity of the water column. Echosounders are generally mounted to the ship hull or on a side-mounted pole.

Multibeam Theory

- Multibeam (or swath) sonar uses a transmit source and a receive array of sonar transducers that emits fan-shaped pulses down toward the seafloor across a wide angle perpendicular to the path of the sensor through the water.
- Ship's motion and sonar pulse location controlled for via DGPS and motion reference units (MRU).
- Individual transects are stitched together to form large 2 or 3 dimensional views of the seafloor and associated structures and bed forms capable of being resolved by the resolution of the system.
- Equipment - Odom ES3 Multibeam – 247 kHz

Sub Bottom Profiler

Sub-bottom profiler (SBP) uses a lower frequency sound source (typically 2-12 kHz) to identify and measure various sediment layers that exist below the sediment/water interface. These systems typically can image sediment layers and geological features 1 – 20 m below the sea surface. SBP used during the 2008 survey consisted of four Masa 1097 3.5 kHz Transducers in an over-the-side tow sled. A single transducer was later installed in the vessels sea-chest to provide less noisy data. This is part of the Knudsen 320 system

High-resolution Seismic Profiling

An integral part of the shallow hazards surveys is high-resolution seismic profiling using three different acoustic source systems. Seismic systems operate on the principal that an acoustic impulse will reflect part of its energy upon encountering a density interface. This is accomplished through the use of a high-frequency subbottom profiler. The high-resolution profiling system, which uses smaller acoustic sources, was utilized as opposed to low-resolution systems or deep exploration seismic systems. The surveys were geared toward providing detail of the surficial and shallow subsurface geology and <u>not</u> toward hydrocarbon exploration. The high-resolution profiles provide the detailed information that is not resolved in the deep seismic profiles.

Equipment Potentially Affecting Marine Mammals

While the sonar equipment used for the project generates high sound energy, the equipment operates at frequencies (>100 kHz) beyond the effective hearing range of the marine mammals encountered during the project (Richardson et al. 1995). However, the equipment proposed for the seismic profiling operates at a frequency range and sound level that could potentially affect marine mammal behavior if it occurs within a relatively close distance to the sound source (Richardson et al. 1995). JASCO modeled the sound levels of three different sparker configurations (mult-itip @ 1.5 kj, single tip @ 6 kj, and dual single tip @ 12 kj) and found the single dual tip sparker produced the highest sound levels**.** While the take estimates of marine mammals in the IHA application were calculated for a much louder 4-gun array, the configuration of the seismic profiler actually used during the shallow hazards survey was a 6 kj sparker. Consequently, the sound level used during the survey was much lower than presented in the IHA application.

5.0 Marine Mammal Monitoring Program

Vessel-based Monitoring

Vessel-based observers monitored marine mammals from the shallow hazards survey vessel during (1) all daylight hours during seismic activity and most daylight hours during no-seismic activity, (2) startups, and (3) at night when marine mammals were suspected of either approaching or within the safety radii. Observations were also made during daylight periods during transits between Nome and the program area at the beginning and end of the shallow hazards survey program.

During the shallow hazards survey program two marine mammal observers (MMOs) were based aboard the vessel. Observers followed a schedule so one observer monitored marine mammals near the seismic vessel during ongoing daytime operations and nighttime start ups of the sparker. MMO(s) were on duty in shifts no longer than 4 hours. The vessel crew was instructed to assist in detecting marine mammals and implementing mitigation requirements (when practical). Before the start of the shallow hazards survey program the crew and MMOs were given training on marine mammal identification and data recording prepared by Jay Brueggeman.

The shallow hazards survey vessel was a suitable platform for marine mammal observations. During daytime, the MMO(s) scanned the area around the vessel systematically with reticle binoculars (e.g., 7 × 50 West Marine) and with the naked eye. A laser range finder (Leica LRF 1200 laser rangefinder) was available to assist with distance estimation. It is useful in training observers to estimate distances visually, but is generally not useful in measuring distances to animals directly for a variety of reasons, primarily associated with the low angle between the marine mammal and the vessel platform. During darkness, NVDs (Night Vision Devices) were available (ITT F500 Series Generation 3 binocular-image intensifier), if and when required.

MMOs and the crew were instructed to immediately shut down the sparker when a marine mammal was detected within or about to enter the designated safety radius. The observer(s) were further instructed to maintain watch to determine when the animal(s) left the safety radius. Seismic operations could only resume when the animal was outside the safety radius. The animal was considered to have cleared the safety radius if it was visually observed to have left the safety radius, or if it had not been seen within the radius for 15 minutes (pinnipeds) or 30 minutes (cetaceans).

MMOs were instructed to record all observations and airgun shutdowns in a standardized format. Data were entered onto field forms and later input into Excel spreadsheets for analysis. The accuracy of the data was verified by subsequent manual and computer-based checking of the database.

Data Analysis

Subareas

The program area consisted of the following subareas used in the analysis: Klondike, Burger, Pipeline Route, Other, and Transit. Klondike was the focus of the program where essentially all of the seismic activity occurred during the program. There was no-seismic activity at Burger or along the pipeline route and a very brief amount in the rest of the area traversed by the shallow hazards survey vessel. In addition, the vessel spent a brief time at Burger and the potential Pipeline Routes. For these reasons Burger, Pipeline, and the other areas outside of Klondike were combined into a single area termed "all other areas" in this report. The transit subarea was the route traveled between Nome and the program area at the beginning and the end of the shallow hazards survey program. Since most of this area is outside of the program area, it was not included in the analysis except to present species observed by the MMOs.

Groups of marine mammal species were combined for the analysis since some species were difficult to distinguish in the water or sample sizes were too small to analyze by species. Ringed, spotted, bearded, ribbon, and unidentified seals/pinnipeds were combined into one group, since ringed and spotted are difficult to distinguish, bearded seals were far less common, ribbon seals were very uncommon, and there were a number of unidentified seals. Since there were only three unidentified pinnipeds, which were most likely seals based on the location and association with other seals combined with an absence of walrus at the time, they were included in the single seal group. Cetacean species were usually separated into a single group of gray whales since they comprised 9 of the 10 total sightings. Walrus and polar bear were separately analyzed, since they are managed by USFWS. Although this report is intended for the NMFS to fulfill the IHA requirement, walrus and polar bear were included to meet the reporting requirements of the USFWS.

The analysis focused on comparing marine mammal use within the Klondike Prospect to the other survey areas in the program area. Within Klondike, the analysis focused on comparing marine mammal use during seismic and no-seismic activity to evaluate any effects on marine mammals from the shallow hazards survey program. Seismic versus no-seismic activity is used in this report to describe use of the sparker, which was the only sound source used for the shallow hazards survey. Marine mammal use was also compared between Klondike absent of seismic activity and other survey areas where there was no-seismic activity to assess any potential effects between an area exposed to seismic activity and one free of seismic activity. The areas are not perfect treatment and control areas but provide a rough indication of potential response to marine mammals to an area exposed to seismic activity. There was no analysis of data collected during the transit between the program area and Nome since it was not in the program area.

Line Transect Estimation of Densities

Density was calculated for seals but not for cetaceans, walrus, or polar bears since there were insufficient sightings to obtain a meaningful density estimate. Density was calculated by using the line transect estimation method (Burnham et al. 1980).

Density was calculated as follows:

$$D = \frac{n \times S \times f(0)}{2 \times L \times g(0)}$$

where

D	=	density of a species in number of animals/km^2
n	=	number of sightings
S	=	mean group size
f(0)	=	sighting probability density on the trackline
L	=	length of trackline completed (in km)
g(0)	=	probability of seeing a group directly on the trackline

The parameters f(0) and g(0) are correction factors to minimize biases in estimates of actual number of marine mammals. The parameter f(0) accounts for the reduced probability of detecting an animal as its distance increases from the trackline. The f(0) value used to calculate density was derived by using the software Distance 5, release 2 (Thomas et al., 2006). The parameter g(0) accounts for animals surfaced or sub-surfaced on the trackline but missed during the survey. The g(0) value used to calculate density was one which assumes observers saw all animals on the trackline. Experiments were not conducted in the field to calculate the value, but it is likely that observers saw most if not all of the seals on the trackline due to the experience of the observers, height of the platform, and survey conditions.

Estimating Number of Marine Mammals within the Behavioral Disturbance Radii

Under current NMFS guidelines (e.g., NMFS 2000), “safety radii” for marine mammals around airgun arrays are customarily defined as the distances within which received pulse levels are ≥180 dB re 1 µPa (rms) for cetaceans and ≥190 dB re 1 µPa (rms) for pinnipeds. These safety criteria are based on an assumption that seismic pulses at lower received levels will not injure these animals or impair their hearing abilities, but that higher received levels *might* have some such effects; however, there is no evidence in the scientific literature indicating these levels cause either temporary or permanent hearing loss in Arctic marine mammals, so the received levels are precautionary (Richardson et al. 1995).

In addition to the standard safety radii based on the ≥190 and ≥180 dB (rms) distances for pinnipeds and cetaceans, respectively, NMFS (in the IHAs) required the ≥160 dB radius be monitored during all seismic activity. Marine mammals exposed to ≥160 dB (rms) are assumed by NMFS to be potentially subject to behavioral disturbance. However, for certain groups such as dolphins and pinnipeds, available data indicate that disturbance is unlikely to occur unless received levels are higher, perhaps ≥170 dB (rms). Behavioral disturbance from seismic operations has been reported in the literature to be temporary and short term with no biologically significant effect on the individual or population of Arctic marine mammals (NRC 2005).

JASCO measured distances where received levels decreased below 190, 180, and 160 dB re 1 µPa (rms) from three sparker (1.5, 6 and 12 kj) configurations. Measurements were made in the program area immediately before the start of shallow hazards survey program. As mentioned earlier, the sound source used during the project was a 6 kj sparker. The measured distances for the 6kj sparker are as follows.

Level of Ensonification	Distance
190 dB	13 m
180 dB	41 m
160 dB	368 m

NMFS requires powerdown or shutdown procedures to be implemented when a marine mammal is sighted within or approaching the applicable safety radius while the airguns are operating; the configuration of the sparker was not suitable for the power down procedure so only the shutdown procedure was followed during operations. A shutdown involved suspending operation of the sparker when a mammal was first sighted within or approaching its safety radius.

Take was estimated by multiplying density of a given marine mammal species or group of species by the area ensonified from the seismic sounds source within the behavioral disturbance criteria established by NMFS. The area ensonified was determined by the length of trackline covered during seismic activity times the distance (1,170 m) received levels declined to 160 dB from the trackline times two in order to account for both sides of the trackline. Only the trackline surveyed and animals recorded during seismic activity were used to calculate take.

6.0 Results

Species Abundance and Composition

A total of 222 sighting of 279 marine mammals representing 8 species was recorded during the shallow hazards survey program (Table 1). Seals comprised the highest proportion (78%) followed by walrus (18%), cetaceans (4%), and one polar bear (<1%). Of the seals, ringed and spotted seals together were most common (41%), ribbon least common (<1%), and bearded seals intermediate (18%); unidentified seals and pinnipeds

(40%, most of the three unidentified pinnipeds were likely seals) made up the remaining sightings. Of the 11 cetaceans recorded, all were gray whales except for 1 minke whale and 1 unidentified whale. There were a total of 11 juvenile/subadult animals including 5 bearded seals, 3 ringed/spotted seals, 2 unidentified seals, and 1 gray whale. There were no beluga or bowhead whales observed during the shallow hazards survey program.

A total of 79 (28%) marine mammal sightings were recorded at Klondike (Table 1). Ringed, spotted (including one juvenile), and bearded seals, and walrus were observed at Klondike. The majority (86%) of the walrus recorded during the program were at Klondike. Most (72%) of the marine mammals including all 10 gray whales recorded during the program were observed outside of Klondike with few marine mammals observed along the pipeline route (5 seals) and none at Burger. A few seals (14) and the only minke whale were recorded during the transit between Nome and the program area.

Table 1 Total marine mammals sightings and number recorded during monitoring program in the Chukchi Sea 2008

Species	**Klondike**		**Burger**		**Pipeline**		**Other**		**Transit**		**Total**	
	Sightings	**No**	**Sightings**	**No**	**Sightings**	**No**	**Sightings**	**No**	**Sightings**	**No**	**Sightings**	**No**
Ringed/ Spotted Seal	7	7					37	42 (2)	4	4	48	53 (2)
Ringed Seal	1	1					4	4	1	1	6	6
Spotted Seal	10	12 (1)			1	1	14	15	2	3	27	31 (1)
Bearded Seal	6	6			3	3 (1)	26	30 (4)			35	39 (5)
Ribbon Seal							1	1			1	1
Pacific Walrus	14	43					2	7			16	50
Unidentified Seal	10	10			1	1	64	70 (2)	3	3	78	84 (2)
Unidentified Pinniped							1	1	2	2	3	3
Subtotal	48	79 (1)	0	0	5	5 (1)	149	170 (8)	12	13	214	267 (10)
Gray Whale							5	9 (1)			5	9 (1)
Minke Whale									1	1	1	1
Unidentified Whale							1	1			1	1
Subtotal	0	0	0	0	0	0	6	10 (1)	1	1	7	11 (1)
Polar Bear							1	1			1	1
Total	**48**	**79 (1)**	**0**	**0**	**5**	**5 (1)**	**156**	**181 (9)**	**13**	**14**	**222**	**279 (11)**

Effort

MMOs observed a total of 467 hours covering 3,452 km from the shallow hazards survey vessel (Table 2). The majority (67%) of the effort occurred at Klondike where seismic activity was almost three times greater (72%) than no-seismic activity (28%) (Figure 3). The remaining effort (33%) was mostly in the broader area outside of the pipeline and Burger subareas, since each of these two areas had less than 10 hours of effort because ice cover prevented shallow hazards survey operations. A total of 32 hours of marine mammal monitoring occurred during the transits. There was no-seismic activity in these areas except for a short period for sound validation.

MMOs monitored the shallow hazards survey activities during 80% of the 55 total days of operation. Only limited monitoring occurred when sea states were too high (> 5 sea state) to effectively see marine mammals and no monitoring occurred when the vessel was docked at Wainwright for resupply or other activities related to the operation. Monitoring occurred during all daylight hours unless prevented by poor weather conditions (high sea states, poor visibility, etc).

Table 2 Marine mammal monitoring effort during seismic and no-seismic activity in the Chukchi Sea

	Effort (hr)			Effort (km)		
Survey Location	**Seismic Activity**	**No-seismic Activity**	**Total Effort (hr)**	**Seismic Activity**	**No-seismic Activity**	**Total Effort (km)**
Klondike	224	89	313	1515	522	2,037
Burger	0	6	6	0	14	14
Pipeline	0	8	8	0	57	57
Other	1	107	108	10	969	979
Transit	0	32	32	0	365	365
Total	**225**	**242**	**467**	**1,525**	**1,927**	**3,452**

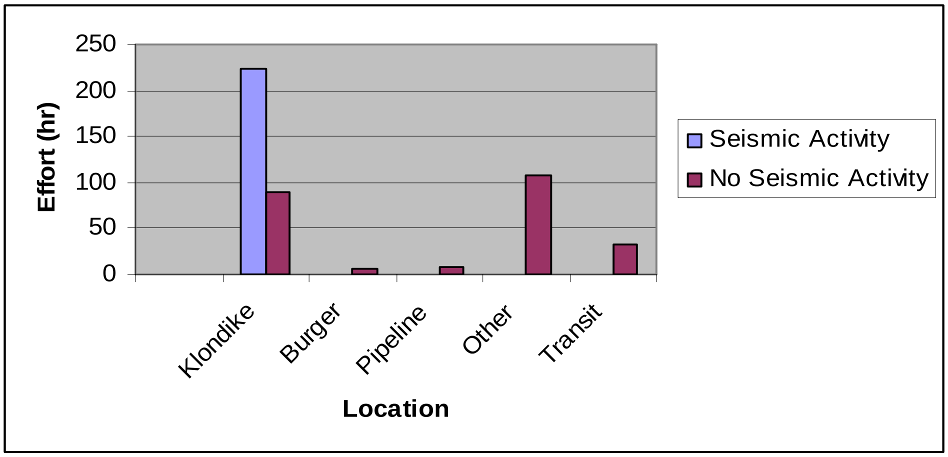

Figure 3 Marine mammal monitoring effort (hr) from the shallow hazards survey vessel during seismic and no-seismic activity by survey location

Observation Conditions

Sea state, visibility, and glare were recorded to gauge observation conditions during the marine mammal monitoring program at Klondike and elsewhere in the program area. High sea states, poor visibility, and severe glare can substantially reduce the effectiveness of detecting marine mammals and subsequently influence the results of the shallow hazards survey activities on marine mammals.

Sea state conditions below six are considered acceptable for surveying marine mammals. Higher sea states make detecting a marine mammal difficult. Sea state conditions were acceptable almost 75 % of the time at Klondike and 90% of the time at the other survey areas (Figure 4). In addition, sea state conditions were acceptable most of the time during both seismic (80%) and no-seismic activities (70%) at Klondike (Figure 5).

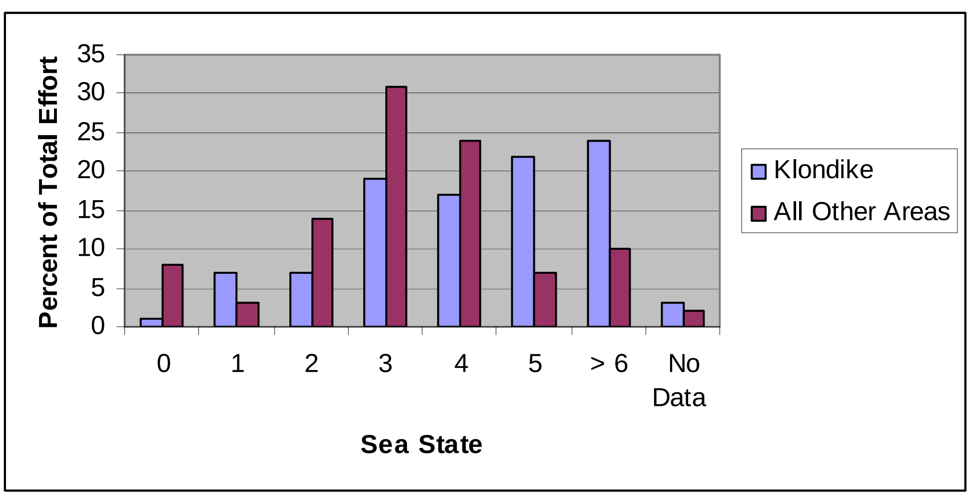

Figure 4 Sea state conditions at Klondike compared to all other areas surveyed during the monitoring program

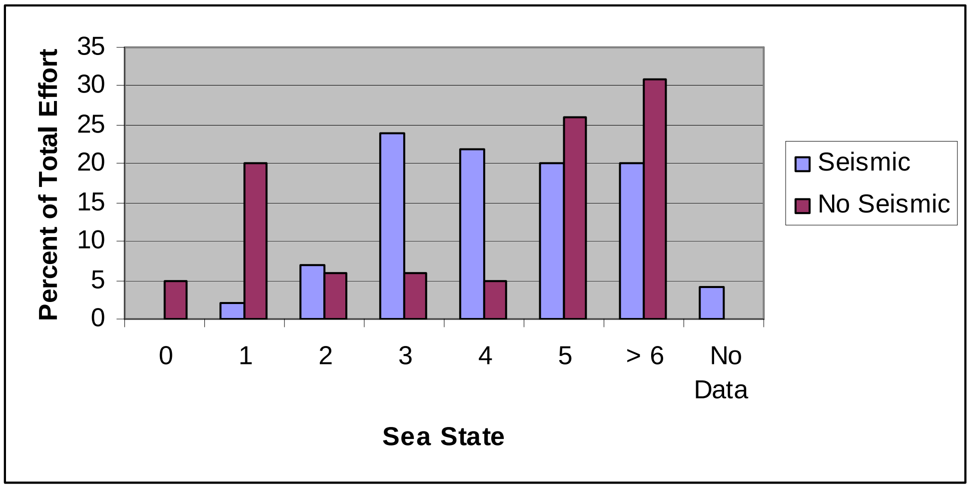

Figure 5 Sea state conditions during seismic and no-seismic activity at Klondike during the monitoring program

Higher visibility enables a greater area to be monitored for marine mammals, which adds to the quality of the data. Visibility from the vessel was limited to less than 1 km only about 10% of the time at Klondike and all other areas (Figure 6). Visibilities greater than 3 km occurred over 70 % of the time and greater than 5 km over 50% of the time at Klondike. Percentages at these distances were slightly higher in all other areas. High percentages of effort also occurred at these viewing distances for both seismic and no-seismic activity (Figure 7).

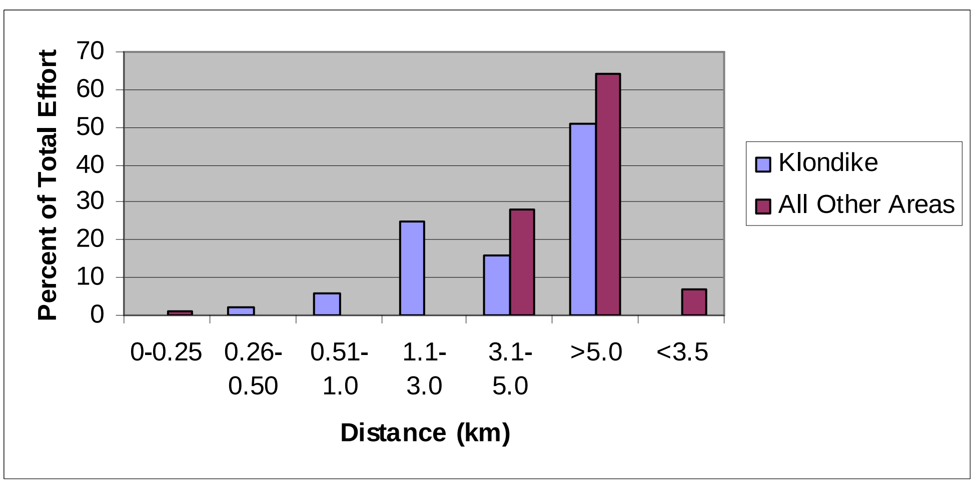

Figure 6 Visibility distance from vessel during marine mammal monitoring program at Klondike and all other areas (the last category is visibility varied between 0-3.5 km)

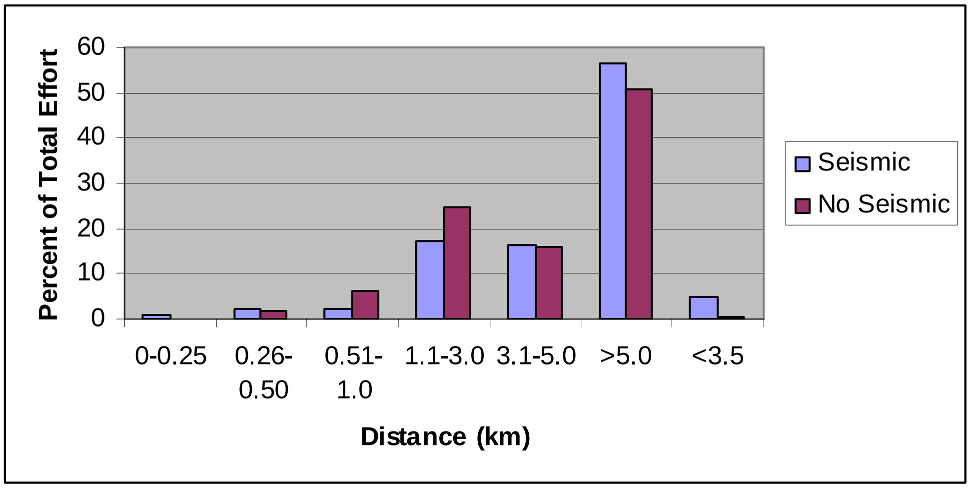

Figure 7 Visibility distance from vessel during marine mammal monitoring program at Klondike (the last category is visibility varied between 0-3.5 km)

Glare like sea state affects the ability to detect marine mammals by reducing the area effectively seen by an MMO. Little to no glare occurred at Klondike and all other areas most (>70%) of the time during the program (Figure 8). Similar conditions occurred during seismic and no-seismic activity (Figure 9). These results show that observation conditions as measured by glare, sea state, and visibility were suitable for the MMOs to effectively detect and monitor marine mammals the majority of the time during the shallow hazards survey program.

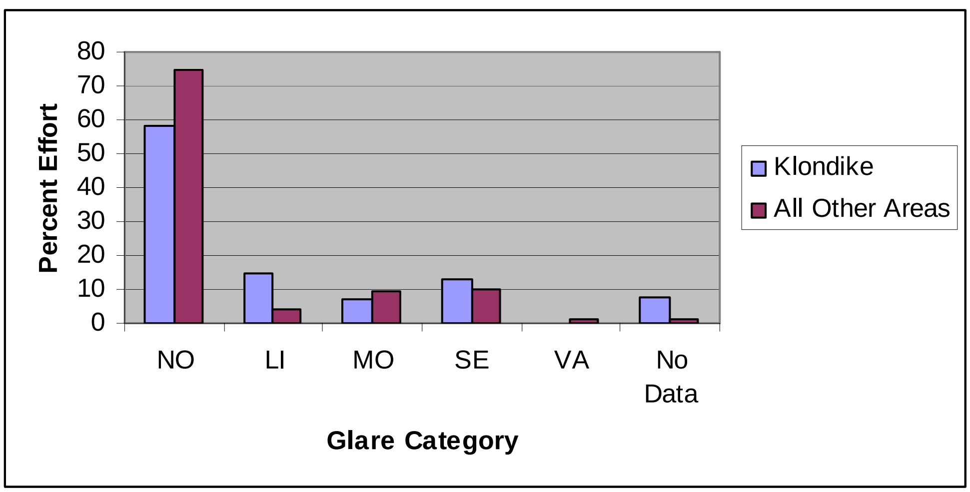

Figure 8 Glare conditions at Klondike and all other areas during marine mammal monitoring program (NO=no glare, LI=little glare, MO=moderate glare, SE=severe glare, VA=variable glare)

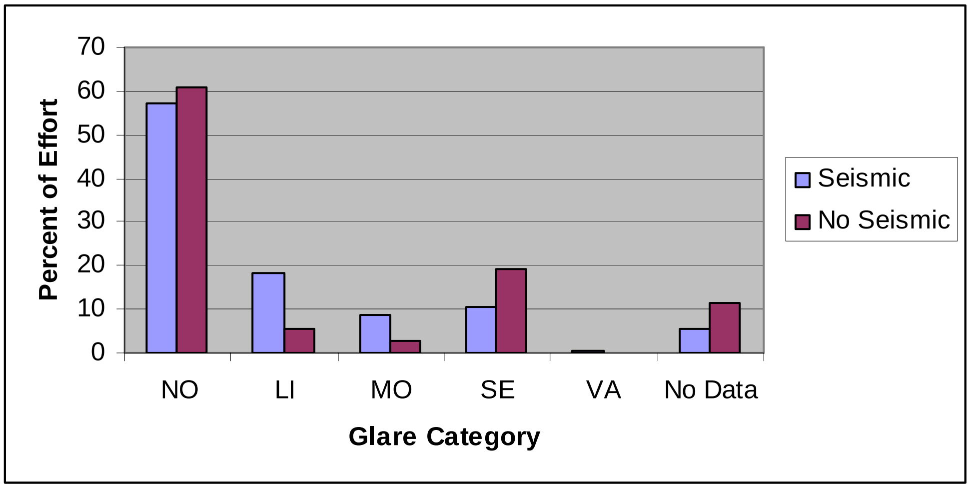

Figure 9 Glare conditions during seismic and no-seismic activity at Klondike during marine mammal monitoring program

Spatial and Temporal Distribution

Marine mammals were widespread and present throughout the shallow hazards survey program but there were some temporal differences between Klondike and the other areas. Seals were widely distributed in the program area (Figure 10). Their numbers were relatively similar from early September to mid October with a slight peak in late September; no seals were seen in the latter half of October at Klondike (Figure 11). Walruses were only observed from mid September to mid-October with the highest encounter rates during the latter half of September. Most walrus were offshore in Klondike (Figure 12). No gray whales or polar bears were recorded at Klondike.

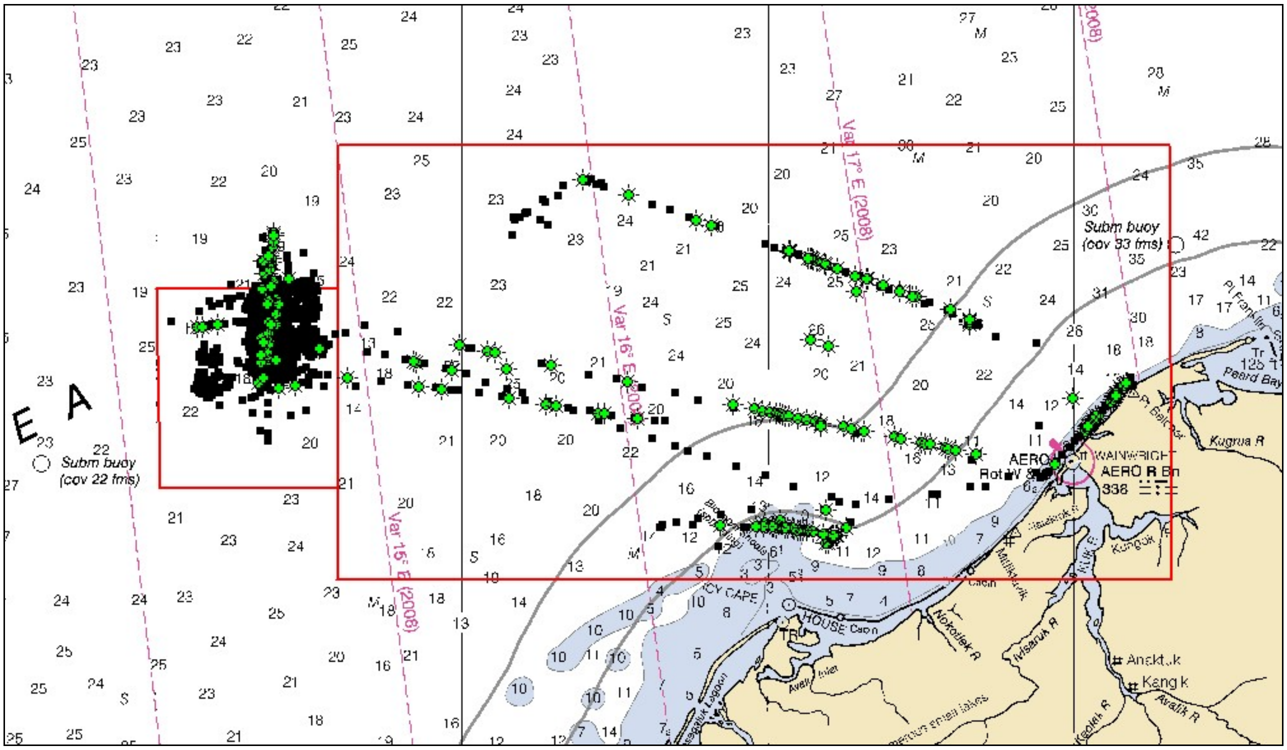

Figure 10 Seal distribution (black represents trackline positions and green seal locations, the small box corresponds to Klondike and the larger box includes all other survey areas)

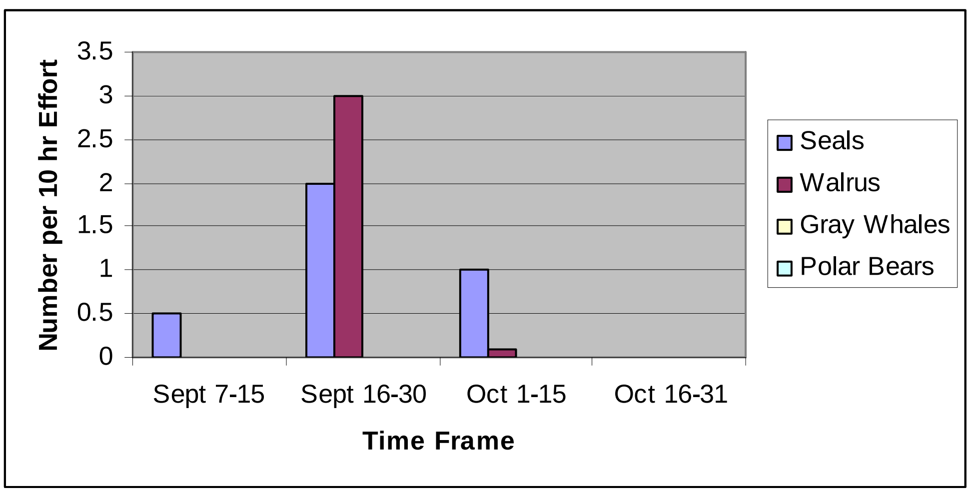

Figure 11 Marine mammal encounter rates at Klondike

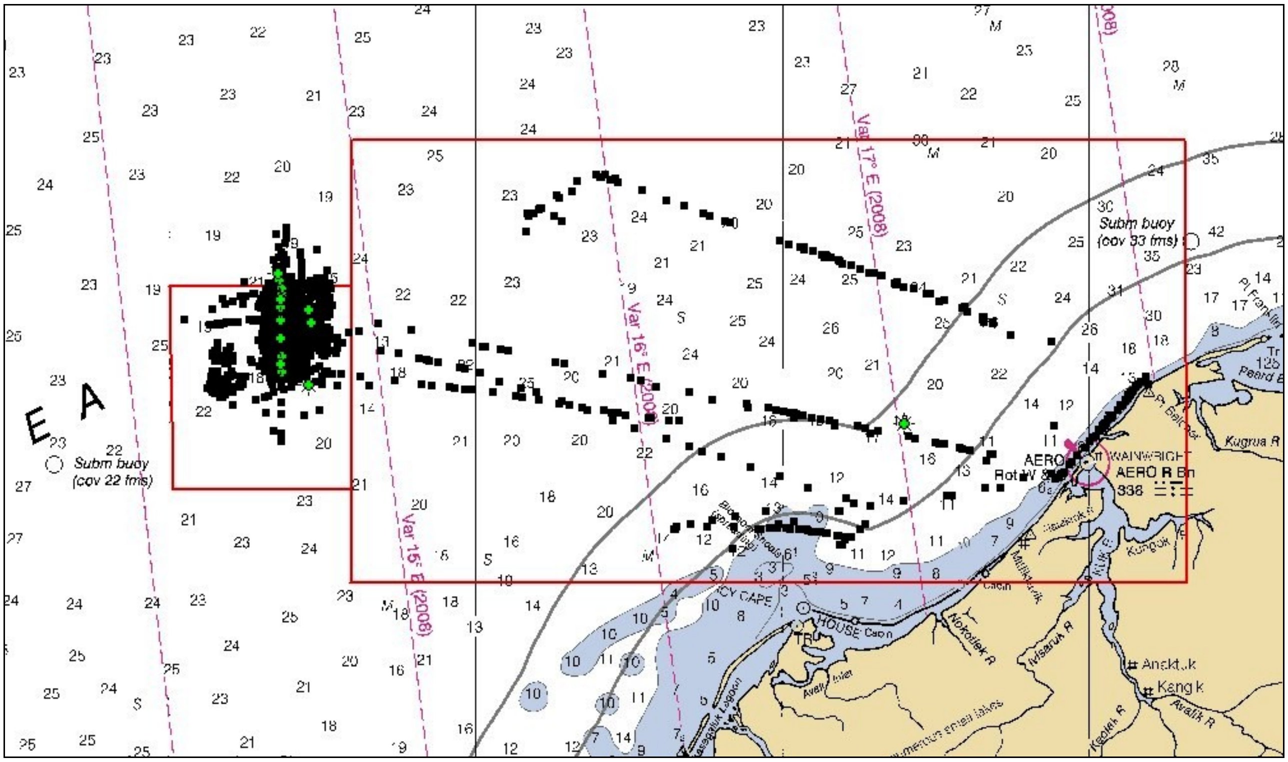

Figure 12 Walrus distribution (green represents walrus locations)

The pattern of marine mammal use in the other areas surveyed was generally similar to Klondike for seals and walrus including encounter rates peaking in the latter half of September (Figure 13). However, seals were observed during all four time periods while walrus were only observed in the later half of September. Gray whales were primarily encountered during the first half of September after which no more were recorded until the last half of October when two gray whales was recorded. All gray whales were widespread relatively close to shore (Figure 14). The single polar bear was recorded during the first half of September also closer to shore (Figure 15). These results show that seals were present during the entire time span of the shallow hazards survey program while the other species occurred intermittently. Furthermore, the temporal pattern of seal use was similar between Klondike and the other areas except seal use at Klondike was not observed during the last half of October.

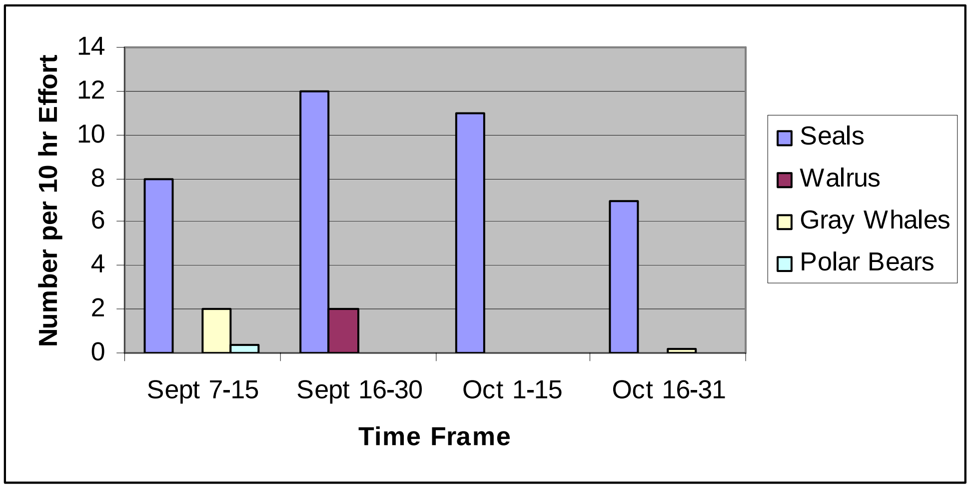

Figure 13 Marine mammal encounter rates at areas other than Klondike or during transit between Nome and the program area

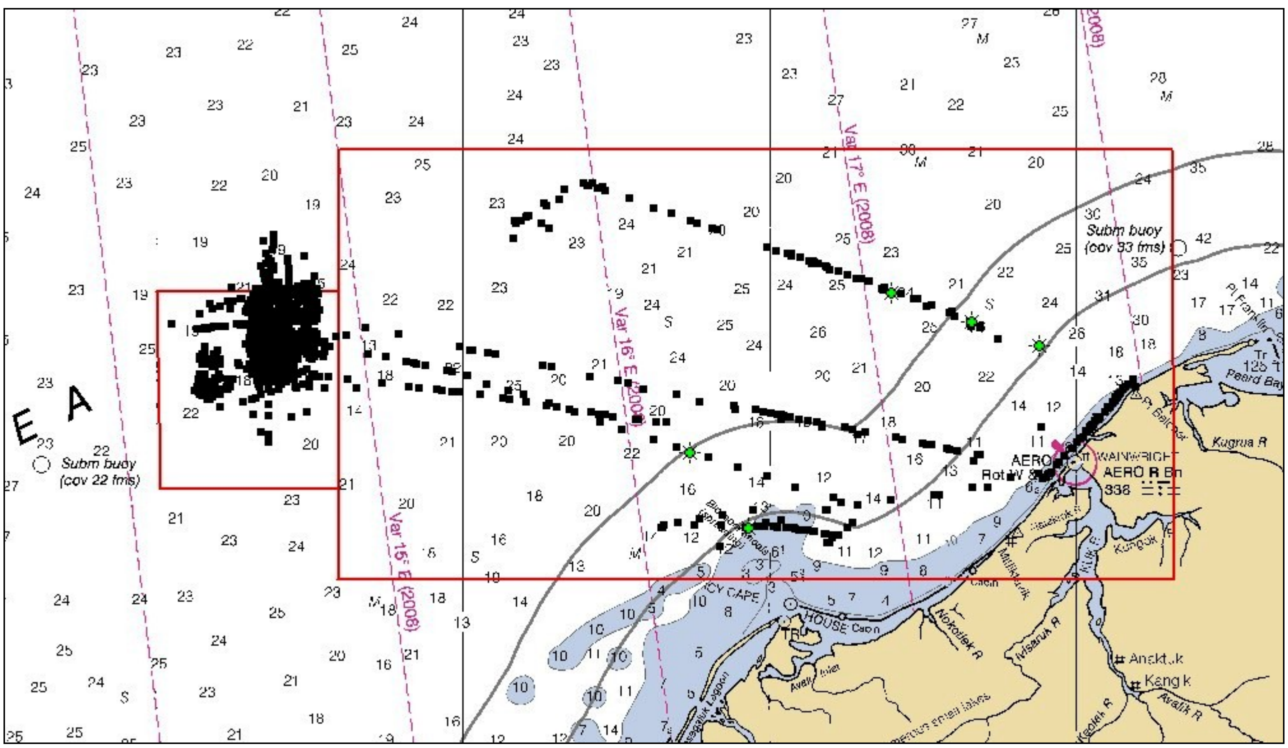

Figure 14 Cetacean distribution (green represents cetacean, primarily gray whale locations)

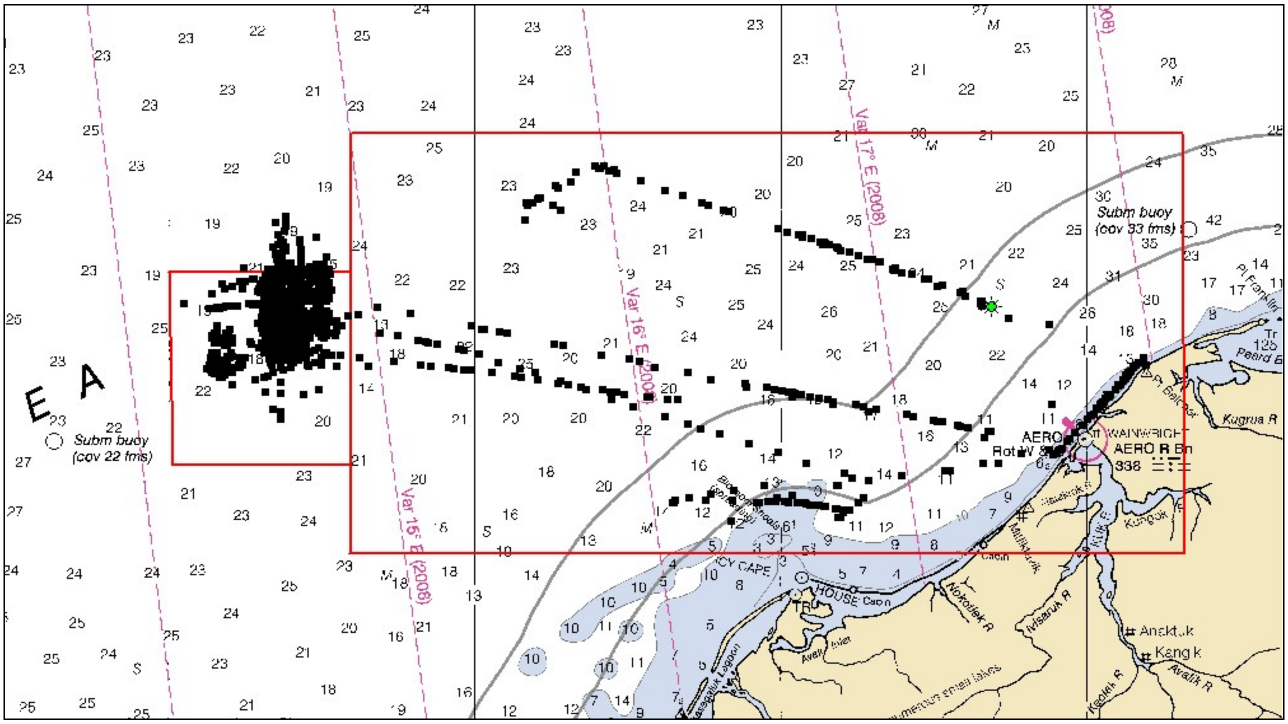

Figure 15 Polar bear distribution (green represents polar bear location)

Seismic versus No-seismic Activity Comparison

Number of sightings, distance from the shallow hazards survey vessel, and behavior during seismic and no-seismic activity were analyzed to assess potential effects of shallow hazards survey operations on the behavior of marine mammals. Travel direction was recorded in the field for cetaceans but too few cetaceans were observed to provide a meaningful analysis and seal are too variable in their movements to apply this measure to them. These measures are discussed below.

Fewer marine mammal sightings were recorded during seismic than no-seismic activity at Klondike. Twenty-eight percent of all seal sightings were recorded during seismic activity which represented 73% of the total survey effort at Klondike (Figure 16). While sample size for walrus was too small (14 groups) at Klondike to provide a meaningful comparison, it is noteworthy that only 1 of 14 walrus sightings was recorded during seismic activity. No comparison could be made for cetaceans or polar bears, since none were recorded at Klondike.

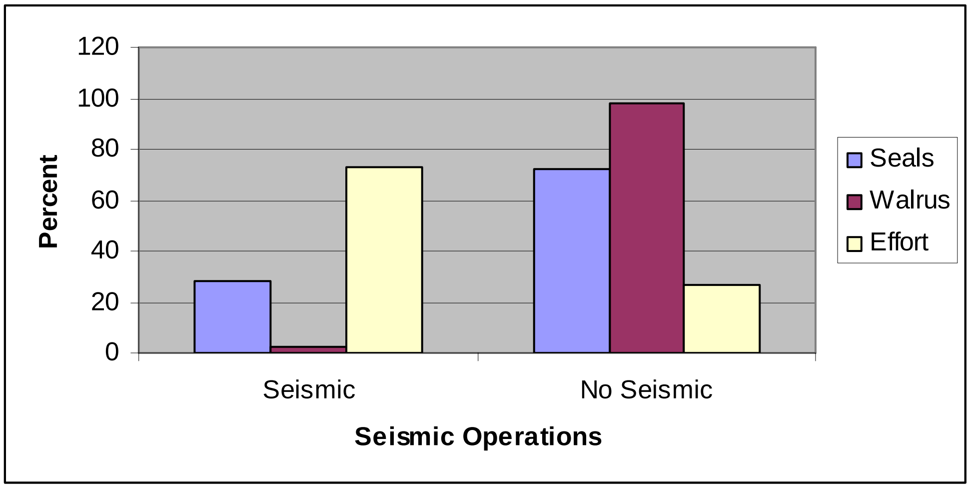

Figure 16 Comparison of seal and walrus sightings relative to effort during seismic and no-seismic activity at Klondike

Seal density was correspondingly lower during seismic than no-seismic activity for seals at Klondike, which was also less than the density for all other survey areas (Table 3). Estimated density during no-seismic activity was over 7 times higher than during seismic activity (0.0.284 vs 0.038 seals/km²). Seal density in Klondike during no-seismic activity was about a third as high (0.284 vs 0.920 seals/km²) as the density for all other survey areas, suggesting seals unequally used the two areas during periods of no-seismic activity. There were too few sightings of walrus (16), cetaceans (7), and polar bears (1) to calculate a meaningful density.

Table 3 Estimated seal density at Klondike and the other areas surveyed in the program area

Location	Activity	Number of Sightings	Average group size	F(0)[1]	Survey Distance Times Two (km)	G(0)	Estimated Density (no./km²)
Klondike	Seismic	10	1.0	11.45	3030	1	0.038
	No-seismic	24	1.08	11.45	1044	1	0.284
All other survey area (other, burger, pipeline)	No-seismic	152	1.1	11.45	2080	1	0.920

[1] The f(0) value corresponds to an effective strip width of 90 m

Comparisons of marine mammal distances from the vessel for seismic and no-seismic activity were limited by the small sample sizes during seismic activity. However, some general patterns were detectable, particularly for seals. Most (88-100%) seals were observed relatively close (< 100 m) to the vessel for both activities (Figure 17). Numbers increased for both activities over the first three distance categories from the vessel, beyond which there were only a few seals. The pattern between Klondike (with no-seismic activity) and other survey areas had some similarities but differences included a higher percentage (46% vs 13%) of seal sightings further (> 100 m) from the vessel than observed at Klondike (Figure 18). Numbers increased with increasing distance from the vessel for both areas but the number of sightings peaked further from the vessel in survey areas outside of Klondike. No seals were observed within 5 m of the vessel either inside or outside of Klondike. The differences between the two areas may be due to sample size, which was six times greater than at Klondike (24 vs 151 sightings). Too few walrus groups were observed at Klondike to make a meaningful comparison between seismic and no-seismic activity, however, the one walrus observed at Klondike during seismic activity was between 6 and 30 m of the vessel. All other walrus were observed during no-seismic activity, and they were consistently between 31 and 600 m from the vessel inside and outside of Klondike. Most cetaceans (4 of 6) were 101 m to 600 m of the vessel, although two were beyond 1500 m. The single polar bear was over 200 m from the vessel.

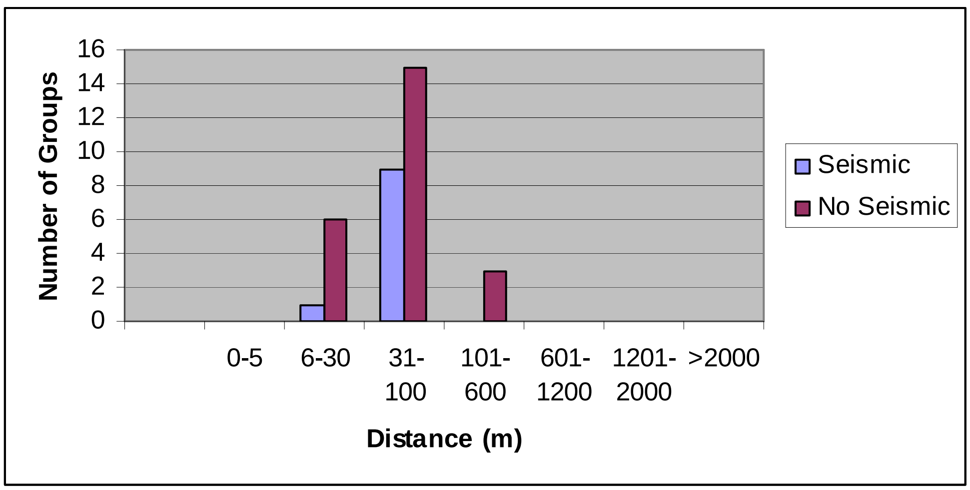

Figure 17 Distance of seals (including unidentified pinnipeds) from shallow hazards survey vessel during seismic and no-seismic activity at Klondike Prospect

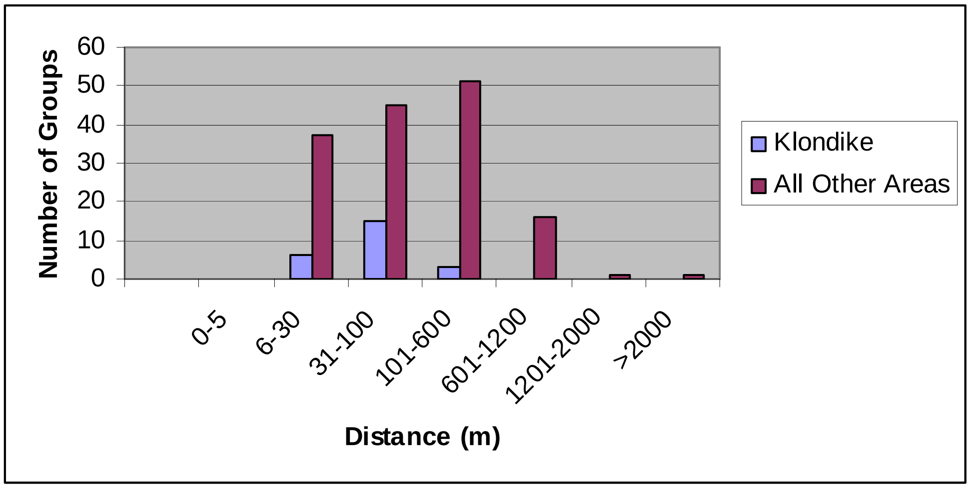

Figure 18 Distance of seals (including unidentified pinnipeds) from shallow hazards survey vessel during no-seismic activity at the Klondike Prospect compared to all other areas

Behavior patterns of seals were different during seismic and no-seismic activity at Klondike (Figure 19). Looking was the most common behavior during seismic while swimming was the most common behavior during no-seismic activity. Other behaviors (diving) represented a small proportion of the sightings. Differences were also apparent in the behavioral patterns of seals observed at Klondike (no-seismic activity) compared to those recorded in the other survey areas. While the prominent behavior at Klondike was swimming, looking was most often recorded in the other survey areas. While the difference in behavior at Klondike suggests some response to seismic activity, the effect is discounted by having seals display the same dominate behavior (looking) both in areas outside and inside of Klondike. Ireland et al. (2008) also reported looking and swimming as dominate behaviors during seismic and no-seismic activity in the Chukchi Sea. The differences observed within Klondike and between Klondike and other survey areas were likely influenced by the sample size, which was much smaller at Klondike (24 vs 164 sightings). Therefore, either the small sample size reduced the value of behavior as a measure for assessing seal response to seismic activity or the operation did not affect behavior. The behavior of the one walrus observed during seismic operation was looking while those observed during no-seismic activity were primarily swimming. Cetaceans were observed swimming (3), blowing (2), and diving (1) while the single bear was resting behind a wall of sea ice and did not move even as the vessel passed it.

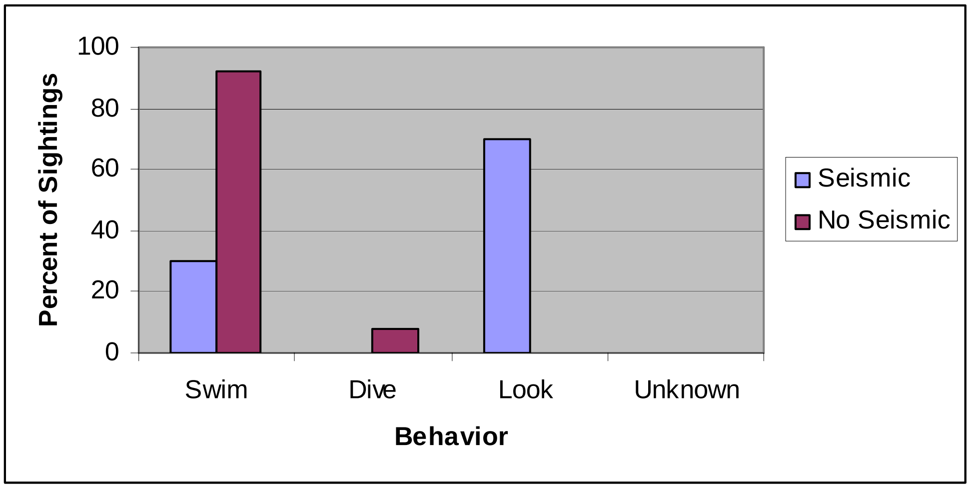

Figure 19 Seal behavior during seismic and no-seismic activity at Klondike Prospect

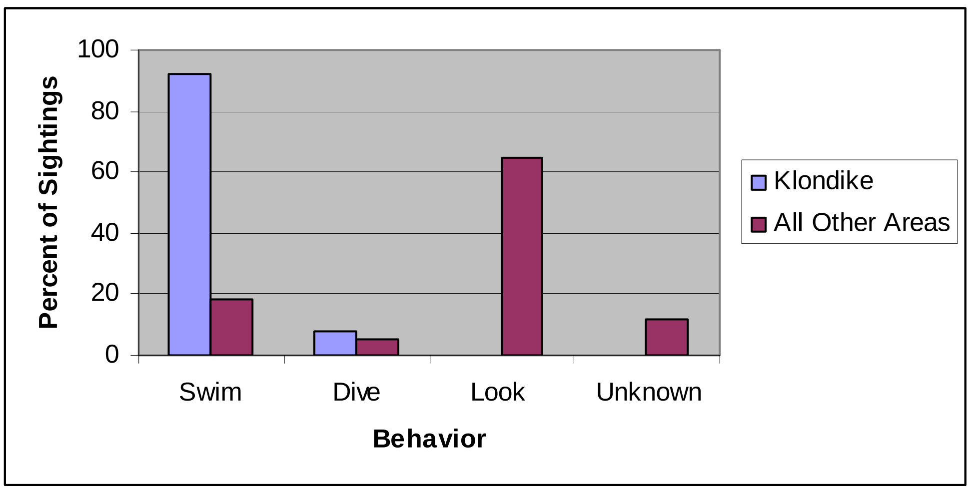

Figure 20 Seal behavior during no-seismic activity at Klondike compared to all other survey areas

Marine Mammals Observed and Estimated in the Safety and Behavioral Disturbance Radii

The number of marine mammals observed within the 160 dB behavioral disturbance radii included ten seals, no whales or polar bears, and one walrus. Seal species included one bearded seal, three ringed/spotted seals, and six unidentified seal species. There were no pinnipeds in the 190 dB safety zones during seismic activity; therefore, there were no shutdowns of the operations.

The estimated take is provided in Table 4. The take is presented as a range based on the actual number observed during seismic activity and either an estimated number or the high count in the program area. The observed number provided the lower end of the range and other number the high end of the range. An estimated number was only calculated for seals observed during seismic activity, which was derived by multiplying the density (0.038 seals/km² from Table 3) times twice the product of the trackline length (1515 km from Table 2) times the width (0.368) of the 160 dB ensonified area from the trackline. Values recorded during seismic activity best reflected seal density for calculating take. The resulting seal take ranged between 10 and 42 seals. There was one observed take of a walrus but no information to indicate there was any take of polar bears or whales. Any take of these animals would not likely have exceeded the total number (50, 10, and1 respectively) of each species or group observed in the entire program area. Species-specific take of seals can be estimated from the total take by allocating the take by the proportion of each species observed during seismic activity. This would include 30% (3-13) for ringed/spotted seals, 10% (1-4) for bearded seals, and 60% (6-25) for unidentified seals.

Table 4 Observed and estimated take of marine mammals during seismic activity at Klondike

Safety/ Disturbance Radii	**Distance (m) from Source**	**No of Seals**		**No of Whales**		**No of Walruses**		**No of Bears**	
		Observed	**Estimated**	**Observed**	**Estimated**	**Observed**	**Estimated**	**Observed**	**Estimated**
≥190 dB	13	0				0		0	
≥180 dB	41	NA		0					
≥160 dB	368	10	<42	0	<10	1	<50	0	1

The observed take of marine mammals was likely closer to the actual than estimated take, particularly for cetaceans, walrus, and polar bears for several reasons. The primary reason is the MMOs were able to visually (aided by binoculars) cover the radii because the size of the affected area was relatively small. In addition, MMOs watched during all daylight hours and observation conditions (sea state, glare, visibility) were predominantly acceptable for effectively detecting marine mammals. It would be unlikely the MMOs combined with the trained bridge crew would not see most if not all, seals, whales, walrus, or polar bears within the radii because of their large sizes and other characteristics. Most animals if missed by the MMOs would have been missed during nighttime seismic activity, but the number was likely small given the relatively small proportion of darkness and seismic activity at night relative to the total program.

7.0 Discussion

The life history results of the marine mammal monitoring program are generally similar to those reported in other studies of the region. Species composition of pinnipeds was typical for the region including ringed, bearded, spotted, and ribbon seals and walruses. Cetacean species composition was also typical represented by primarily gray whales and one minke whale that was south of the program area. The lack of sightings of beluga and bowhead whales was likely associated with the timing of the shallow hazards survey program. Belugas and bowheads passed through the region of the program before it began and after it ended, which is confirmed by satellite tracking of the seasonal movements of both species (Suydam et al. 2005). Bowheads also appear to migrate north of the program area in the fall as they cross the Chukchi Sea in a rather straight line from Barrow to Wrangell Island before heading south along the Siberian coast to the Bering Sea. Recent acoustic studies suggest some bowheads may occur in the Chukchi Sea during summer (Ireland et al. 2008). The occurrence of a polar bear was expected particularly since certain areas were partially ice covered during the early part of the shallow hazards survey program.

The relative abundance of marine mammal species was also consistent with that reported in other studies for the region (Ireland et al. 2008). Seals were the most abundant followed by walruses, whales and lastly polar bears. While ringed/spotted seals were not readily distinguishable in the water, they jointly were the most abundant marine mammals. Ribbon seals were the least abundant with bearded seals intermediate. Walrus were present but most were north of the program area in the pack ice, which is typical during the open-water season. The most common cetacean species was the gray whale, which summers in the region in large numbers. Few polar bears would be expected since most of the shallow hazards survey operations were outside of the pack ice.

The spatial and temporal distribution of marine mammals reflected the typical patterns reported by other investigators in the region. Seals were widespread in the region and encountered throughout the program, with the greatest number encountered in the middle of the program. Most seals were encountered in open water (71%), but on several occasions relatively large concentrations of seals were observed near patches of sea ice. Seals commonly inhabit open water during summer but higher densities are commonly near the edge of the pack ice. Gray whales were observed nearer to shore both at the beginning and end of the program, with most seen in the first half of September. Gray whales feed throughout the summer, most commonly nearshore. Walrus were mostly observed offshore during the middle of the program with the majority in the latter half of September. Most walrus summer in the pack ice although a few occasionally occur in open water south of the pack ice. The one bear was seen early in the program when, as mentioned earlier, scattered ice was present in parts of the program area.

The most noticeable effect on marine mammals was that considerably fewer seals were observed during seismic rather than no-seismic activity and within Klondike than in the other survey areas, suggesting a possible localized effect consistent with results from studies involving multiple airgun seismic programs (Ireland et al. 2008). Other measures used to confirm possible seismic effects were behavior and distance from vessel during seismic and no-seismic activity. Only behavior differed between the two conditions, but it may have been biased by the small number of seals observed during seismic activity. In addition, the predominant seal behavior during both seismic activity at Klondike and also in the other areas surveyed outside of Klondike was the same (looking), suggesting seismic activity likely had no effect on seal behavior. Other investigators have reported no consistent relationship between exposure to much stronger seismic noises than produced by a sparker and proportions of seals engaged in other recognizable behaviors, e.g. “looked” and “dove”(Miller et al. 2005; Moulton and Lawson 2002). Similarly, there was no corroborating substantial change in seal distances from vessel, a result consistent with other studies (Miller et al 2005; Moulton and Lawson 2002). Nor were observation conditions a factor since they were mostly acceptable for detecting seals during both seismic as well as no-seismic activity. Other factors that could have added to the discrepancy include prey distribution and abundance, habitat quality, social interactions, distance from the coast (Klondike vs other areas), and the configuration of the shallow hazards surveys, which was confined to a series of closely spaced lines in a small part of the Klondike Prospect. It seems possible that factors other than the shallow hazards surveys contributed to the lower number of seals observed during seismic activity, particularly since the level of noise generated by the single sparker was not far reaching and was low frequency. The normal hearing range of seals is above 1 kHz which is considerably above the frequency of the single sparker.

The overall effect of the shallow hazards survey operations on marine mammals was no more than negligible on the individuals and there was no effect on the populations. This is reflected by the small numbers of animals exposed to seismic activity within the behavioral disturbance zone, which represent considerably less than one percent of the populations.

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