Gray Whales – There are no data on the reactions of gray whales to production activities similar to those in operation at Northstar. Oil production platforms of a very different type have been in place off California for many years. Gray whales regularly migrate through that area (Brownell 1971), but no detailed data on distances of closest approach or possible noise disturbance have been published. Oil industry personnel have reported seeing whales near platforms, and that the animals approach more closely during low-noise periods (Gales 1982; McCarty 1982). Playbacks of recorded production platform noise indicate that gray whales react if received levels exceed ~123 dB re 1 µPa—similar to the levels of drilling noise that elicit avoidance (Malme et al. 1984).

A typical migrating gray whale tolerates steady, low-frequency industrial sounds at received levels up to about 120 dB re 1 µPa (Malme et al. 1984). Gray whales may tolerate higher-level sounds if the sound source is offset to the side of the migration path (Tyack and Clark 1998). Also, gray whales generally tolerate repeated low-frequency seismic pulses at received levels up to about 163–170 dB re 1 µPa measured on an (approximate) rms basis. Above those levels avoidance is common. Because the reaction thresholds to both steady and pulsed sounds are slightly higher than corresponding values for bowheads, reaction distances for gray whales would be slightly less than those for bowheads. In the unlikely event that gray whales occur near Northstar, disturbance effects would be highly localized and would have no biological consequences for individual whales or the population. Given the infrequent occurrence and low numbers of gray whales in the area, it is most likely that there would be no disturbance effects from sound sources on or associated with the island.

Beluga Whales – In the Canadian Beaufort Sea, beluga whales were seen within several feet of an artificial island. During the island's construction, belugas were displaced from the immediate vicinity of the island, but not from the general area (Fraker 1977a). Belugas in the Mackenzie River estuary showed less response to a stationary dredge than to moving tug/barge traffic. They approached as close as 400 m (1,312 ft) from stationary dredges. Underwater sounds from Northstar Island are weaker than those from the dredge. In addition, belugas occur only infrequently in nearshore waters in the Prudhoe Bay region. They also have relatively poor hearing sensitivity at the low frequencies of most construction noises. Therefore, effects of construction and related sounds on belugas would be expected to be negligible.

Responses of beluga whales to drilling operations are described in Richardson et al. (1995a) and summarized here. In the Mackenzie Estuary during summer, belugas have been seen regularly within 100 to 150 m (328 to 492 ft) of artificial islands (Fraker 1977a, b; Fraker and Fraker 1979). However, in the Northstar area, belugas are present only during late summer and autumn, and almost all of them are migrating through offshore waters far seaward of Northstar. Only a very small proportion of the population enters nearshore waters. In spring, migrating belugas showed no overt reactions to recorded drilling noise (< 350 Hz) until within 200 to 400 m (656 to 1,312 ft) of the source, even though the sounds were measurable up to 5 km away (3.1 mi; Richardson et al. 1991). During another drilling noise playback study, overt reactions by belugas within 50 to 300 m (164 to 984 ft) involved increased swimming speed (Stewart et al. 1983). The short reaction distances are probably partly a consequence of the poor hearing sensitivity of belugas at low frequencies (Richardson et al. 1995b). In general, very few belugas are expected to approach Northstar Island, and any such occurrences would be restricted to the late summer/autumn period. Even those few belugas would show no more than localized and brief avoidance reactions, limited to the area within several hundred meters of the island.

There are no specific data on the reactions of beluga whales to production operations similar to those at Northstar. Personnel from production platforms in Cook Inlet, Alaska, report that belugas are seen within 9 m (30 ft) of some rigs, and that steady noise is non-disturbing to belugas (Gales 1982; McCarty 1982). Beluga whales are regularly observed near the Port of Anchorage and the extensive dredging/maintenance activities that operate there regularly (NMFS 2003). Pilot whales, killer whales, and unidentified dolphins were also reported near Cook Inlet platforms. In that area, flare booms might attract belugas, possibly because the flares attract salmon in that area. Attraction of belugas to prey concentrations is not likely to occur at Northstar because belugas are predominantly migrating rather than feeding when in that area, and because only a very small proportion of the beluga population occurs in nearshore waters. Overall, effects of routine production activities on belugas are expected to be negligible.

Effects of Aircraft Activity

Helicopters are the only aircraft associated with Northstar drilling and oil production operations for crew transfer and supply and support. Helicopter traffic occurs during late spring/summer and fall/early winter when travel by ice roads, hovercraft or vessels is not possible. Twin otters are used for routine pipeline inspections.

Low passes by aircraft over a cetacean, including a bowhead, gray or beluga whale, result in short-term responses or no discernible reaction. Responses can include sudden dives, churning the water with the flippers and/or flukes, or rapidly swimming away from the aircraft track (reviewed in Richardson et al. 1995b; see also Patenaude et al. 2002). Belugas often roll and apparently look upward at the aircraft. The activity of the animal at the time of the overflight tends to be related to the "severity" of the reaction, with feeding or socializing animals the least likely to respond. Responses range from no overt reaction to a dramatic disruption of activities. Known or suspected reasons for this variation include aircraft altitude, engine setting changes, type of aircraft, weather conditions, and whale activity at the time. Whales appear less disturbed by quiet aircraft flying at slow speeds and reduced engine power. Single overflights may elicit a sudden dive, which probably represents a startle reaction to the visual appearance or sudden noise of the aircraft. Reactions tend to be more common when aircraft altitude is low (e.g., 75–150 m or 250–500 ft) and infrequent when higher (300–450 m or 1,000–1,500 ft), but there is much variability. Continued disturbance by an aircraft, such as prolonged circling overhead at low altitude, often results in dispersal of the individuals and departure from the area.

There is little likelihood of project-related helicopter and aircraft traffic over bowheads during the fall migration. Helicopter and aircraft traffic is between the shore and Northstar Island. Almost all bowhead whales migrate west in waters farther north. Helicopters maintain an altitude of 305 m (1,000 ft) above sea level while traveling over water to and from Northstar whenever weather conditions allow. It is unlikely that there will be any need for helicopters or aircraft to circle or hover over the open water other than when landing or taking off. Gray whales are uncommon in the area and there is little likelihood that any will be overflown by a helicopter or aircraft. The 305+ m (1,000+ ft) planned flight altitude will minimize any disturbance that might occur if a gray whale is encountered. Even if several bowheads or (less likely) gray whales did react to a single helicopter or aircraft overflight, the reaction would be brief and of no long-term consequence to the whales.

Likewise, there is little likelihood of helicopter disturbance to belugas. Brief reactions by belugas are common when a helicopter is low (e.g., at 75 to 150 m or 250 to 500 ft altitude) but

uncommon when it is higher (300 to 450 m or 1,000 to 1,500 ft). However, there is much variability (Richardson et al. 1995b; Patenaude et al. 2002). Because of the predominantly offshore migration route of belugas, very few (if any) will be overflown during helicopter flights over nearshore waters. Any overflights are most likely to be at an altitude of 305 m (1,000 ft) or more. Therefore, few belugas will react to helicopters. Any such reactions will be brief and of no long-term significance to individuals or the population.

Effects of Vessel Activity

Reactions of cetaceans to vessels often include changes in general activity (e.g., from resting or feeding to active avoidance), changes in surfacing-respiration-dive cycles, and changes in speed and direction of movement. As with aircraft, responses to vessel approaches tend to be reduced if the animals are actively involved in a specific activity such as feeding or socializing (reviewed in Richardson et al. 1995b). Past experiences of the animals with vessels are important in determining the degree and type of response elicited from a whale-vessel encounter.

Whales react most noticeably to erratically moving vessels with varying engine speeds and gear changes, and to vessels in active pursuit. Avoidance reactions by bowheads sometimes begin as subtle alterations in whale activity, speed and heading as far as 4 km (2.5 mi) from the vessel. Consequently, the closest point of approach is farther from the vessel than if the cetacean had not altered course. Bowheads sometimes begin to swim actively away from approaching vessels when they come within 2–4 km (1.2–2.5 mi). If the vessel approaches to within several hundred meters, the response becomes more noticeable and whales sometimes change direction to swim perpendicularly away from the vessel path (Richardson et al. 1985, 1995b; Richardson and Malme 1993).

During the drilling and oil production phase of the Northstar development, most vessel traffic involves slow-moving tugs and barges and smaller faster-moving vessels providing local transport of equipment, supplies and personnel. Much of this traffic will occur during August and early September before many whales are in the area. Some vessel traffic during the broken ice periods in the spring and fall may also occur. Alternatively, small hovercraft may be used during the spring and fall when the ice is too thin to allow safe passage by large vehicles over the ice road.

Whale reactions to slow-moving vessels are less dramatic than are their reactions to faster and/or erratic vessel movements. Bowhead, gray and beluga whales often tolerate the approach of slow-moving vessels within several hundred meters. This is especially so when the vessel is not directed toward the whale and when there are no sudden changes in direction or engine speed (Wartzok et al. 1989; Richardson et al. 1995b; Heide-Jørgensen et al. 2003).

Most vessel traffic associated with Northstar will be inshore of the bowhead and beluga migration corridor, and/or prior to the migration season of bowhead and beluga whales. Underwater sounds from hovercraft are generally lower than for standard vessels since the sound is generated in air, rather than underwater. If vessels or hovercraft do approach whales, a small number of individuals may show short-term avoidance reactions. These will be of no long-term significance to individuals and the population.

The highest levels of underwater sound produced by routine Northstar operations are generally associated with Northstar-related vessel operations. These vessel operations around Northstar sometimes result in sound levels high enough that a small number of the bowheads in the southern

part of the migration corridor appear to be deflected slightly offshore (see above). To the extent that offshore deflection occurs as a result of Northstar, it is mainly attributable to Northstar-related vessel operations. As previously described, this deflection is expected to involve few whales and generally small deflections, and is unlikely to have important consequences for individual bowheads or their populations.

Most vessel traffic associated with Northstar will be south and west of Cross Island. The vessel traffic is not expected to affect subsistence activities at Cross Island.

Effects of Oil on Cetaceans

Bowhead and beluga whales migrate through the Alaskan Beaufort Sea, and a limited number of gray whales sometimes occur in the area during some years. Almost all of these whales are north of the barrier islands, and most of the belugas follow a far-offshore migration corridor.

The specific effects of an oil spill on bowhead, gray, or beluga whales are not well known. Direct mortality is unlikely. However, exposure to spilled oil potentially leads to skin irritation, baleen fouling which might reduce feeding efficiency, respiratory distress from inhalation of hydrocarbon vapors, consumption of some contaminated prey items, and temporary displacement from contaminated feeding areas. Geraci and St. Aubin (1990) summarize effects of oil on marine mammals, and Bratton et al. (1993) provides a synthesis of knowledge of oil effects on bowhead whales. The number of whales that might be contacted by a spill would depend on the size, timing, and duration of the spill. Whales may not avoid oil spills, and some have been observed feeding within oil slicks. These topics are discussed in more detail in subsequent paragraphs.

In the case of an oil spill occurring during migration periods, disturbance of the migrating cetaceans from cleanup activities may have more of an impact than the oil itself. Human activity associated with cleanup efforts could deflect whales away from the path of the oil. However, noise created from cleanup activities likely will be short term and localized with no long-term consequences for individuals or populations. In fact, whale avoidance of clean-up activities may benefit whales by displacing them from the oil spill area.

There is no concrete evidence that oil spills, including the much studied Santa Barbara Channel and Exxon Valdez spills, have caused the death of cetaceans (Geraci 1990; Brownell 1971; Harvey and Dahlheim 1994). It is suspected that some individually identified killer whales that disappeared from Prince William Sound during the time of the Exxon Valdez spill were casualties of that spill. However, no clear cause and effect relationship between the spill and the disappearance could be established (Dahlheim and Matkin 1994). The AT-1 pod of transient killer whales that sometimes inhabits Prince William Sound has continued to decline after the Exxon Valdez oil spill, and has been nominated for listing on the Endangered Species List. No effects on humpback whales in Prince William Sound were evident after the Exxon Valdez spill (von Ziegesar et al. 1994). There was some temporary displacement of humpback whales out of Prince William Sound, but this could have been caused by oil contamination, boat and aircraft disturbance, displacement of food sources, or other causes.

Migrating gray whales were apparently not greatly affected by the Santa Barbara spill. There appeared to be no relationship between the spill and mortality of marine mammals. The higher than usual counts of dead marine mammals recorded after the spill represented increased survey effort

(Brownell 1971; Geraci 1990). The conclusion was that whales were either able to detect the oil and avoid it or were unaffected by it (Geraci 1990).

Oiling of External Surfaces

Whales rely on a layer of blubber for insulation, so oil would have little if any effect on thermoregulation by whales. Effects of oiling on cetacean skin appear to be minor and of little significance to the animal's heath (Geraci 1990). It can be assumed that if oil contacted the eyes, effects would be similar to those observed in ringed seals; continued exposure of the eyes to oil could cause permanent damage (St. Aubin 1990).

Ingestion

Whales could ingest oil if their food is contaminated, or oil could also be absorbed through the respiratory tract. Some of the ingested oil is voided in vomit or feces but some is absorbed and can cause toxic effects (Geraci 1990). When returned to clean water, contaminated animals can depurate this internal oil (Engelhardt 1978, 1982). Whales exposed to an oil spill are unlikely to ingest enough oil to cause serious internal damage (Geraci and St. Aubin 1980, 1982) and this kind of damage has not been reported (Geraci 1990).

Fouling of Baleen

Baleen itself is not damaged by exposure to oil and is resistant to effects of oil (St. Aubin et al. 1984). Crude oil could coat the baleen and reduce filtration efficiency; however, effects may be temporary (Braithwaite 1983; St. Aubin et al. 1984). Most of the oil that would coat the baleen is removed after 30 min and less than 5% would remain after 24 h (Bratton et al. 1993). Effects of oiling of the baleen on feeding efficiency appear to be minor (Geraci 1990).

Avoidance

Some cetaceans can detect oil and sometimes avoid it, but others enter and swim through slicks without apparent effects (Geraci 1990; Harvey and Dahlheim 1994). Bottlenose dolphins apparently could detect and avoid slicks and mousse but did not avoid light sheens on the surface (Smultea and Würsig 1995). After the Regal Sword spill, various species of baleen and toothed whales were observed swimming and feeding in areas containing spilled oil southeast of Cape Cod, MA (Goodale et al. 1981).

Factors Affecting the Severity of Effects

Effects of oil on whales in open water are likely to be negligible, but there could be effects on whales where both the oil and the whales are at least partly confined in leads or at ice edges (Geraci 1990). In spring migrating bowhead and beluga whales migrate through leads in the ice. At this time, the migration can be concentrated in narrow corridors defined by the leads. However, given the probable alongshore trajectory of oil spilled from Northstar in relation to the whale migration route through offshore waters, interactions between oil slicks and whales are unlikely in spring.

In fall, the migration route of bowheads can be close to shore (Blackwell et al. 2009). If fall migrants were moving through leads in the pack ice, or were concentrated in nearshore waters, some bowhead whales might not be able to avoid oil slicks and could be subject to prolonged

contamination. However, the autumn migration past the Northstar area extends over several weeks and most of the whales travel along routes well north of Northstar. Thus, only a small minority of the whales are likely to approach patches of spilled oil. Additionally, vessel activity associated with spill cleanup efforts may deflect the small number of whales traveling nearshore farther offshore, and thereby reduce the likelihood of contact with spilled oil. Also, during years when movements of oil and whales might be partially confined by ice, the bowhead migration corridor tends to be farther offshore (Treacy 1997; LGL and Greeneridge 1996a; Moore 2000).

Effects of Oil-Spill Cleanup Activities

General issues related to oil-spill cleanup activities are discussed under "Pinnipeds", above. The potential effects on cetaceans are expected to be less than those on seals. Cetaceans tend to occur well offshore where cleanup activities (in the open-water season) are unlikely to be as concentrated. Also, cetaceans are transient and, during the majority of the year, absent from the area. However, if intensive cleanup activities were necessary during the autumn whale hunt, this could affect subsistence hunting (see Section 8, below).

Conclusions Regarding Effects on Cetaceans

The proposed activity will consist of oil production and associated gas injection, minor construction operations (i.e., island maintenance and repair), and possible drilling activity during two main periods: the ice-covered season and the open-water season. During the ice-covered season, cetaceans will not be in the Northstar areas. The planned activities will have no effect on bowhead or beluga whales migrating east through offshore waters of the Beaufort Sea during the spring. In the event of an oil spill during winter or spring, it is unlikely that much oil would be carried into the whale migration corridor.

In the open-water period, the principal activities will be related to oil production, and associated helicopter and vessel traffic. Underwater sounds from continuous production activities on the islands are not expected to be detectable more than about 2–4 km (1.2–2.5 mi) offshore of Northstar Island. Sounds of transient nature, such as vessel traffic can be detectable to distances of ~30 km (18.6 mi) from the island. Disturbance to bowhead, gray and beluga whales by on-island activities will be limited to substantially less than that distance. Helicopter traffic will be limited to nearshore areas between the mainland and the islands, and is very unlikely to approach or disturb whales. Barge and vessel traffic will be located mainly inshore of the whales, and will involve vessels moving slowly, in a straight line, and at constant speed. Little disturbance or displacement of whales by vessel traffic is expected. Vessels operating for prolonged periods around Northstar may at times produce sufficient underwater sound to cause slight offshore deflection or other behavioral changes in a small minority of the bowheads passing Northstar at those times. No biologically significant consequences are expected either for individual bowheads or for the population.

8. ANTICIPATED IMPACT ON SUBSISTENCE

The anticipated impact of the activity on the availability of the species or stocks of marine mammals for subsistence uses.

Inupiat hunters emphasize that all marine mammals are sensitive to noise, and take pains to make as little extraneous noise as possible when hunting. Seals are also said to be cautious of any

unusual visual stimulus, especially if it is in motion. At the same time, seals are said to be curious and will sometimes investigate unusual objects, and can be attracted by imitating the normal, non-vocal sounds that seals make on the ice. In general, seals are sensitive to their surroundings, are especially responsive to sound, and may avoid unusual sounds.

Bowhead whales often show avoidance or other behavioral reactions to underwater noise from industrial activities, but often tolerate the weaker noise received when the same activities are occurring farther away. Various studies have provided information about these sound levels and distances (e.g., Richardson and Malme 1993; Richardson et al. 1995a, b; Miller et al. 1999). However, scientific studies done to date have limitations, as discussed in part by Moore and Clarke (1992) and in MMS (1997). Inupiat whalers believe that some migrating bowheads are diverted by noises at greater distances than have been demonstrated by scientific studies (e.g., Rexford 1996; MMS 1997). The whalers have also mentioned that bowheads sometimes seem more "skittish" and more difficult to approach when industrial activities are underway in the area (Galginaitis 2006). There is also concern about the persistence of any deflection of the bowhead migration corridor, and the possibility that sustained deflection might influence subsistence farther “downstream” during the fall migration.

Recently, there has been concern among Inupiat hunters that barges and other vessels operating within or near the bowhead migration corridor may deflect whales for an extended period (J.C. George, NSB-DWM, pers. comm.). It has been suggested that, if the headings of migrating bowheads are altered through avoidance of vessels, the whales may subsequently maintain the “affected” heading well past the direct zone of influence of the vessel. This might result in progressively increasing deflection as the whale progresses west. However, crew boats and barges supporting Northstar remain well inshore of the main migration corridor, so this type of effect is unlikely to occur in response to these types of Northstar-related vessel traffic.

Monitoring studies conducted under the provisions of incidental take authorizations can provide some of the data needed to resolve questions about the radius of influence of industrial activities on bowheads (e.g., Richardson [ed.] 1999, 2008). Monitoring studies during the Northstar project were designed in consultation with representatives of the whalers to help ensure consensus on the methods and on the meaning of the results (Section 13). In addition, BP developed a plan of cooperation with the whalers in previous years (see Section 12) to reduce any potential interference with the hunt.

Potential effects on subsistence could result from direct actions of oil development upon the biological resources or from associated changes in human behavior. For example, the perception that marine mammals might be contaminated or “tainted” by an oil spill could affect subsistence patterns whether or not many mammals are actually contaminated. The following discussion addresses both aspects.

Marine Mammal Harvests in the Project Area

Residents of the village of Nuiqsut are the primary subsistence users in the project area. The communities of Barrow and Kaktovik also harvest resources that pass through the area of interest but do not hunt in or near the Northstar area. Subsistence hunters from all three communities conduct an annual hunt for autumn-migrating bowhead whales. Barrow also conducts a bowhead hunt in spring. Residents of all three communities hunt seals. Other subsistence activities include fishing, waterfowl

and seaduck harvests, and hunting for walrus and beluga, polar bears, caribou, and moose. Relevant harvest data are summarized in Tables 8 and 9.

The annual take of bowhead whales has varied due to (a) changes in the allowable quota level and (b) year-to-year variability in ice and weather conditions, which strongly influence the success of the hunt. Locations of bowhead whale strikes and kills are available through the North Slope Borough, Alaska Eskimo Whaling Commission, Galginaitis (2009), and EDAW/AECOM 2007.

Nuiqsut is the community closest to the Northstar development (~87 km or 54 mi southwest from Northstar). Nuiqsut hunters harvest bowhead whales only during the fall whaling season (Long 1996). In recent years, Nuiqsut whalers have typically landed three or four whales per year (Table 9). Nuiqsut whalers concentrate their efforts on areas north and east of Cross Island, generally in water depths greater than 20 m (65 ft; Galginaitis 2009). Cross Island is the principal base for Nuiqsut whalers while they are hunting bowheads (Long 1996). Cross Island is located approximately 27 km (16.8 mi) east of Northstar.

Kaktovik whalers search for whales east, north and occasionally west of Kaktovik. Kaktovik is located approximately 200 km (124 mi) east of Northstar Island. The western-most reported harvest location was about 21 km (13 mi) west of Kaktovik, near 70º10'N, 144º11'W (Kaleak 1996). That site is about 180 km (112 mi) east of Northstar Island.

Barrow whalers search for whales much farther from the Northstar construction area—about 250+ km (175+ mi) to the west. However, given the westward migration of bowheads in autumn, Barrow (unlike Kaktovik) is "downstream" from the Northstar region during that season. Barrow hunters have expressed concern about the possibility that bowheads might be deflected offshore by Northstar and then remain offshore as they pass Barrow.

TABLE 8. Subsistence harvest data (as percent of total harvest) by species, total harvest and Per Capita harvest. Source: Table 7.3 in Braund and Kruse (2009). The footnotes in the Table refer to more detailed source information summarized by Braund and Kruse (2009).

	Point Lay[1]	Barrow[2]		Wainwright[3]	Nuiqsut[4]	Kaktovik[4]	
Resource	1987	1962-82[1]	1987-89	1988-89	1993	1962-82	1992-93
Bowhead Whale	—	21%	38%	35%	29%	28%	63%
Caribou	16	58	27	23	31	16	11
Walrus	4	5	9	27	—	3	—
Bearded Seal	2	3	4	5	—	7	2
Hair Seals	4	4	2	1	3	4	1
Beluga Whales	64	1	—	1	—	6	—
Polar Bears	<1%	—	2	2	—	3	1
Moose	2	—	3	<1%	2	4	1
Dall Sheep	—	—	<1%	<1%	—	4	3
Muskox	—	—	<1%	<1%	—	—	2
Grizzly Bear	<1%	—	—	—	<1%	—	—
Small Land Mammals	<1%	—	<1%	<1%	<1%	—	—
Birds	5	1	4	2	2	—	2
Fishes	3	7	11	5	34	22	13
Vegetation	<1%	—	<1%	<1%	<1%	—	—
Total	100%	100%	100%	100%	100%	100%	100%
Total Harvest (lb)	100,681	928,205	702,660	304,047	267,818	32,408	170,939
Per Capita Harvest (lb)	819	540	233	638	742	219	886

TABLE 9. Bowhead landings at Barrow, Nuiqsut and Kaktovik, 1978–2005 (from Burns et al. 1993; IWC Reports SC/59/BRG4, SC/60/BRG10, SC61/BRG6; Alaska Eskimo Waling Commission [AEWC]; J.C. George, NSB DWM; and EDAW/AECOM 2007).

Year	IWC Quota for whaling villages in Alaska	Barrow		Kaktovik		Nuiqsut	
		Quota	Landed	Quota	Landed	Quota	Landed
1973	N/A	N/A	17	N/A	3	N/A	1
1974	N/A	N/A	9	N/A	2	N/A	0
1975	N/A	N/A	10	N/A	0	N/A	0
1976	N/A	N/A	23	N/A	2	N/A	0
1977	N/A	N/A	20	N/A	2	N/A	0
1978	14 landed or 20 struck	3 landed or 5 struck	4	1 landed or 2 struck	2	1 landed or 2 struck	0
1979	18 landed or 27 struck	5 landed or 7 struck	3	2 landed or 3 struck	5	1 landed or 3 struck	0
1980	18 landed or 26 struck	6 landed or 7 struck	9	2 landed or 3 struck	1	1 landed or 1 struck	0
1981	16 landed or 27 struck	9	4	3	3	1	0
1982	17 landed or 27 struck	5	0	2	1	1	1
1983	18 landed or 27 struck	4	2	2	1	1	0
1984	27 struck	8	4	3	1	1	0
1985	27 struck	4	5	2	0	1	0
1986	32 struck	9	8	3	3	2	1
1987	32 struck	9	7	3	0	2	1
1988	35 struck	11	11	2	1	2	0
1989	41 landed or 44 struck	15	10	2+1	3	2	2
1990	41 landed or 47 struck	15	11	2	2	2	0
1991	41 landed or 44 struck	15	12	2	1	2	1
1992	41 landed or 54 struck	18	22	3	3	3	2
1993	41 landed or 54 struck	18 (+5)	23	3	3	3	3
1994	41 landed or 52 struck	18	16	3	3	3	0
1995	68 struck	22 (+2)	19	3+1	4	4	4
1996	77 struck	22	24	3	1	4	2
1997	76 struck	22 (+8)	30	3+1	4	4	3
1998	77 struck	22	16	3	3	4	4
1999	75 struck	22	24	3	3	4	3
2000	75 struck	22	18	3	3	4	4
2001	75 struck	22	27	3	4	4	3
2002	75 struck	22	22	3	3	4	4
2003	75 struck	22	16	3	3	4	4
2004	75 struck	22	21	3	3	4	3
2005	75 struck	22	29	3	3	4	1
2006	75 struck	22	22	3	3	4	4
2007	75 struck	22	20	3	3	4	3
2008	75 struck	22	21	3	3	4	4

Effects of Routine Production Operations, Repair and Maintenance

Bowhead Whale Harvest

The disturbance and potential displacement of bowhead whales and other marine mammals by sounds from vessel traffic or on-island activities are the principal concerns related to subsistence use of the area. The harvest of marine mammals is central to the culture and subsistence economies of the coastal North Slope communities. In particular, if elevated noise levels displace migrating bowhead whales farther offshore, this could make harvest of these whales more difficult and dangerous for hunters. The harvest could also be affected if bowheads are more "skittish" when exposed to vessels or impact hammering noise.

Few bowhead whales approach the project area before the end of August, and autumn whaling at Cross Island generally does not begin until after 1 September. Whaling at Cross Island is usually completed by late September, and the bowhead migration usually ends by late October. Insofar as possible, BP's vessel traffic near areas of particular concern for whaling will be completed before the end of August.

Drilling at Northstar began in December 2000 and production operations began in late October 2001. The planned well-drilling program was completed in May 2004. Drilling activities to drill new wells, conduct well maintenance, and drill well side-tracks continued in 2006 (6 wells), 2007 (2 wells) and 2008 (2 wells). The drill rig is expected to be demobilized by barge during the 2010 open-water period. Although future drilling is not specifically planned, drilling of additional wells or well workover may be required at some time during 2011–2016. Production will continue for the foreseeable future at Northstar.

Underwater sounds from drilling and production operations on an artificial gravel island are not very strong, and are not expected to travel more than about 10 km (6.2 mi; Table 5). Vessel sounds account for the highest sound levels at Northstar, and at times they are detectable considerably farther away (Blackwell and Greene 2006). Harvests have remained high at Cross Island in recent years despite sounds from Northstar, and in most recent years the quota has been filled quickly (Galginaitis 2007, 2008, 2009).

Northstar is west of the main hunting area for Nuiqsut hunters. On most occasions, even the bowheads traveling along the southern edge of the migration corridor are not expected to hear sounds from Northstar until the whales are well west of the main hunting area. (Times with considerable vessel activity at Northstar would be the exception.) As noted above, when industrial sounds at Northstar were high, some bowheads traveling in the southern part of the migration corridor appeared to have been deflected a few kilometers farther offshore or to have called less often (McDonald et al. 2008; Richardson et al. 2008a). This effect would not be expected to occur offshore of Cross Island, 27 km (16.8 mi) east of Northstar.

In addition to activities at Northstar, drilling and production operations will include slow-moving vessels, a hovercraft, and limited helicopter activity. Overt whale reactions to slow-moving vessels and to helicopters traveling in a straight line are limited to close distances and short durations. In addition, whenever possible, helicopters will fly at a minimum altitude of 305 m (1,000 ft). Most vessel and helicopter traffic will be well inshore of the bowhead migration corridor. Bowhead whales will rarely be approached by these vessels and helicopters, any such approaches will not be

within the area where Nuiqsut hunters usually search for bowheads, and any whale reactions to these approaches will be brief and localized.

The monitoring implemented during 2000–2004 (Richardson [ed.] 2008) has provided data that resolve many of the previous uncertainties about the characteristics and propagation of construction and operational noises, and about their effects on bowhead whales. Sounds from important BP activities associated with Northstar have been recorded and the resulting acoustic data have been described in the final comprehensive report (Richardson [ed.] 2008), various annual reports (Richardson [ed.] 2006, 2007; Aerts and Richardson [eds.] 2008, 2009) and papers (e.g., Blackwell and Greene 2004, 2005, 2006; Greene et al. 2008). The whale migration in the area just west of Cross Island and offshore of Northstar has been monitored, and the migration corridor has been found to be no more than slightly and locally affected by Northstar. These results from intensive monitoring, along with the successful harvests at Cross Island in recent years, indicate that any effects of Northstar on bowheads have not reduced the availability of bowheads for the Nuiqsut subsistence hunters.

In summary, it is not expected that routine production activities will affect the accessibility of bowhead whales to hunters. Nonetheless, BP recognizes that it is difficult to determine the maximum distance at which whale reactions to industry activities occur, and that effects may extend to distances somewhat greater than those demonstrated in the scientific studies. As in previous years, BP will discuss a plan of cooperation with the whalers (Section 12) to reduce any potential interference with the hunt. The timing and characteristics of production, drilling and other operations at Northstar, and of barge and aircraft traffic west and south of Cross Island, will be addressed in that agreement. In addition, BP recognizes that the presence of Northstar instills a sense of anxiety among the hunters with regard to potential impacts, even though these potential impacts do not appear to be occurring.

Pinniped and Beluga Harvests

Coastal communities in the Beaufort Sea also take seals plus small numbers of walruses and beluga whales. The seal harvest during winter and spring is principally of ringed seals. During the open water period both ringed and bearded seals are commonly taken. Belugas are not a significant subsistence resource at Nuiqsut, given the offshore migration routes and the lack of any coastal concentrations in that area. Subsistence issues relating to walruses (and polar bears) are considered in separate incidental take regulations of the U.S. Fish and Wildlife Service and are not discussed further here.

Nuiqsut hunters may hunt seals year-round, but during recent years most of the seal harvest has been during the early summer in open water (the late Thomas Napageak, pers. comm.). In summer, boat crews hunt ringed, spotted and bearded seals. The most important seal hunting area for Nuiqsut hunters is off the Colville Delta, extending as far west as Fish Creek and as far east as Pingok Island (149º40'W). Pingok Island, the closest edge of the main sealing area, is ~17 mi (27 km) west of Northstar. Sealing occurs in this area by snow machine before break-up and by boat during the summer. Cross Island is a productive area for seals, but is too far from Nuiqsut to be used on a regular basis. During the whaling season, the hunters at Cross Island concentrate on bowhead whales, not seals.

Drilling and oil production activities at Northstar have little potential to influence seal hunting activities by residents of Nuiqsut, given the distance of these development sites from areas where

Nuiqsut residents usually hunt seals. In winter and spring, a small number of ringed seals may be disturbed and possibly displaced from areas near Northstar, and from locations near ice roads. During the open water season, displacement of seals would also be highly localized. Effects of support traffic (vessels and helicopters) on seals are expected to be minor and to be limited to the areas along the routes of travel, most of which will be well to the east of the main hunting area. Thus, it is unlikely that drilling and production activity, or associated traffic, would have a significant negative impact on Nuiqsut seal hunting. Concerns about this are addressed in the plan of cooperation (Section 12).

Effects of Oil Spills

Oil spills might affect the hunt for bowhead whales. The harvest period for bowhead whales is probably the time of greatest risk that a relatively large-scale spill would reduce the availability of bowhead whales for subsistence uses. Pipeline spills are possible for the total production period of Northstar. Spills could occur at any time of the year. However, spills at most times of year would not affect bowheads, as bowheads are present near Northstar for only several weeks during late summer and early autumn. Bowheads travel along migration corridors that are far offshore of the planned production islands and pipelines during spring, and somewhat offshore of those facilities during autumn. Under the prevailing east-wind conditions, oil spills from Northstar would not move directly into the main hunting area east and north of Cross Island. However, oil spills could extend into the hunting area under certain wind and current regimes (Anderson et al. 1999).

Even in case of a major spill, it is unlikely that more than a small minority of the bowheads encountered by hunters would be contaminated by oil. However, disturbance associated with reconnaissance and cleanup activities could affect whales and thus accessibility of whales to hunters. In the very unlikely event that a major spill incident occurred during the relatively short fall whaling season, it is possible that hunting would be affected significantly.

Ringed seals are more likely than bowheads to be affected by spill incidents, because they occur in the development areas throughout the year and are more likely than whales to occur close to Northstar. Small numbers of bearded seals could also be affected, especially by a spill during the open-water season. Potential effects on subsistence use of seals will still be relatively low, as the areas most likely to be affected are not areas heavily used for seal hunting. However, wind and currents could carry spilled oil west from Northstar to areas where seal hunting occurs. It is possible that oil-contaminated seals could be harvested.

Oil spill cleanup activity could exacerbate and increase disturbance effects on subsistence species, cause localized displacement of subsistence species, and alter or reduce access to those species by hunters. On the other hand, the displacement of marine mammals away from oil-contaminated areas by cleanup activities would reduce the likelihood of direct contact with oil and thus tainting or other impacts on the mammals.

One of the most persistent effects of EVOS was the reduced harvest and consumption of subsistence resources, due to the local perception that they had been tainted by oil (Fall and Utermohle 1995). The concentrations of petroleum-related aromatic compound (AC) metabolites in the bile of harbor seals were greatly elevated in harbor seals from oiled areas of Prince William Sound. Mean concentrations of phenanthrene (PHN) equivalents for oiled seals from PWS was over 70 times greater than for control areas, and over 20 times higher than for presumably unoiled areas of

PWS (Frost et al. 1994b). Concentrations of hydrocarbons in harbor seal tissues collected in PWS one year after EVOS were not significantly different from seals collected in non-oiled areas; however, average concentrations of AC metabolites in bile were still significantly higher than those observed in un-oiled areas (Frost et al. 1994b). The pattern of reduced consumption of marine subsistence resources by the local population persisted for at least a year. Most affected communities had returned to documented pre-spill harvest levels by the third year after the spill. Even then, some households in these communities still reported that subsistence resources had not recovered to pre-spill levels. Harvest levels of subsistence resources for the three communities most affected by the spill still were below pre-spill averages even after three years. By then, the concern was mainly about smaller numbers of animals rather than contamination. However, contamination remained an important concern for some households (Fall and Utermohle 1995). As an example, an elder stopped eating local salmon after the spill, even though salmon is the most important subsistence resource and he ate it every day up to that point. Similar effects could be expected after a spill on the North Slope, with the extent of the decline in harvest and use, and the temporal duration of the effect, dependent upon the size and location of the spill. This analysis reflects the local perception that oil spills pose the greatest potential danger associated with offshore oil production.

Summary

In summary, direct effects of routine drilling and oil production activities upon subsistence uses of marine mammals (mainly ringed seals and bowhead whales) will be minimal. In winter, the ringed seal is the only relevant species present. Winter use of the development areas by subsistence hunters is limited or nil. No seal hunting or harvests were observed during the intensive marine mammals monitoring from 1997–2002 or subsequent observations of seals by island personnel. Seals are also present near Northstar throughout the open water season, but are not hunted in those locations to any significant extent. Bowhead whales are absent in the early part of the open water season. Bowheads migrate through the general area during late summer and autumn, mainly offshore of Northstar. Ongoing production and maintenance activities, and possible resumption of drilling activities, are not expected to affect the bowhead migration corridor or bowhead behavior in the hunting areas used by Nuiqsut, Kaktovik, or Barrow whalers.

Local concerns about these issues will be addressed in the updated Plan of Cooperation (Section 12) and by ongoing monitoring (Section 13). An acoustic and marine mammal monitoring program is planned for 2011–2016. This program will measure underwater sounds from Northstar and provide a basis for determining if there are major changes in utilization of the Northstar area by marine mammals (which are not expected). The future monitoring program will be revised as necessary based on guidance from the NMFS and NSB-DWM.

The only situation in which there could be direct, major effects on subsistence would be in the unlikely event of a large oil spill during whaling. The probability of such a spill occurring over the life of the field is low (S.L. Ross Environmental Research Ltd. 1998). However, because subsistence harvests are socio-culturally based, perception is an important component that cannot be adequately addressed by biological studies alone (Fall and Utermohle 1995).

9. ANTICIPATED IMPACT ON HABITAT

The anticipated impact of the activity upon the habitat of the marine mammal populations, and the likelihood of restoration of the affected habitat.

Food of Seals and Whales

The ringed seal, the most common seal near Northstar, feeds on fish and a variety of benthic species, including crabs and shrimp. Bearded seals feed mainly on benthic organisms, primarily crabs, shrimp, and clams. Spotted seals feed on pelagic and demersal fish, as well as shrimp and cephalopods. They are known to feed on a variety of fish including herring, capelin, sand lance, Arctic cod, saffron cod, and sculpins.

Bowhead whales feed in the eastern Beaufort Sea during summer and early autumn, but continue feeding to varying degrees while on their migration through the central and western Beaufort Sea in the late summer and fall (Richardson and Thomson [eds.] 2002). When feeding in relatively shallow areas such as those where oil development may occur, bowheads feed throughout the water column. However, feeding is concentrated at depths where zooplankton is concentrated (Würsig et al. 1984, 1989; Richardson [ed.] 1987; Griffiths et al. 2002). Lowry and Sheffield (2002) found that copepods and euphausiids were the most common prey found in stomach samples from bowhead whales harvested in the Kaktovik area from 1979 to 2000. Areas to the east of Barter Island appear to be used regularly for feeding as bowhead whales migrate slowly westward across the Beaufort Sea (Thomson and Richardson 1987; Richardson and Thomson [eds.] 2002). However, in some years, sizable groups of bowhead whales have been seen feeding as far west as the waters just east of Point Barrow near the Plover Islands (Braham et al. 1984; Ljungblad et al. 1985; Landino et al. 1994). The situation in September–October 1997 was unusual in that bowheads fed widely across the Alaskan Beaufort Sea, including higher numbers in the area east of Barrow than reported in any previous year (S. Treacy and D. Hansen, MMS, pers. comm.).

Beluga whales feed on a variety of fish, shrimp, squid and octopus (Burns and Seaman 1985). Very few beluga whales occur near Northstar; their main migration route is much further offshore.

Gray whales are primarily bottom feeders, and benthic amphipods and isopods form the majority of their summer diet, at least in the main summering areas west of Alaska (Oliver et al. 1983; Oliver and Slattery 1985). Farther south, gray whales have also been observed feeding around kelp beds, presumably on mysid crustaceans, and on pelagic prey such as small schooling fish and crab larvae (Hatler and Darling 1974).

Marine Fish

Two kinds of fish inhabit marine waters in the study area: (1) true marine fish that spend all of their lives in salt water, and (2) anadromous species that reproduce in fresh water and spend parts of their life cycles in salt water.

Most arctic marine fish species are small, benthic forms that do not feed high in the water column. The majority of these species are circumpolar and are found in habitats ranging from deep

offshore water to water as shallow as 5–10 m (16–30 ft; Fechhelm et al. 1995). The most important pelagic species, and the only abundant pelagic species, is the Arctic cod. The Arctic cod is a major vector for the transfer of energy from lower to higher trophic levels (Bradstreet et al. 1986). In summer, Arctic cod can form very large schools in both nearshore and offshore waters (Craig et al. 1982; Bradstreet et al. 1986). Locations and areas frequented by large schools of Arctic cod cannot be predicted, but can be almost anywhere. The Arctic cod is a major food source for beluga whales, ringed seals, and numerous species of seabirds (Frost and Lowry 1984; Bradstreet et al. 1986).

Anadromous Dolly Varden char and some species of whitefish winter in rivers and lakes, migrate to the sea in spring and summer, and return to fresh water in autumn. Anadromous fish form the basis of subsistence, commercial, and small regional sport fisheries. Dolly Varden char migrate to the sea from May through mid-June (Johnson 1980) and spend about 1.5 to 2.5 months there (Craig 1989). They return to rivers beginning in late July or early August with the peak return migration occurring between mid-August and early September (Johnson 1980). At sea, most anadromous corregonids (whitefish) remain in nearshore waters within several kilometers of shore (Craig 1984, 1989). They are often termed "amphidromous" fish in that they make repeated annual migrations into marine waters to feed, returning each fall to overwinter in fresh water.

Marine Invertebrates

Benthic organisms are defined as bottom dwelling creatures. Infaunal organisms are benthic organisms that live within the substrate and are often sedentary or sessile (bivalves, polychaetes). Epibenthic organisms live on or near the bottom surface sediments and are mobile (amphipods, isopods, mysids, and some polychaetes). Epifauna, which live attached to hard substrates, are rare in the Beaufort Sea because hard substrates are scarce there. A small community of epifauna, the Boulder Patch, occurs in Stefansson Sound.

The benthic environment near Northstar appears similar to that reported in various other parts of the Arctic (Ellis 1960, 1962, 1966; Dunbar 1968; Wacasey 1975). Many of the nearshore benthic marine invertebrates of the Arctic are circumpolar and are found over a wide range of water depths (Carey et al. 1975). Species identified include polychaetes (*Spio filicornis*, *Chaetozone setosa*, *Eteone longa*), bivalves (*Cryrtodaria kurriana*, *Nucula tenuis*, *Liocyma fluctuosa*), an isopod (*Saduria entomon*), and amphipods (*Pontoporeia femorata*, *P. affinis*).

Nearshore benthic fauna have been studied in lagoons west of Northstar and near the mouth of the Colville River (Kinney et al. 1971, 1972; Crane and Cooney 1975). The waters of Simpson Lagoon, Harrison Bay, and the nearshore region support a number of infaunal species including crustaceans, mollusks and polychaetes. In areas influenced by river discharge, seasonal changes in salinity can greatly influence the distribution and abundance of benthic organisms. Large fluctuations in salinity and temperature that occur over a very short time period, or on a seasonal basis, allow only the very adaptable, opportunistic species to survive (Alexander et al. 1974). Since shorefast ice is present for many months, the distribution and abundance of most species depends on annual (or more frequent) recolonization from deeper offshore waters (Woodward Clyde Consultants 1995). Due to ice scouring, particularly in water depths of <2.4 m (8 ft), infaunal communities tend to be patchily distributed. Diversity increases with water depth until the shear zone is reached at 15–25 m (50–80 ft; Carey 1978). Biodiversity then declines due to ice gouging between the landfast ice and the polar pack ice (Woodward Clyde Consultants 1995).

Effects of Routine Production Operations

Noise Effects on Food of Seals and Whales

Construction activities produced both impulsive sounds (e.g., pile driving) and longer-duration sounds. Short, sharp sounds can cause overt or subtle changes in fish behavior. Chapman and Hawkins (1969) tested the reactions of whiting (hake) in the field to an airgun. When the airgun was fired, the fish dove from 25 to 55 m (80 to 180 ft) depth and formed a compact layer. The whiting dove when received sound levels were higher than 178 dB re 1 μPa (Pearson et al. 1992).

Pearson et al. (1992) conducted a controlled experiment to determine effects of strong noise pulses on several species of rockfish off the California coast. They used an airgun with a source level of 223 dB re 1 μPa. They noted:

- startle responses at received levels of 200–205 dB re 1 μPa and above for two sensitive species, but not for two other species exposed to levels up to 207 dB;
- alarm responses at 177–180 dB for the two sensitive species, and at 186 to 199 dB for other species;
- an overall threshold for the above behavioral response at about 180 dB;
- an extrapolated threshold of about 161 dB for subtle changes in the behavior of rockfish; and
- a return to pre-exposure behaviors within the 20-60 minute exposure period.

In summary, fish often react to sounds, especially strong and/or intermittent sounds of low frequency. Sound pulses at received levels of 160 dB re 1 μPa may cause subtle changes in behavior. Pulses at levels of 180 dB may cause noticeable changes in behavior (Chapman and Hawkins 1969; Pearson et al. 1992; Skalski et al. 1992). It also appears that fish often habituate to repeated strong sounds rather rapidly, on time scales of minutes to an hour. However, the habituation does not endure, and resumption of the strong sound source may again elicit disturbance responses from the same fish. Underwater sound levels from Northstar Island, even during construction, were lower than the response threshold reported by Pearson et al. (1992), and are not likely to result in significant effects to fish near Northstar.

The reactions of fish to research vessel sounds have been measured in the field with forward-looking echosounders. Sound produced by a ship varies with aspect and is lowest directly ahead of the ship and highest within butterfly-shaped lobes to the side of the ship (Misund et al. 1996). Because of this directivity, fish that react to ship sounds by swimming in the same direction as the ship may be guided ahead of it (Misund 1997). Fish in front of a ship that show avoidance reactions may do so at ranges of 50 to 350 m (164 to 1148 ft; Misund 1997), though reactions probably will depend on the species of fish. In some instances, fish will avoid the ship by swimming away from the path and will become relatively concentrated to the side of the ship (Misund 1997). Most schools of fish will show avoidance if they are not in the path of the vessel. When the vessel passes over fish, some species, in some cases, show sudden escape responses that include lateral avoidance and/or downward compression of the school (Misund 1997). Some fish show no reaction. Avoidance reactions are quite variable and depend on species, life history stage, behavior, time of day, whether the fish have fed, and sound propagation characteristics of the water (Misund 1997).

Behavior of zooplankters is not expected to be affected by drilling and production operations at Northstar. These animals have exoskeletons and no air bladders. Many crustaceans can make sounds and some crustacea and other invertebrates have some type of sound receptor. However, the reactions of zooplankters and benthic animals to sound are, for the most part, not known. Their abilities to move significant distances are limited or nil, depending on the type of animal. Impacts on zooplankton behavior are predicted to be negligible and this would translate into negligible impacts on feeding bowheads.

Habitat Disruption

The main impact issues associated with drilling and production activity will be temporarily elevated noise levels, as other emissions are strictly controlled, and bottom disturbance is a natural phenomenon in this region. Sea floor surface disruption associated with island construction and pipeline trenching likely resulted in disturbance to benthic communities within the island and pipeline footprint. These communities have a naturally patchy distribution. In nearshore areas such as the Northstar development and along the pipeline route, these communities are subject to natural seasonal disruption by ice scour and ice gouging of the sea floor and transport of significant amounts of suspended sediments due to river outflow and coastal erosion (MBC 2003). This suggests that recovery of disturbed areas will occur in a manner similar to that occurring after natural disturbance, except for those areas buried by island construction. Effects of pipeline trenching on total suspended sediments in the water column were localized within ~500 m (1,640 ft) and effects are likely indistinguishable from naturally occurring disturbances to the benthos by sea ice, river outflow, and coastal erosion (MBC 2003). In addition, the island slope protection system introduced hard bottom structures for possible colonization by arctic kelp species, some invertebrates and fish.

Oil Spills

Oil spill probabilities for the Northstar project have been calculated based on historic oil spill data. Probabilities vary depending on assumptions and method of calculation. A recent reanalysis of worldwide oil spill data indicates the probability of a large oil spill (>1,000 barrels) during the lifetime of Northstar is low (S.L. Ross Environmental Research Ltd. 1998). That report uses standardized units such as well-years and pipeline mile-years to develop oil spill probabilities for the Northstar project. Well-years represent the summed number of years that the various wells will be producing, and mile-years represent the length of pipeline times the amount of time the pipeline is in service. The calculated probability of a large oil spill allows for the state-of-the-art engineering and procedures used at Northstar. That probability is far lower than previously-estimated probabilities (23-26%), which were based on MMS studies of offshore oil field experience in the Gulf of Mexico and California (USACE 1998a).

Oil Effects on Foods of Seals and Whales

Arctic cod and other fishes are a principal food item for beluga whales and seals in the Beaufort Sea. Anadromous fish are more sensitive to oil when in the marine environment than when in the fresh water environment (Moles et al. 1979). Generally, arctic fish are more sensitive to oil than are temperate species (Rice et al. 1983). However, fish in the open sea are unlikely to be affected by an oil spill. Fish in shallow nearshore waters could sustain heavy mortality if an oil slick were to remain in the area for several days or longer. Fish concentrations in shallow nearshore areas

that are used as feeding habitat for seals and whales could be unavailable as prey. Because the animals are mobile, effects would be minor during the ice-free period.

Effects of oil on zooplankton as food for bowhead whales were discussed by Richardson ([ed.] 1987). Zooplankton populations in the open sea are unlikely to be depleted by the effects of an oil spill. Oil concentrations in water under a slick are low and unlikely to have anything but very minor effects on zooplankton. Zooplankton populations in near surface waters could be depleted; however, concentrations of zooplankton in near-surface waters generally are low compared to those in deeper water (Bradstreet et al. 1987; Griffiths et al. 2002).

Some bowheads feed in shallow nearshore waters (Bradstreet et al. 1987; Richardson and Thomson [eds.] 2002). Wave action in nearshore waters could cause high concentrations of oil to be found throughout the water column. Oil slicks in nearshore feeding areas could contaminate food and render the site unusable as a feeding area. However, bowhead feeding is uncommon along the coast near the Northstar Development area, and contamination of certain areas would have only a minor impact on bowhead feeding.

Effects of oil spills on zooplankton as food for seals would be similar to those described above for bowhead whales. Effects would be restricted to nearshore waters. During the ice-free period, effects on seal feeding would be minor.

Bearded seals consume benthic animals. Wave action in nearshore waters could cause oil to reach the bottom through adherence to suspended sediments (Sanders et al. 1990). There could be mortality of benthic animals and elimination of some benthic feeding habitat. During the ice-free period, effects on seal feeding would be minor.

Effects on availability of feeding habitat would be restricted to shallow nearshore waters. During the ice-free period, seals and whales could find alternate feeding habitats.

The ringed seal is the only marine mammal present near Northstar in significant numbers during the winter. An oil spill in shallow waters could affect habitat availability for ringed seals during winter. The oil could kill ringed seal food and/or drive away mobile species such as the arctic cod.

Effects of an oil spill on food supply and habitat would be locally significant for ringed seals in shallow nearshore waters in the immediate vicinity of the spill and oil slick in winter. Effects of an oil spill on marine mammal foods and habitat under other circumstances would be negligible.

Oil Effects on Habitat Availability

The subtidal marine plants and animals associated with the Boulder Patch community of Stefansson Sound are not likely to be affected directly by an oil spill from Northstar Island, seaward of the barrier islands and farther west. The only type of oil that can reach the subtidal organisms (located in 5 to 10 m [16 to 33 ft] of water) will be highly dispersed oil created by heavy wave action and vertical mixing. Such oil has no measurable toxicity (MMS 1996). The amount and toxicity of oil reaching the subtidal marine community is expected to be so low as to have no measurable effect. However, oil spilled under the ice during winter, if it reached the relevant habitat, could act to reduce the amount of light available to the kelp species and other organisms directly beneath the spill. This could be an indirect effect of a spill. Due to the highly variable winter lighting conditions, any

reduction in light penetration resulting from an oil spill would not be expected to have a significant impact on the growth of the kelp communities.

Depending on the timing of a spill, planktonic larval forms of organisms in arctic kelp communities such as annelids, mollusks, and crustaceans may be affected by floating oil. The contact may occur anywhere near the surface of the water column (MMS 1996). Due to their wide distribution, large numbers, and rapid rate of regeneration, the recovery of marine invertebrate populations is expected to occur soon after the surface oil passes. Spill response activities are not likely to disturb the prey items of whales or seals sufficiently to cause more than negligible effects.

Summary

Overall, the continuation of ongoing Northstar activities is not expected to cause significant impacts on habitats used by marine mammals, or on the food sources that marine mammals utilize. No observations of impacted habitat or food were made during the construction phase and none are anticipated during continued operations. A major oil spill is unlikely, but if it occurred it could have at least local and short-to-medium term effects on habitat availability, especially for seals occupying nearshore waters near the development site where the spill occurred.

10. ANTICIPATED IMPACT OF HABITAT LOSS OR MODIFICATION

The anticipated impact of the loss or modification of the habitat on the marine mammal populations involved.

The footprint for Northstar Island covers ~25 acres of benthic habitat and ~21 acres of seabed were excavated for the two pipelines. Much of the island footprint was in place prior to the beginning of Northstar construction in 2000 as a result of the construction of Seal Island at the same site in 1982. The small additional area covered and excavated was not known to influence marine mammal use.

Ice habitat for ringed seal breathing holes and lairs (especially for mothers and pups) is normally associated with pressure ridges or cracks (Smith and Stirling 1975). The amount of habitat altered by Northstar ice-road construction is minimal compared to the overall habitat available in the region. Densities of ringed seals on the ice near Northstar during late spring are similar to those elsewhere in the region (Miller et al. 1998b; Link et al. 1999; Moulton et al. 2002, 2005). Ringed seals use multiple breathing holes (Smith and Stirling 1975; Kelly and Quakenbush 1990), and are not expected to be adversely affected by the loss of 1–2 breathing holes within the thickened ice road. Ringed seals near Northstar appear to have the ability to open new holes and create new structures throughout the winter, and ringed seal use of landfast ice near Northstar did not appear to be much different than that of ice 2–3.5 km away (1.2–2.2 mi; Williams et al. 2002). Active seal structures were found within 10s of meters of thickened ice (Williams et al. 2006b, c). A few ringed seals occur within areas of artificially thickened ice if cracks that can be exploited by seals form in that thickened ice.

Bowheads are not present near Northstar during the winter and are not normally found in the development area during July through mid-August. Starting in late August and continuing until late October, bowheads may travel close enough to Northstar to hear sounds from Northstar Island or to

encounter vessel traffic to and from the island. Some of these migrating bowhead whales might be displaced seaward by the planned activities. To the extent that there is offshore displacement of bowheads as a result of Northstar, it is a subtle and inconsistent effect involving no more than a small proportion of the passing bowheads (Richardson et al. 2008b). Feeding does not appear to be an important activity by bowheads migrating through the central part of the Alaskan Beaufort Sea in most years. In the absence of important feeding areas, the potential diversion of a small number of bowheads from parts of the Northstar development area is not expected to have any significant or long-term consequences for individual bowheads or their population. Bowheads or other whales are not predicted to be excluded from any habitat.

11. MITIGATION MEASURES

The availability and feasibility (economic and technological) of equipment, methods, and manner of conducting such activity or other means of effecting the least practicable adverse impact upon the affected species or stocks, their habitat, and on their availability for subsistence uses, paying particular attention to rookeries, mating grounds, and areas of similar significance.

To minimize the likelihood that impacts will occur to the species, stocks and subsistence use of marine mammals, all activities associated with the Northstar development will be conducted in accordance with all Federal, state and local regulations. BP will coordinate important activities with the relevant Federal and state agencies. These will include the National Marine Fisheries Service, U.S. Fish and Wildlife Service, Minerals Management Service, Biological Resources Division of the U.S. Geological Survey, and Alaska Department of Fish and Game. BP will also coordinate important activities with local authorities (North Slope Borough), representatives of communities (Barrow, Nuiqsut, and Kaktovik), and representatives of whaling captains (Alaska Eskimo Whaling Association (AEWC), and the Barrow (BWCA), Nuiqsut (NWCA), and Kaktovik (KWCA) Whaling Captains Associations. A plan of cooperation was developed between BP and the subsistence users in the region during the previous 5-yr regulations. We anticipate annual renewal/renegotiation of these documents during the subsequent period. This will ensure efforts have been made by BP to minimize the possibility that operational, maintenance, and training activities interfere with the fall hunt for bowheads, and that all activities are conducted safely.

BP has participated in all peer-review workshops convened by NMFS in Seattle and Anchorage since 1998 to discuss ringed seal and bowhead whale mitigation and monitoring methods and results of studies. BP plans to participate in future peer-review workshops sponsored by NMFS.

Mitigation during Production, Facilities Repair and Maintenance

Ice-covered Season

During winter and spring activities on the sea ice, the ringed seal is the only marine mammal species under the jurisdiction of NMFS that is likely to be encountered near Northstar. Winter activities are planned to commence on the sea ice as early as practical before female ringed seals have established their birth lairs and before pups are born. The most likely effects of these early winter activities will be temporary and localized disturbance to a small number of adult and subadult ringed seals. This disturbance will result from ice road construction, traffic on the ice, spill response training, emergency evacuation training, and exposure to noise and vibration from island activities.

Seals may be displaced for a few hours from the immediate area of some activities (Kelly et al. 1986). However, if displacement occurs it is limited to a distance of, at most, 100 m (320 ft) from activities such as those proposed for Northstar (Williams et al. 2006b, c).

Female ringed seals establish their birth lairs before pupping in late March to April. It was thought that female seals would avoid establishing birth lairs in close proximity to on-going activities associated with Northstar. However, the closest suspected birth lairs were found ~1,600 m (1 mi) from the island and 54 m (177 ft) from the ice road in 2001 (Williams et al. 2006b, c). Results of all studies of structure location and seal distribution indicate that no more than limited displacement of ringed seals has occurred.

In the event that construction activities are required after 1 March in a previously undisturbed area of floating landfast ice (i.e., in waters deeper than 3 m [9.8 ft]), a survey with dogs will be completed to delineate an area where activities may proceed without disturbing seal structures or, alternatively, another suitable approach will be taken in consultation with NMFS. In case of dog surveys, trained dogs will search all floating sea ice for any ringed seal structures. Those surveys will be done prior to the new proposed activity on the floating sea ice, to provide information needed to prevent injury or mortality of young seals. Seal structures will be avoided by 150 m (429 ft) during subsequent BP activities, when practicable. Since 2001, no BP's activities took place after 1 March in previously undisturbed areas during late winter and as such no on-ice searches were conducted.

A report will be prepared describing the area searched, activities that occurred, and methods of any surveys with dogs that BP conducts to locate ringed seal lairs that are to be avoided by on-ice activities initiated after mid-March. A report will be submitted to NMFS in preliminary form 90 days after the proposed activity is complete, and in its entirety (methods, results, and discussion) as described for the annual reporting requirement in Section 13.

Broken Ice and Open-water Season

All non-essential boat, hovercraft, barge, and air traffic will be scheduled to avoid periods when whales are migrating through the area. Helicopter operations have the potential to disturb marine mammals. Helicopter flights will be primarily during ice breakup or freeze-up. Unless limited by weather conditions, a minimum flight altitude of 305 m (1,000 ft) ASL will be maintained, except during takeoff and landing. No flights over whales or subsistence hunters are anticipated. Helicopter flights to Northstar will occur in a corridor from the mainland. Essential traffic has been and will continue to be closely coordinated with the NSB and AEWC to avoid disrupting subsistence activities.

The number of marine mammals that are likely to be exposed to activities related to ongoing Northstar operations and maintenance is small relative to their regional populations. Past monitoring has indicated that effects of Northstar activities (with mitigation measures in place) have been limited, when they occur, to short-term behavioral changes by a small number of individual ringed seals and bowhead whales. (Similar short-term behavioral effects might possibly occur in very small numbers of bearded and spotted seals, and beluga or gray whales, though there is no indication of effects on those species as a result of Northstar activities to date.) These behavioral changes have resulted in no greater than negligible impacts on individuals or on the species or stocks. Effects of future (2011–2016) Northstar activities are expected to be no greater than those during initial and

continued production in 2002–2009, and less than during the construction period in 2000–2001. No specific rookeries, areas of concentrated feeding or mating, or other areas of special significance for marine mammals occur in or near the planned operational area, although some ringed seal breeding occurs in the general area during the ice covered season.

Impact hammering activities may occur at any time of year to repair sheetpile or dock damage due to ice impingement. Impact hammering is most likely to occur during the ice-covered season or break-up period and would not be scheduled during the fall bowhead migration. Based on studies by Blackwell et al. (2004a), it is predicted that only impact driving of sheet piles or pipes that are in the water (i.e., those on the dock) could produce received levels of 190 dB re 1 µPa (rms), and then only in immediate proximity to the pile. The impact pipe driving in June and July 2000 did not produce received levels as high as 180 dB re 1 µPa (rms) at any location in the water. This was attributable to attenuation by the gravel and sheetpile walls (Blackwell et al. 2004a). We anticipate that received levels for any pile driving that might occur within the sheetpile walls of the island in future would also be less than 180 dB_{rms} at all locations in the water around the island. If impact pile driving were planned in areas outside the sheetpile walls, it is possible that received levels underwater might exceed the 180 dB re 1 µPa (rms) level. Under present NMFS criteria, pinnipeds are not to be exposed to pulses with received levels above 190 dB, and whales are not be exposed to levels above 180 dB re 1 μPa_{rms} (NMFS 2000). Mild and infrequent TTS does not have long-term negative effects on hearing. However, to prevent or at least minimize exposure to sound levels that might elicit TTS, a safety zone will be established and monitored for presence of seals and whales. Establishment of the safety zone of any source predicted to result in received levels underwater above 180 dB_{rms} will be analyzed using existing data collected in the waters of the Northstar facility (see Section 13).

If observations and mitigation are required, a marine mammal observer stationed at an appropriate viewing location on the island will conduct watches commencing 30 minutes prior to the onset of impact hammering or other identified activity. See Section 13 for a detailed description of the observer program. If pinnipeds are seen within the 190 dB re 1 µPa contour (the "safety zone"), then operations will be shut down immediately until the mammals move beyond outside the "safety zone". Whales are very unlikely to be present; however, if they are observed within the 180 dB re 1 µPa (rms) zone, operations will shut down. If no mammal is seen within the “safety zone” for 20 minutes, it will be assumed to have moved beyond the "safety zone", and the activity can resume. During the lifetime of the requested Letter of Authorization, safety criteria different from the provisional 180 and 190 dB criteria of NMFS (2000) may be accepted by NMFS. If so, the new criteria would apply.

A Communications Plan and Conflict Avoidance Agreement (see Section 12) have been negotiated with subsistence hunters and their representatives, and implemented, in previous years. BP expects that these plans will be further discussed and refined in subsequent years. This will confirm that efforts have been made by BP to minimize the possibility that Northstar operations, including vessels, helicopters and other ancillary operations, interfere with the subsistence hunt of bowhead whales.

Contingency Plan for Oil Spills

An oil spill prevention and contingency response plan was developed and approved by the Alaska Department of Environmental Conservation, U.S. Department of Transportation, U.S. Coast Guard, and U.S. Minerals Management Service. The plan has been amended since its initial

approval. Major changes since 1999 include the following: seasonal drilling restrictions from June 1 to July 20 and from October 1 until ice becomes 18 inches thick; changes to the response planning standard for a well blowout as a result of reductions in well production rates; and deletion of ice auguring for monitoring potential sub-sea oil pipeline leaks during winter following demonstration of the LEOS leak detection system. Future changes to the response planning standards may be expected in response to declines in well production rates and pipeline throughput.

The plan consists of five parts:

1. Response Action Plan: provides initial emergency response actions and oil spill response scenarios.
2. Prevention Plan: describes facility prevention measures.
3. Supplemental Information: provides background information on the facility, including descriptions of the facility, the receiving environment for potential spills, the incident command system, maximum response operating limitations, response resources (personnel and equipment), response training and drills, and protection of environmentally sensitive areas.
4. Best Available Technology (BAT): provides a rationale for the prevention technology in place at the facility and a determination of whether or not it is BAT.
5. Response Planning Standard: provides calculations of the applicable response planning standards for Northstar, including a detailed basis for the calculation reductions to be applied to the response planning standards.

The plan incorporates by reference a detailed map atlas that summarizes the resources that might be at risk from an oil spill on a seasonal basis, sensitive shoreline types, and key hydrographic, topographic and facility information.

12. PLAN OF COOPERATION

Where the proposed activity would take place in or near a traditional Arctic subsistence hunting area and/or may affect the availability of a species or stock of marine mammal for Arctic subsistence uses, the applicant must submit either a plan of cooperation or information that identifies what measures have been taken and/or will be taken to minimize any adverse effects on the availability of marine mammals for subsistence uses. A plan must include the following:

(i) A statement that the applicant has notified and provided the affected subsistence community with a draft plan of cooperation;

(ii) A schedule for meeting with the affected subsistence communities to discuss proposed activities and to resolve potential conflicts regarding any aspects of either the operation or the plan of cooperation;

(iii) A description of what measures the applicant has taken and/or will take to ensure that proposed activities will not interfere with subsistence whaling or sealing; and

(iv) What plans the applicant has to continue to meet with the affected communities, both prior to and while conducting activity, to resolve conflicts and to notify the communities of any changes in the operation.

The AEWC and BP established a conflict avoidance agreement to mitigate the noise and/or traffic impacts of offshore oil and gas production related activities on subsistence whaling.

In addition, the NSB and residents from Barrow, Nuiqsut, and Kaktovik participated in the development of the Final Environmental Impact Statement (FEIS) for the Northstar project. Local residents provided traditional knowledge of the physical, biological, and human environment that has been incorporated into the Northstar FEIS. Also included in the Northstar FEIS is information gathered from the 1996 community data collection, along with relevant testimony during past public hearings in the communities of Barrow, Nuiqsut, and Kaktovik. This data collection has helped ensure that the concerns of NSB residents about marine mammals and subsistence are taken into account in the development of the project designs, permit stipulations, monitoring programs, and mitigation measures.

BP meets annually with communities on the North Slope to discuss the Northstar Development project. Stakeholder and peer review meetings convened by NMFS have been held at least annually from 1998 to the present to discuss proposed monitoring and mitigation plans, and results of completed monitoring and mitigation. Those meetings have included representatives of the concerned communities, the AEWC, the NSB, federal, state, and university biologists, the Marine Mammal Commission, and other interested parties. One function of those meetings has been to coordinate planned construction and operational activities with subsistence whaling activity. The conflict avoidance agreement may address the following:

- Operational agreement and communications procedures
- Where/when agreement becomes effective
- General communications scheme, by season
- Northstar Island operations, by season
- Conflict avoidance
- Seasonally sensitive areas
- Vessel navigation
- Air navigation
- Marine mammal and acoustic monitoring activities
- Measures to avoid impacts to marine mammals
- Measures to avoid conflicts in areas of active whaling
- Emergency assistance
- Dispute resolution process

13. MONITORING AND REPORTING PLAN

The suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species, the level of taking or impacts on populations of marine mammals that are expected to be present while conducting activities and suggested means of minimizing burdens by coordinating such reporting requirements with other schemes already applicable to persons conducting such activity. Monitoring plans should include a description of the survey techniques that would be used to determine the movement and activity of marine mammals near the activity site(s) including migration and other habitat uses, such as feeding.

The proposed monitoring program is based on continuation of previous monitoring conducted at Northstar. However, BP is aware that changes to the plan can be made through consultation with the NSB, NMFS, and AEWC while this application is being processed and during the process of renewal of the regulations for the period 2011–2016.

A comprehensive analysis of the results of the acoustical and marine mammal monitoring program to date has recently been completed (Richardson [ed.] 2008). Results of this intensive monitoring suggest that (1) there are no measurable effects on seals from Northstar activities, and (2) there are limited but measurable effects on movement patterns of calling bowhead whales passing Northstar. The effects on bowheads are limited to the southernmost part of the migration corridor during periods with relatively noisy operations (generally boat and barge operations). The new monitoring plan proposes annual monitoring for changes in (I) the relative numbers of ringed seals near Northstar, (II) the relative numbers of bowhead whale calls near Northstar during September, and (III) sound levels emanating from Northstar during September. The September monitoring effort for bowheads and sound levels will coincide with the bulk of the bowhead whale migration past

Northstar, terminating before the onset of freeze-up. Also, BP proposes additional monitoring as a contingency under two conditions, described below. Results from monitoring will be reported in a single annual report. In addition, a five-year comprehensive report will be prepared in 2015.

No monitoring is proposed specifically for bearded or spotted seals or for gray or beluga whales, as their occurrence near Northstar is extremely limited. Few, if any, observations of these species were made during the intensive monitoring from 1999 to 2004 and biological effects are not expected. However, if sightings of these (or other) species are made, those observations will be included in the monitoring reports that will be prepared.

Annual Monitoring

Ringed Seal Monitoring

BP proposes to continue the long-term observer program, conducted by island personnel, of ringed seals during the spring, summer, and early autumn. This program is intended to assess the continued long-term stability of ringed seal abundance and habitat use near Northstar as indexed by counts obtained on a regular and long-term basis. The proposed approach is to continue the Northstar seal count that is conducted during the period 15 May–15 July from the 33 m (109 ft) high process module by Northstar staff following a standardized protocol since 2005. Counts are made on a daily basis (weather permitting), between 11:00–19:00, in an area of ~950 m (3,116 ft) around the island, for a duration of ~15 minutes. Counts will only be made during periods with visibility of 1 km (0.62 mi) or more and with a cloud ceiling of more than 90 m (300 ft).

Bowhead Whale Monitoring

BP proposes to continue monitoring the bowhead migration in 2011 and subsequent years for ~30 days each September through the recording of bowhead calls. BP proposes to deploy a DASAR (Directional Autonomous Seafloor Acoustic Recorder; Greene et al. 2004) or similar recorder about 15 km or 9 mi north of Northstar, consistent with a location used in past years (as far as conditions allow). The data of the offshore recorder can provide information on the total number of calls detected, the temporal pattern of calling during the recording period, and possibly the bearing to calls, and call types. These data can be compared with corresponding data from the same site in previous years (this is location EB in 2001–2007 and C in 2008–2009). If substantially higher or lower numbers of calls are recorded than were recorded at that site in previous years, further analyses and additional monitoring will be considered in consultation with NMFS and North Slope Borough representatives. A second DASAR, or similar recorder, will be deployed at the same location to provide a reasonable level of redundancy.

Acoustic Monitoring of Northstar Sounds

BP proposes to install an acoustic recorder about 450 m (1,476 ft) north of Northstar, in the same area where sounds have been recorded since 2001. This recorder will be installed for ~30 days each September, corresponding with the deployment of the offshore DASAR (or similar recorder). The near-island recorder will be used to record and quantify sound levels emanating from Northstar. If island sounds are found to be significantly stronger or more variable than in the past, and if it is expected that the stronger sounds will continue in subsequent years, then further consultation with

NMFS and NSB will occur to determine if more analyses or changes in monitoring strategy are appropriate. A second acoustic recorder will be deployed to provide a reasonable level of redundancy.

Contingency Monitoring

If BP needs to conduct an activity capable of producing pulsed underwater sound with levels ≥180 or ≥190 dB re 1 μPa (rms) at locations where whales or seals could be exposed, BP proposes to monitor safety zones defined by those levels. One or more on-island observers, as necessary to scan the area of concern, will be stationed at location(s) providing an unobstructed view of the predicted safety zone. The observer(s) will scan the safety zone continuously for marine mammals for 30 minutes prior to the operation of the strong source. Observations will continue during all periods of operation. If whales and seals are detected within the (respective) 180 or 190 dB distances, a shutdown or other appropriate mitigation measure (as agreed upon with NMFS) would be implemented. The sound source will be allowed to operate again when the marine mammals were observed to leave the safety zone or if the observer has determined that no marine mammals have been within the safety zone for 15 minutes. If marine mammal safety criteria recognized by NMFS change before or during the 5-year period under consideration, BP will adopt new monitoring and mitigation measures in consultation with NMFS.

If BP initiates significant on-ice activities (e.g., construction of new ice roads, trenching for pipeline repair, or projects of similar magnitude) in previously undisturbed areas after 1 March, trained dogs, or a comparable method, will be used to search for seal structures. If seal structures are found within 150 m (492 ft) of the proposed area of operations, BP will adjust the area of operations or adopt appropriate mitigation measures. Those mitigation measures will be defined in consultation with NMFS and North Slope Borough Biologists.

Reports

BP proposes the submission of a single annual monitoring report, with the first report to cover the activities from April through October 2011, and subsequent reports to cover activities from November of one year through October of the next year. It is proposed that the first report, concerning April–October 2011, and the annual report for subsequent years (to cover monitoring during a 12-month November–October period) would be submitted by 1 June of the following year.

The annual reports will provide summaries of BP's Northstar activities. These summaries will include the following: dates and locations of ice-road construction, on-ice activities, vessel/hovercraft operations, oil spills, emergency training, and major repair or maintenance activities thought to alter the variability or composition of sounds in a way that might have detectable effects on ringed seals or bowhead whales. The annual reports will also provide details of ringed seal and bowhead whale monitoring, the monitoring of Northstar sound via the nearshore DASAR, descriptions of any observed reactions, and documentation concerning any apparent effects on accessibility of marine mammals to subsistence hunters.

BP also proposes to submit a single comprehensive report on the monitoring results from 2011 to mid-2015 no later than 240 days prior to expiry of the renewed Regulations.

If specific mitigation is required for activities on the sea ice initiated after 1 March (requiring searches with dogs for lairs), or during the operation of strong sound sources (requiring visual

observations and shut-down), then a preliminary summary of the activity, method of monitoring, and preliminary results will be submitted within 90 days after the cessation of that activity. The complete description of methods, results and discussion will be submitted as part of the annual report.

Any observations concerning possible injuries, mortality, or an unusual marine mammal mortality event will be transmitted to NMFS within 48 hours.

14. COORDINATING RESEARCH TO REDUCE AND EVALUATE POTENTIAL INCIDENTAL TAKE

Suggested means of learning of, encouraging, and coordinating research opportunities, plans, and activities relating to reducing such incidental taking and evaluating its effects.

BP coordinated the past marine mammal monitoring programs for the open-water and ice-covered seasons during operation of Northstar with MMS, NMFS, ADF&G, University of Alaska, and other industrial groups conducting related work. Provided that an acceptable methodology and business relationship can be worked out in advance, BP will continue to work with any number of external entities, including other energy companies, agencies, universities, and NGOs, in its efforts to manage, understand, and fully communicate information about environmental impacts related to Northstar activities.

BP is also interested in better understanding cumulative effects. In the past, BP has been an active participant in the National Academy's cumulative effects study. In addition, BP sponsored workshops intended to design better approaches to cumulative effects studies. The challenge in this case is determining a responsible approach to considering cumulative effects from sound. We are open to ideas and discussion and welcome comments from stakeholders with regard to assessment of cumulative effects from sound. BP currently plans to sponsor a series of workshops intended to develop methods for assessing cumulative effects associated with underwater sound, tentatively starting in 2010.

BP has contributed to studies of ringed seals through the Coastal Marine Institute of the University of Alaska (Kelly et al. 2004). BP will coordinate its proposed seal monitoring during the ice-covered season with any ongoing monitoring of on-ice work or any other related research on seals in the area surrounding Northstar.

BP plans to involve Inupiat personnel as well as biologists and acousticians in the monitoring and research programs proposed here. This will provide more opportunities for exchange of traditional and scientific knowledge.

BP anticipates that NMFS and peer reviewers will comment on the draft final reports on the marine mammal and acoustical monitoring work. BP will provide copies of draft monitoring reports to the North Slope Borough, the Alaska Eskimo Whaling Commission, and the Minerals Management Service for their review. Comments received as a result of the review processes will provide additional opportunities for input from and coordination with other groups with interests and experience in the area.

III. LITERATURE CITED

Aerts, L.A.M. 2009. Introduction, description of BP's activities, and record of seal sightings, 2008. p1-1 to p1-19 *In*: L.A.M Aerts and W.J. Richardson (eds., 2009, q.v.).

Aerts, L.A.M. and W.J. Richardson [eds.]. 2008. Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar Oil Development, Alaskan Beaufort Sea, 2007: Annual Summary Report. LGL Rep. P1005b. Rep. from LGL Alaska Res. Assoc. Inc. (Anchorage, AK), Greeneridge Sciences Inc. (Santa Barbara, CA) and Applied Sociocultural Res. (Anchorage, AK) for BP Exploration (Alaska) Inc., Anchorage, AK.

Aerts, L.A.M. and R. Rodrigues. 2008. Introduction, description of BP's activities, and record of seal sightings, 2007. p1-1 to p1-18 *In*: L.A.M Aerts and W.J. Richardson (eds., 2008, q.v.).

Aerts, L.A.M. and W.J. Richardson [eds.]. 2009. Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar Oil Development, Alaskan Beaufort Sea, 2008: Annual Summary Report. LGL Rep. P1081. Rep. from LGL Alaska Res. Assoc. Inc. (Anchorage, AK), Greeneridge Sciences Inc. (Santa Barbara, CA) and Applied Sociocultural Res. (Anchorage, AK) for BP Exploration (Alaska) Inc., Anchorage, AK.

Aerts, L.A.M., M. Blees, S.B. Blackwell, C.R Greene Jr., K.H Kim, D. Hannay and M. Austin. 2008. Marine mammal monitoring and mitigation during BP Liberty OBC seismic survey in Foggy Island Bay, Beaufort Sea, July-August 2008: 90-day report. LGL Rep. P1011-1. Rep. from LGL Alaska Research Associates Inc., LGL Ltd., Greeneridge Sciences Inc. and JASCO Research Ltd. for BP Exploration Alaska.

Alexander, V., D.C. Burrell, J. Chang, T.R. Cooney, C. Coulon, J.J. Crane, J.A. Dygas, G.E. Hall, P.J. Kinney, D. Kogl, T.C. Mowatt, A.S. Naidu, T.E. Osterkamp, D.M. Schell, R.D. Seifert, and R.W. Tucker. 1974. Environmental studies of an arctic estuarine system: final report. R74-1. Sea Grant Report 73-16. Inst. Marine Sci., Univ. Alaska, Fairbanks, AK.

Anderson, E., K. Jayko, C. Galagan and H. Rines. 1999. Oil spill model application for the Beaufort Sea. ASA 99-090. Rep. from Applied Science Assoc. Inc., Narragansett, RI, for BP Explor. (Alaska) Inc., Anchorage, AK. 16 p.

Angliss, R.P., and K.L. Lodge. 2002. Alaska marine mammal stock assessments, 2002. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-133, 224 p.

Angliss, R.P., and B.M. Allen. 2009. Alaska marine mammal stock assessments, 2008. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-193, 258 p.

Arnold, B.W. 1996. Visual monitoring of marine mammal activity during the Exxon 3-D seismic survey/Santa Ynez Unit, offshore California/9 November to 12 December 1995. Rep. from Impact Sciences Inc., San Diego, CA, for Exxon Co. U.S.A., Thousand Oaks, CA. 25 p.

Au, W.W.L. 1993. The sonar of dolphins. Springer-Verlag, New York, NY. 277 p.

Au, W.W.L. 1997. Some hot topics in animal bioacoustics. J. Acoust. Soc. Am. 101(5, Pt. 1):2433-2441.

Awbrey, F.T., J.A. Thomas and R.A. Kastelein. 1988. Low-frequency underwater hearing sensitivity in belugas, *Delphinapterus leucas*. J. Acoust. Soc. Am. 84(6):2273-2275

Berta, A., R. Racicot and T. Deméré 2009. The comparative anatomy and evolution of the ear in Balaenoptera mysticetes. Abstr. 18th Bienn. Conf. Biol. Mar. Mamm., Quebec, Oct. 2009, p. 33.

Blackwell, S.B. and C.R. Greene. 2002. Acoustic measurements in Cook Inlet, Alaska, during August 2001. Report from Greeneridge Sciences Inc., Santa Barbara, CA, for Nat. Mar. Fish. Serv., Anchorage AK.

Kastak, D., B.L. Southall, R.J. Schusterman and C. Reichmuth Kastak. 2005. Underwater temporary threshold shift in pinnipeds: effects of noise level and duration. J. Acoust. Soc. Am. 118(5): 3154-3163.

Kastak, D., C. Reichmuth, M.M. Holt, J. Mulsow, B.L. Southall and R.J. Schusterman. 2007. Onset, growth, and recovery of in-air temporary threshold shift in a California sea lion (*Zalophus californianus*). J. Acoust. Soc. Am. 122(5): 2916-2924.

Kastelein, R.A., P. Wensveen, L. Hoek and J.M. Terhune. 2009a. Underwater hearing sensitivity of harbor seals (*Phoca vitulina*) for narrow noise bands between 0.2 and 80 kHz. J. Acoust. Soc. Am. 126(1):476-483.

Kastelein, R.A., P.J. Wensveen, L. Hoek, W.C. Verboom and J.M. Terhune. 2009b. Underwater detection of tonal signals between 0.125 and 100 kHz by harbor seals (*Phoca vitulina*). J. Acoust. Soc. Am. 125(2): 1222-1229.

Kelly, B.P. 1988. Bearded seal, *Erignathus barbatus*. p. 77-94 In: J.W. Lentfer (ed.), Selected Marine Mammals of Alaska/Species Accounts with Research and Management Recommendations. Marine Mammal Commission, Washington, DC. 275 p.

Kelly, B.P. and L. Quakenbush. 1990. Spatiotemporal use of lairs by ringed seals (*Phoca hispida*). Can. J. Zool. 68(12):2503-2512.

Kelly, B.P., O.R. Harding, and M. Kunnasranta. 2004. Timing and re-interpretation of ringed seal surveys. p. 32-37 In: V. Alexander (ed.), Coastal Marine Institute, Annual Report No. 10. OCS Study MMS 2004-002. 119 p.

Kelly, B.P., L. Quakenbush and J.R. Rose. 1986. Ringed seal winter ecology and effects of noise disturbance. Outer Cont. Shelf Environ. Assess. Progr., Final Rep. Princ. Invest., NOAA, Anchorage, AK 61(1989):447-536. 536p. OCS Study MMS 89-0026, NTIS PB89-234645.

Kelly, B.P., J.J. Burns and L.T. Quakenbush. 1988. Responses of ringed seals (*Phoca hispida*) to noise disturbance. p. 27-38 In: W.M. Sackinger, M.O. Jeffries, J.L. Imm and S.D. Treacy (eds.), Port and Ocean Engineering under Arctic Conditions, Vol. II; Symposium on Noise and Marine Mammals. Geophysical Inst., Univ. Alaska, Fairbanks, AK. 111 p.

Ketten, D.R. 2000. Cetacean ears. p. 43-108 In: W.W.L. Au, A.N. Popper and R.R. Fay (eds.), Hearing by whales and dolphins. Springer-Verlag, New York, NY. 485 p.

Kinney, P., D. Schell, V. Alexander, A.S. Naidu, C.P. McRoy, and D.C. Burnell. 1971. Baseline data study of the Alaskan arctic aquatic environment. Eight-month progress report 1970. Inst. Mar. Sci, Univ. Alaska. R71-4. Fairbanks, AK.

Kinney, P., D. Schell, V. Alexander, D.C. Burnell, R. Cooney, and A.S. Naidu. 1972. Baseline data study of the Alaskan arctic aquatic environment. Inst. Mar. Sci., Univ. Alaska. R72-3. Fairbanks, AK.

Knudsen, V.O., R.S. Alford and J.W. Emling. 1948. Underwater ambient noise. J. Mar. Res. 7(3):410-429.

Kooyman, G.L., R.L. Gentry and W.B. McAlister. 1976. Physiological impact of oil on pinnipeds. Unpubl. Final Rep., Res. Unit 71, to Outer Cont. Shelf Envir. Assess. Program, BLM/NOAA. 26 p.

Kooyman, G.L., R.W. Davis and M.A. Castellini. 1977. Thermal conductance of immersed pinniped and sea otter pelts before and after oiling with Prudhoe Bay crude. p. 151-157 In: D.A. Wolfe (ed.), Fate and effects of petroleum hydrocarbons in marine ecosystems and organisms. Pergamon Press, Oxford.

Koski, W.R. and S.R. Johnson. 1987. Behavioral studies and aerial photogrammetry. Section 4 in Responses of bowhead whales to an offshore drilling operation in the Alaskan Beaufort Sea, autumn 1986. Rep. from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for Shell Western Exploration and Production Inc., Anchorage, AK.

Koski, W.R. and G.W. Miller. 2002. Habitat use by different size classes of bowhead whales in the eastern Alaskan Beaufort Sea during late summer and autumn. p. 10-1 to 10-21 (Chap. 10) In: W.J. Richardson and D.H. Thomson (eds.), Bowhead whale feeding in the eastern Alaskan Beaufort Sea: update of scientific and traditional information, vol. 1. OCS Study MMS 2002-012; LGL Rep. TA2196-7. Rep. from LGL Ltd., King City, Ont., for U.S. Minerals Manage. Serv., Anchorage, AK, and Herndon, VA. 420 p.

Koski, W.R. and G.W. Miller. 2009. Habitat use by different size classes of bowhead whales in the Central Beaufort Sea during late summer and autumn. Arctic 62(2):137-150.

Koski, W.R., R.A. Davis, G.W. Miller and D.E. Withrow. 1993. Reproduction. p. 239-274 In: J.J. Burns, J.J. Montague and C.J. Cowles (eds.), The bowhead whale. Spec. Publ. 2. Soc. Mar. Mamm., Lawrence, KS. 787 p.

Koski, W.R., D.J. Rugh, A.E. Punt and J. Zeh. 2004. A new approach to estimating the length-frequency distribution of the Bering-Chukchi-Beaufort bowhead whale population using aerial photogrammetry and a summary of other life-history parameters estimated from photoidentification / photogrammetry data. Working Paper SC/56/BRG2. Int. Whal. Comm., Cambridge, U.K. 25 p.

Landino, S.W., S.D. Treacy, S.A. Zerwick and J.B. Dunlap. 1994. A large aggregation of bowhead whales (*Balaena mysticetus*) feeding near Barrow, Alaska, in late October 1992. Arctic 47(3):232-235.

Le Boeuf, B.J., H. Pérez-Cortés M., J. Urbán R., B.R. Mate and F. Ollervides U. 2000. High gray whale mortality and low recruitment in 1999: potential causes and implications. Journal of Cetacean Research and Management 2:85-99.

Lelli, B. and D.E. Harris. 2001. Human disturbances affect harbor seal haul-out behavior: can the law protect these seals from boaters? Macalester Environmental Review. 23 October 2001. www.macalester.edu/~envirost/MacEnvReview/harbor_seal.htm

Lerczak, J.A., K.E.W. Shelden, and R.C. Hobbs. 2000. Application of suction-cup-attached VHF Transmitters to the study of beluga, *Delphinapterus leucas*, surfacing behavior in Cook Inlet, Alaska. Marine Fisheries Review 62(3):99-111.

Lesage, V., C. Barrette and M.C.S. Kingsley. 1993. The effect of noise from an outboard motor and a ferry on the vocal activity of beluga (*Delphinapterus leucas*) in the St. Lawrence estuary, Canada. Abstr. 10th Bienn. Conf. Biol. Mar. Mamm., Galveston, TX, Nov. 1993:70. 130 p.

Lesage, V., C. Barrette, M.C.S. Kingsley and B. Sjare. 1999. The effect of vessel noise on the vocal behavior of belugas in the St. Lawrence River estuary, Canada. Mar. Mamm. Sci. 15(1):65-84.

LGL and Greeneridge. 1996a. Northstar Marine Mammal Monitoring Program, 1995: Baseline surveys and retrospective analyses of marine mammal and ambient noise data from the Central Alaskan Beaufort Sea. Rep. from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for BP Explor. (Alaska) Inc., Anchorage, AK. 104 p.

LGL and Greeneridge. 2000. Technical plan for marine mammal and acoustic monitoring during construction of BP's Northstar Oil Development in the Alaskan Beaufort Sea, 2000-2001, August 2000 ed. Rep. from LGL Alaska Res. Assoc. Inc. (Anchorage), LGL Ltd. (King City, Ont.), and Greeneridge Sciences Inc. (Santa Barbara, CA), for BP Explor. (Alaska) Inc., Anchorage, AK. 80 p.

Link, M.R., T.L. Olson and M.T. Williams. 1999. Ringed seal distribution and abundance near potential oil development sites in the central Alaskan Beaufort Sea, spring 1998. LGL Rep. P-430. Rep. from LGL Alaska Res. Assoc. Inc., Anchorage, AK, for BP Explor. (Alaska) Inc., Anchorage, AK. 58 p.

Ljungblad, D.K., S.E. Moore and D.R. Van Schoik. 1983. Aerial surveys of endangered whales in the Beaufort, eastern Chukchi, and northern Bering Seas, 1982. NOSC Tech Doc. 605. Rep. from Naval Ocean Systems Center, San Diego, CA for U.S. Minerals Manage. Serv., Anchorage, AK. 382 p. NTIS AD-A134 772/3.

Ljungblad, D.K., S.E. Moore and D.R. Van Schoik. 1984. Aerial surveys of endangered whales in the Beaufort, eastern Chukchi, and northern Bering Seas, 1983: with a five year review, 1979-1983. NOSC Tech Rep. 955. Rep. from Naval Ocean Systems Center, San Diego, CA for U.S. Minerals Manage. Serv., Anchorage, AK. 356 p. NTIS AD-A146 373/6.

Ljungblad, D.K., B. Würsig, S.L. Swartz and J.M. Keene. 1985. Observations on the behavior of bowhead whales (*Balaena mysticetus*) in the presence of operating seismic exploration vessels in the Alaskan Beaufort Sea. OCS Study MMS 85-0076. Rep. from SEACO Inc., San Diego, CA, for U.S. Minerals Manage. Serv., Anchorage, AK. 78 p. NTIS PB87-129318.

Ljungblad, D.K., S.E. Moore and D.R. Van Schoik. 1986. Seasonal patterns of distribution, abundance, migration and behavior of the Western Arctic stock of bowhead whales, Balaena mysticetus in Alaskan seas. Rep. Int. Whal. Comm., Spec. Iss. 8:177-205.

Ljungblad, D.K., S.E. Moore, J.T. Clarke and J.C. Bennett. 1987. Distribution, abundance, behavior and bioacoustics of endangered whales in the Alaskan Beaufort and eastern Chukchi Seas, 1979-86. NOSC Tech. Rep. 1177; OCS Study MMS 87-0039. Rep. from Naval Ocean Systems Center, San Diego, CA, for U.S. Minerals Manage. Serv., Anchorage, AK. 391 p. NTIS PB88-116470.

Long, F., Jr. 1996. History of subsistence whaling by Nuiqsut. p. 73-76 In: Proceedings of the 1995 Arctic Synthesis Meeting. U.S. Minerals Manage. Serv., Alaska OCS Region, Anchorage, AK. 222 p.

Lowry, L.F. and G. Sheffield. 2002. Stomach contents of bowhead whales harvested in the Alaskan Beaufort Sea. p. 18-1 to 18-28 (Chap. 18) In: W.J. Richardson and D.H. Thomson (eds.), Bowhead whale feeding in the eastern Alaskan Beaufort Sea: update of scientific and traditional information, vol. 2. OCS Study MMS 2002-012; LGL Rep. TA2196-7. Rep. from LGL Ltd., King City, Ont., for U.S. Minerals Manage. Serv., Anchorage, AK, and Herndon, VA. 277 p.

Lowry, L.F., K.J. Frost, R. Davis, D.P. DeMaster and R.S. Suydam. 1998. Movements and behavior of satellite-tagged spotted seals (*Phoca largha*) in the Bering and Chukchi Seas. Polar Biol. 19(4):221-230.

Lucke, K., U. Siebert, P.A. Lepper and M.-A. Blanchet. 2009. Temporary shift in masked hearing thresholds in a harbor porpoise (*Phocoena phocoena*) after exposure to seismic airgun stimuli. J. Acoust. Soc. Am. 125(6): 4060-4070.

Lydersen, C. and M.O. Hammill. 1993. Diving in ringed seal (*Phoca hispida*) pups during the nursing period. Can. J. Zool. 71(5):991-996.

MacGillivray, A.O., D.E. Hannay, R.G. Racca, C.J. Perham, S.A. MacLean, M.T. Williams. 2003. Assessment of industrial sounds and vibrations received in artificial polar bear dens, Flaxman Island, Alaska. Final report to ExxonMobil Production Co. by JASCO Research Ltd., Victoria, British Columbia and LGL Alaska Research Associates, Inc., Anchorage, Alaska. 60 p.

Maher, W.J. 1960. Recent records of the California gray whale (*Eschrichtius glaucus*) along the north coast of Alaska. Arctic 13(4):257-265.

Malme, C.I., P.R. Miles, C.W. Clark, P. Tyack and J.E. Bird. 1984. Investigations of the potential effects of underwater noise from petroleum industry activities on migrating gray whale behavior/Phase II: January 1984 migration. BBN Rep. 5586. Rep. from Bolt Beranek & Newman Inc., Cambridge, MA, for U.S. Minerals Manage. Serv., Anchorage, AK. Var. pag. NTIS PB86-218377.

Malme, C.I., B. Würsig, J.E. Bird and P. Tyack. 1988. Observations of feeding gray whale responses to controlled industrial noise exposure. Pp. 55-73. In: W.M. Sackinger, M.O. Jefferies, J.L. Imm, S.D. Treacy (eds.) Port and Ocean Engineering Under Arctic Conditions, Volume II. University of Alaska, Fairbanks, Alaska. 111pp.

Mansfield, A.W. 1967. Seals of arctic and eastern Canada. Fish. Res. Board Can. Bul. 137. 35 p.

Mate, B.R. 2006. The Spring Northward Migration and Summer Feeding of Mother Gray Whales in the Eastern North Pacific Ocean, Bering Sea and Chukchi Sea. Report to LGL Ltd. (Sidney, B.C. Canada) on the Tagging of Eastern North Pacific Gray Whales—2005. Agreement Number EA1666.10A

Mate, B.R. and J.T. Harvey (eds.) 1987. Acoustic deterrents in marine mammal conflicts with fisheries. ORESU-W-86-001. Oregon State Univ., Sea Grant Coll. Progr., Corvallis, OR. 116 p.

MBC Applied Environmental Sciences. 2003. Proceedings of the Ninth Information Transfer Meeting. OCS Study MMS 2003-42. by MBC Applied Environmental Sciences, Costa Mesa, CA. for U.S. Dept. Int., Minerals Management Service, Alaska OCS Region, Anchorage, AK. 93 pp. plus attachments.

McCarty, S.L. 1982. Survey of the effect of outer continental shelf platforms on cetacean behavior. p. C-1 to C-31 In: R.S. Gales (ed.), Effects of noise of offshore oil and gas operations on marine mammals--an introductory assessment, vol. 2. App. 3 in NOSC Tech. Rep. 844. Naval Ocean Systems Cent., San Diego, CA. 300 p. NTIS AD-A123700.

McDonald, T.L., W.J. Richardson, C.R. Greene, Jr., S.B. Blackwell, C. Nations, and R. Nielson. 2008. Detecting changes in distribution of calling bowhead whales exposed to fluctuating anthropogenic sounds. p. 9 1 to 9 45 *In*: W.J. Richardson (ed., 2008, q.v.). LGL Rep. P1004.

Miller, G.W., R.E. Elliott and W.J. Richardson. 1996. Marine mammal distribution, numbers and movements. p. 3-72 In: LGL and Greeneridge, Northstar marine mammal monitoring program, 1995: Baseline surveys and retrospective analyses of marine mammal and ambient noise data from the central Alaskan Beaufort Sea. Rep. from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for BP Explor. (Alaska) Inc., Anchorage, AK. 104 p.

Miller, G.W., R.E. Elliott, W.R. Koski and W.J. Richardson. 1997. Whales [1996]. (Chap. 5, 115 p.) In: W.J. Richardson (ed.), 1997 (q.v.).

Miller, G.W., R.E. Elliott and W.J. Richardson. 1998b. Whales. [1997]. (Chap. 5) In: W.J. Richardson (ed., 1998, q.v.).

Miller, G.W., R.E. Elliott, W.R. Koski, V.D. Moulton and W.J. Richardson. 1999. Whales [1998]. p. 5-1 to 5-109 In: W.J. Richardson (ed.), 1999 (q.v.).

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

Milne, A.R. and J.H. Ganton. 1964. Ambient noise under Arctic-Sea ice. J. Acoust. Soc. Am. 36(5):855-863.

Misund, O.A. 1997. Underwater acoustics in marine fisheries and fisheries research. Review of Fish Biology and Fisheries 7(1):1-34.

Misund, O.A., J.T. Øvredal, and M.T. Hafsteinsson. 1996. Reactions of herring schools to the sound field of a survey vessel. Aquatic Living Resources 9(1):5-11.

MMS. 1996. Beaufort Sea Planning Area oil and gas lease sale 144/Final Environmental Impact Statement. OCS EIS/EA MMS 96-0012. U.S. Minerals Manage. Serv., Alaska OCS Reg., Anchorage, AK. Two volumes. Var. pag.

MMS. 1997. Arctic seismic synthesis and mitigating measures workshop/Proceedings. OCS Study MMS 97-0014. U.S. Minerals Manage. Serv., Anchorage, AK. 165 p.

Moles, A., S.D. Rice and S. Korn. 1979. Sensitivity of Alaskan freshwater and anadromous fishes to Prudhoe Bay crude oil and benzene. Trans. Amer. Fish. Soc. 108:408-414.

Moore, S.E. 2000. Variability in cetacean distribution and habitat selection in the Alaskan Arctic, Autumn 1982-91. Arctic 53(4)448-460.

Moore, S.E. and J.T. Clarke. 1992. Patterns of bowhead whale distribution and abundance near Barrow, Alaska, in fall 1982-1989. Mar. Mamm. Sci. 8(1):27-36.

Moore, S.E. and D.K. Ljungblad. 1984. Gray whales in the Beaufort, Chukchi, and Bering seas: distribution and sound production. p. 543-559 In: M.L. Jones, S.L. Swartz and S. Leatherwood (eds.), The gray whale *Eschrichtius robustus*. Academic Press, Orlando, FL. 600 p.

Moore, S.E. and R.R. Reeves. 1993. Distribution and movement. p. 313-386 In: J.J. Burns, J.J. Montague and C.J. Cowles (eds.), The bowhead whale. Spec. Publ. 2. Soc. Mar. Mamm., Lawrence, KS. 787 p.

Moore, S.E., D.K. Ljungblad and D.R. Schmidt. 1984. Ambient, industrial and biological sounds recorded in the northern Bering, eastern Chukchi and Alaskan Beaufort Seas during the seasonal migrations of the bowhead whale (*Balaena mysticetus*), 1979-1982. Rep. from SEACO Inc., San Diego, CA, for U.S. Minerals Manage. Serv., Anchorage, AK. 111 p. NTIS PB86-168887.

Moore, S.E., J.T. Clarke and D.K. Ljungblad. 1989. Bowhead whale (*Balaena mysticetus*) spatial and temporal distribution in the central Beaufort Sea during late summer and early fall 1979-86. Rep. Int. Whal. Comm. 39:283-290.

Moore, S.E., D.P. DeMaster, and P.K. Dayton. 2000. Cetacean habitat selection in the Alaskan Arctic during summer and Autumn. Arctic 53(4)432-447.

Moore S.E., W.L. Perryman, F. Gulland, H. Perez-Cortes, P.R.Wade, L. Rojas-Bracho and T. Rowles. 2001. Are gray whales hitting "K" hard? Marine Mammal Science, 17(4):954-958.

Moore, S.E., J.M. Grebmeier, and J.R. Davies. 2003. Gray whale distribution relative to forage habitat in the northern Bering Sea: current conditions and retrospective summary. Can. J. Zool. 81:734-742.

Moulton, V.D. and J.W. Lawson. 2002. Seals, 2001. p. 3-1 to 3-48 In: W.J. Richardson and J.W. Lawson (eds.), Marine mammal monitoring of WesternGeco's open-water seismic program in the Alaskan Beaufort Sea, 2001. LGL Rep. TA2564-4. Rep. from LGL Ltd., King City, Ont., for WesternGeco LLC, Anchorage, AK; BP Explor. (Alaska) Inc., Anchorage, AK; and Nat. Mar. Fish. Serv., Anchorage, AK, and Silver Spring, MD. 95 p.

Moulton, V.D., W.J. Richardson, T.L. McDonald, R.E. Elliott and M.T. Williams. 2002. Factors influencing local abundance and haulout behaviour of ringed seals (*Phoca hispida*) on landfast ice of the Alaskan Beaufort Sea. Can. J. Zool. 80(11):1900-1917.

Moulton, V.D., W.J. Richardson, M.T. Williams and S.B. Blackwell. 2003a. Ringed seal densities and noise near an icebound artificial island with construction and drilling. Acoust. Res. Let. Online. 4(4):112–117.

Moulton, V.D., R.E. Elliott and M.T. Williams. 2003b. Fixed-wing aerial surveys of seals near BP's Northstar and Liberty sites, 2002. p. 4-1 to 4-35 In: W.J. Richardson and M.T. Williams (eds., 2003, q.v.). LGL Rep. TA2702-2.

Moulton, V.D., W.J. Richardson, T.L. McDonald, R.E. Elliott, M.T. Williams and C. Nations. 2005. Effects of an offshore oil development on local abundance and distribution of ringed seals (*Phoca hispida*) of the Alaskan Beaufort Sea. **Marine Mammal Science** 21(2): 217-242.

Moulton, V.D., M.T. Williams, S.B. Blackwell, W.J. Richardson, R.E. Elliot and B. Streever. MS. Zone of displacement for ringed seals (*Pusa hispida*) wintering around offshore oil-industry operations in the Alaskan Beaufort Sea.

Nachtigall, P.E., J.L. Pawloski and W.W.L. Au. 2003. Temporary threshold shifts and recovery following noise exposure in the Atlantic bottlenosed dolphin (*Tursiops truncatus*). J. Acoust. Soc. Am. 113(6):3425-3429.

Nachtigall, P. E., A. Ya. Supin, J.L. Pawloski, and W.W. L. Au. 2004. Temporary threshold shifts after noise exposure in the bottlenose dolphin (*Tursiops truncatus*) measured using auditory evoked potentials. Marine Mammal Science, 20, 673-687.

Nelson, R.R., J.J. Burns, and K.J. Frost. n.d. The Bearded Seal (*Erignathus barbatus*). Alaska Department of Fish and Game.

Nerini, M. 1984. A review of gray whale feeding ecology. p. 423-450 In: M.L. Jones, S.L. Swartz and S. Leatherwood (eds.), The gray whale *Eschrichtius robustus*. Academic Press, Orlando, FL. 600 p.

Nerini, M.K., H.W. Braham, W.M. Marquette and D.J. Rugh. 1984. Life history of the bowhead whale, *Balaena mysticetus* (Mammalia: Cetacea). J. Zool., Lond. 204:443-468.

NMFS (National Marine Fisheries Service). 1995. Small takes of marine mammals incidental to specified activities; offshore seismic activities in southern California/Notice of issuance of an Incidental Harassment Authorization. Fed. Regist. 60(200, 17 Oct.):53753-53760.

NMFS. 1997. Small takes of marine mammals incidental to specified activities; oil and gas exploration drilling activities in the Beaufort Sea/Notice of issuance of an Incidental Harassment Authorization. Fed. Regist. 62(191, 2 Oct.):51637-51643.

NMFS. 2000. Taking marine mammals incidental to construction and operation of offshore oil and gas facilities in the Beaufort Sea/Final rule. Fed. Regist. 65(102, 25 May):34014-34032.

NMFS. 2001. Small takes of marine mammals incidental to specified activities; oil and gas exploration drilling activities in the Beaufort Sea/Notice of issuance of an incidental harassment authorization. Fed. Regist. 66(26, 7 Feb.):9291-9298

NMFS. 2003. Subsistence harvest management of Cook Inlet beluga whales Final Environmental Impact Statement. July 2003. 197 pp.

NMFS. 2005. Endangered fish and wildlife; Notice of Intent to prepare an Environmental Impact Statement. Fed. Regist. 70(7, 11 Jan.): 1871-1875.

NRC. 2005. Marine mamma populations and ocean noise: determining when noise causes biologically significant effects. Committee on characterizing biologically significant marine mammal behaviour, National Research Council. ISBN: 0-309-54667-2, 142 p.

Nowacek, D.P., L.H. Thorne, D.W. Johnston and P.L. Tyack. 2007. Responses of cetaceans to anthropogenic noise. Mamm. Rev. 37(2):81-115.

Oliver, J.S. and P.N. Slattery. 1985. Destruction and opportunity on the sea floor: effects of gray whale feeding. Ecology 66(6):1965-1975.

Oliver, J.S., P.N. Slattery, M.A. Silberstein and E.F. O'Connor. 1983. A comparison of gray whale, *Eschrichtius robustus*, feeding in the Bering Sea and Baja California. Fish. Bull. 81(3):513-522.

Ouellet, P. 1979. Northern whales [LP phonograph record]. Cat. No. 19. Music Gallery Editions, Toronto, Ont.

Parks, S.E., I. Urazghildiiev and C.W. Clark. 2009. Variability in ambient noise levels and call parameters of North Atlantic right whales in three habitat areas. J. Acoust. Soc. Am. 125(2):1230-1239.

Patenaude, N.J., W.J. Richardson, M.A. Smultea, W.R. Koski, G.W. Miller, B. Würsig and C.R. Greene Jr. 2002. Aircraft sound and disturbance to bowhead and beluga whales during spring migration in the Alaskan Beaufort Sea. Mar. Mamm. Sci. 18(2):309-335.

Pearson, W.H., J.R. Skalski and C.I. Malme. 1992. Effects of sounds from a geophysical survey device on behavior of captive rockfish (*Sebastes spp*). Can. J. Fish. Aquatic Sci. 49:1343-1356.

Quakenbush, L.T. 1988. Spotted seal, *Phoca largha*. p. 107-124 In: J.W. Lentfer (ed.), Selected Marine Mammals of Alaska/Species Accounts with Research and Management Recommendations. Marine Mammal Commis., Washington, DC. 275 p.

Rexford, B. 1996. The Alaska Eskimo Whaling Commission and history of subsistence whaling off Point Barrow "Nuvuk" (including General Discussion). p. 77-85 In: Proceedings of the 1995 Arctic Synthesis Meeting. U.S. Minerals Manage. Serv., Alaska OCS Region, Anchorage, AK. 222 p.

Rice, D.W. and A.A. Wolman. 1971. The life history and ecology of the gray whale (*Eschrichtius robustus*). Am. Soc. Mamm. Spec. Publ. 3. 142 p.

Rice, S.D., A. Moles, J.F. Karinen, S. Korn, M.G. Carls, C. Brodersen, J.A. Gharrett and M.M. Babcock 1983. Effects of petroleum hydrocarbons on Alaskan aquatic organisms. Final Rep. to OCEAP by NW Alaska Fisheries Centre, Auke Bay Laboratory, NMFS, NOAA, Auk Bay AK. 145 p.

Richard, P.R., A.R. Martin and J.R. Orr. 1997. Study of summer and fall movements and dive behaviour of Beaufort Sea belugas, using satellite telemetry: 1992-1995. ESRF Rep. 134. Environ. Stud. Res. Funds, Calgary, Alb. 38 p.

Richard, P.R., A.R. Martin and J.R. Orr. 2001. Summer and autumn movements of belugas of the eastern Beaufort Sea stock. Arctic 54(3):223-236.

Richardson, W.J. (ed.). 1987. Importance of the eastern Alaskan Beaufort Sea to feeding bowhead whales, 1985-86. OCS Study MMS 87-0037. Rep. from LGL Ecol. Res. Assoc. Inc., Bryan, TX, for U.S. Minerals Manage. Serv., Reston, VA. 547 p. NTIS PB88-150271.

Richardson, W.J. (ed.). 1999. Marine mammal and acoustical monitoring of Western Geophysical's open-water seismic program in the Alaskan Beaufort Sea, 1998. LGL Rep. TA2230-3. Rep. from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for Western Geophysical, Houston, TX, and U.S. Nat. Mar. Fish. Serv., Anchorage, AK, and Silver Spring, MD. 390 p.

Richardson, W.J. [ed.]. 2006. Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar Oil Development, Alaskan Beaufort Sea, 2005: Annual Summary Report. LGL Rep. TA4209 (rev.). Rep. from LGL Ltd. (King City, Ont.) and Greeneridge Sciences Inc. (Santa Barbara, CA) for BP Explor. (Alaska) Inc., Anchorage, AK. 79 p.

Richardson, W.J. [ed.]. 2007. Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar Oil Development, Alaskan Beaufort Sea, 2006: Annual Summary Report. LGL Rep. TA4441. Rep. from LGL Ltd. (King City, Ont.) and Greeneridge Sciences Inc. (Santa Barbara, CA) for BP Explor. (Alaska) Inc., Anchorage, AK. 78 p.

Richardson, W.J. [ed.]. 2008. Monitoring of industrial sounds, seals, and bowhead whales near BP's Northstar Oil Development, Alaskan Beaufort Sea, 1999–2004. Comprehensive Report, 3rd Update, Feb. 2008. LGL Rep. P1004. Rep. from LGL Ltd. (King City, Ont.), Greeneridge Sciences Inc. (Santa Barbara, CA), WEST Inc. (Cheyenne, WY), and Applied Sociocultural Research (Anchorage, AK) for BP Exploration (Alaska) Inc., Anchorage, AK.

Richardson, W.J. and C.I. Malme. 1993. Man-made noise and behavioral responses. p. 631-700 In: J.J. Burns, J.J. Montague and C.J. Cowles (eds.), The bowhead whale. Spec. Publ. 2. Soc. Mar. Mamm., Lawrence, KS. 787 p.

Richardson, W.J. and D.H. Thomson (eds.). 2002. Bowhead whale feeding in the eastern Alaskan Beaufort Sea: update of scientific and traditional information. OCS Study MMS 2002-012; LGL Rep. TA2196-7. Rep. from LGL Ltd., King City, Ont., for U.S. Minerals Manage. Serv., Anchorage, AK, and Herndon, VA. xliv + 697 p. 2 volumes. NTIS PB2004-101568. Available from www.mms.gov/alaska/ref/AKPUBS.HTM#2002.

Richardson, W.J. and B. Würsig. 1997. Influences of man-made noise and other human actions on cetacean behaviour. Mar. Freshwat. Behav. Physiol. 29(1-4):183-209.

Richardson, W.J., M.A. Fraker, B. Würsig and R.S. Wells. 1985. Behaviour of bowhead whales, *Balaena mysticetus*, summering in the Beaufort Sea: reactions to industrial activities. Biol. Conserv. 32(3):195-230.

Richardson, W.J., B. Würsig and C.R. Greene, Jr. 1986. Reactions of bowhead whales, *Balaena mysticetus*, to seismic exploration in the Canadian Beaufort Sea. J. Acoust. Soc. Am. 79:1117-1128.

Richardson, W.J., B. Würsig and C.R. Greene Jr. 1990. Reactions of bowhead whales, *Balaena mysticetus*, to drilling and dredging noise in the Canadian Beaufort Sea. Mar. Environ. Res. 29(2):135-160.

Richardson, W.J., C.R. Greene Jr., W.R. Koski, M.A. Smultea, with G. Cameron, C. Holdsworth, G. Miller, T. Woodley and B. Würsig. 1991. Acoustic effects of oil production activities on bowhead and white whales visible during spring migration near Pt. Barrow, Alaska--1990 phase. OCS Study MMS 91-0037. Rep. from LGL Ltd., King City, Ont., for U.S. Minerals Manage. Serv., Herndon, VA. 311 p. NTIS PB92-170430.

Richardson, W.J., C.R. Greene Jr., J.S. Hanna, W.R. Koski, G.W. Miller, N.J. Patenaude and M.A. Smultea. 1995a. Acoustic effects of oil production activities on bowhead and white whales visible during spring migration near Pt. Barrow, Alaska—1991 and 1994 phases. OCS Study MMS 95-0051. Rep. from LGL Ltd., King City, Ont., for U.S. Minerals Manage. Serv., Herndon, VA. 539 p.

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

Richardson, W.J., T.L. McDonald, C.R. Greene Jr., and S.B. Blackwell. 2008a. Effects of Northstar on distribution of calling bowhead whales, 2001-2004. P10-1 to 10-44 *In*: W.J. Richardson (ed., 2008, q.v.). LGL Rep. P1004.

Richardson W.J., V.D. Moulton and T.L. McDonald. 2008b. Potential effects of Northstar activities on marine mammals and on their availability for subsistence. P. 14-1 to 14-23 *In:* W.J. Richardson (ed., 2008, q.v.). LGL Rep. P1004.

Ridgway, S.H. and D.A. Carder. 1995. Deep hearing and sonar studies of conditioned white whales *Delphinapterus leucas*. Abstr. 11th Bienn. Conf. Biol. Mar. Mamm., Orlando, FL, Dec. 1995:96. 148 p.

Rodrigues, R. and M.T. Williams. 2006. BP's activities at Northstar, 1999–2004. p. 2-1 to 2-45 In: W.J. Richardson (ed., 2008, q.v.).

Rodrigues, R. and W.J. Richardson. 2007. Introduction, description of BP's activities, and record of seal sightings, 2006. p1-1 to p1-20 *In:*W.J. Richardson (ed., 2007, q.v.).

Rodrigues, R., C.C Kaplan, and W.J. Richardson. 2006. Introduction, description of BP's activities, and record of seal sightings, 2005. p1-1 to p1-13 *In:*W.J. Richardson (ed., 2006 q.v.).

Ross, D. 1976. Mechanics of underwater noise. Pergamon, New York, NY. 375 p. Reprinted 1987, Peninsula Publ., Los Altos, CA.

Rugh, D.J. and M.A. Fraker. 1981. Gray whale (*Eschrichtius robustus*) sightings in eastern Beaufort Sea. Arctic 34(2):186-187.

Rugh, D.J., K.E.W. Shelden and D.E. Withrow. 1997. Spotted seals, *Phoca largha*, in Alaska. Mar. Fish. Rev. 59(1):1-18.

Rugh, D.J., R.C. Hobbs, J.A. Lerczak, and J.M. Breiwick. 2005. Estimates of abundance of the Eastern North Pacific stock of gray whales 1997 to 2002. J. Cetacean Res. Manage. 7(1):1-12.Scheifele, P.M., S. Andrew, R.A. Cooper, M. Darre, F.E. Musiek and L. Max. 2005. Indication of a Lombard vocal response in the St. Lawrence River beluga. J. Acoust. Soc. Am. 117(3, Pt. 1):1486-1492.

S.L. Ross Environmental Research Ltd. 1998. Blowout and spill probability assessment for the Northstar and Liberty oil development projects in the Alaskan North Slope. Final Rep. (November 1998). Prepared for BP Exploration (Alaska) Inc. by S.L. Ross Environmental Research Ltd., Ottawa, Ontario. Available at BPXA, P.O. Box 196612, Anchorage, Alaska, 99519-6612.

Southall, B.L., A.E. Bowles, W.T. Ellison, J.J. Finneran, R.L. Gentry, C.R. Greene, D. Kastak, D.R. 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. Aquatic Mammals 33(4): 415-521.

Stafford, K.M., S.E. Moore, M. Spillane, and S. Wiggins. 2007. Gray whale calls recorded near Barrow, Alaska, throughout the winter of 2003-04. Arctic 60(2): 167-172.

St. Aubin, D.J. 1990. Physiologic and toxic effects on pinnipeds. p 103-127 In: J.R. Geraci and D.J. St. Aubin (eds.), Sea mammals and oil confronting the risks. Academic Press, Inc., San Diego.

St. Aubin, D.J., R.H. Stinson and J.R. Geraci. 1984. Aspects of the structure of baleen, and some effects of exposure to petroleum hydrocarbons. Can. J. Zool. 62:193-198.

Sanders, H.L., J.F. Grassle, G.R. Hampson, L.S. Morse, S. Garner-Price and C.C. Jones. 1990. Anatomy of an oil spill: long-term effects from the grounding of the barge Florida off West Falmouth, Massachusetts. J. Mar. Res. 38:265-380.

Schevill, W.E. and B. Lawrence. 1949. Underwater listening to the white porpoise (*Delphinapterus leucas*). Science 109(2824):143-144.

Schlundt, C.E., J.J. Finneran, D.A. Carder and S.H. Ridgway. 2000. Temporary shift in masked hearing thresholds of bottlenose dolphins, *Tursiops truncatus*, and white whales, *Delphinapterus leucas*, after exposure to intense tones. J. Acoust. Soc. Am. 107(6):3496-3508.

Schlundt, C. E., R.L. Dear, D.A. Carder, and J.J. Finneran, 2006. Growth and recovery of temporary threshold shifts in a dolphin exposed to midfrequency tones with durations up to 128 s. J. Acoust. Soc. Am. 120, 3227.

Schusterman, R., D. Kastak, B. Southall and C. Kastak. 2000. Underwater temporary threshold shifts in pinnipeds: tradeoffs between noise intensity and duration. J. Acoust. Soc. Am. 108(5, Pt. 2):2515-2516.

Shepard, G.W., P.A. Kuumhansl, M.L. Knack, and C.I. Malme. 2001. ANIMIDA Phase I: Ambient and industrial noise measurements near the Northstar and Liberty sites during April 2000. BBN Technical Memorandum No. 1270 prepared for U.S. Department of Interior, Minerals Management Service, Alaska OCS Office.

Sjare, B.L. and T.G. Smith. 1986a. The relationship between behavioral activity and underwater vocalizations of the white whale, *Delphinapterus leucas*. Can. J. Zool. 64(12):2824-2831.

Sjare, B.L. and T.G. Smith. 1986b. The vocal repertoire of white whales, *Delphinapterus leucas*, summering in Cunningham Inlet, Northwest Territories. Can. J. Zool. 64(2):407-415.

Skalski, J.R., W.H. Pearson and C.I. Malme. 1992. Effects of sounds from a geophysical survey device on catch-per-unit-effort in a hook-and-line fishery for rockfish (*Sebastes spp*). Can. J. Fish. Aquatic Sci. 49:1357-1365.

Smith, T.G. 1973. Population dynamics of the ringed seal in the Canadian eastern arctic. Fish. Res. Board Can. Bull. 181. 55 p.

Smith, T.G. 1987. The ringed seal, *Phoca hispida*, of the Canadian Western Arctic. Can. Bull. Fish. Aquat. Sci. 216: 81 p.

Smith, T.G. and I. Stirling. 1975. The breeding habitat of the ringed seal (*Phoca hispida*). The birth lair and associated structures. Can. J. Zool. 53:1297-1305.

Smultea, M.A. and B. Würsig. 1995. Behavioral reactions of bottlenose dolphins to the Mega borg oil spill, Gulf of Mexico 1990. Aquat. Mamm. 21:171-181.

Spence, J. 2006. Controlling underwater noise from offshore gravel islands during production activities. NCE Report 06-003. Rep. from Noise Control Engineering Inc., Billerica, MA, for Minerals Management Service, Herndon, VA. MMS Noise Project #538.

Spraker, T.R., L.F. Lowry, and K.J. Frost. 1994. Gross necropsy and histopathological lesions found in harbor seals. p. 281-312 In: T.R. Loughlin (ed.), Marine mammals and the Exxon Valdez. Academic Press, San Diego, CA.

Stewart, B.S., F.T. Awbrey and W.E. Evans. 1983. Belukha whale (*Delphinapterus leucas*) responses to industrial noise in Nushagak Bay, Alaska: 1983. Outer Cont. Shelf Environ. Assess. Progr., Final Rep. Princ. Invest., NOAA, Anchorage, AK 43(1986):587-616. 702 p. OCS Study MMS 86-0057; NTIS PB87-192118.

Stirling, I. and T.G. Smith. 1977. Interrelationships of Arctic Ocean mammals in the sea ice habitat. p. 129-136 In: Proceedings of the Circumpolar Conference on Northern Ecology. Sect. II. Nat. Res. Counc. Can., Ottawa, Ont.

Stirling, I., M. Kingsley and W. Calvert. 1982. The distribution and abundance of seals in the eastern Beaufort Sea, 1974-79. Can. Wildl. Serv. Occas. Pap. 47. 25 p.

Suydam, R.S., R.P. Angliss, J.C. George, S.R. Braund and D.P. DeMaster. 1995. Revised data on the subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaska eskimos, 1973-1993. Rep. Int. Whal. Comm. 45:335-338.

Suydam, R.S., L.F. Lowry, K.J. Frost, G.M. O'Corry-Crowe and D. Pikok Jr. 2001. Satellite tracking of eastern Chukchi Sea beluga whales into the Arctic Ocean. Arctic 54(3):237-243.

Suydam, R., L. Lowry, K. Frost, G. O'Corry-Crowe and G. VanBlaricom. 2003. Satellite tracking of eastern Chukchi Sea beluga whales in the Beaufort Sea and Arctic Ocean, 1998-2002. Abstr. 15th Bienn. Conf. Biol. Mar. Mamm., Greensboro, NC, Dec. 2003:159.

Swartz, S.L. and M.L. Jones. 1981. Demographic studies and habitat assessment of gray whales, Eschrichtius robustus, in Laguna San Ignacio, Baja California, Mexico. U.S. Mar. Mamm. Comm. Rep. MMC-78/03. 34 p. NTIS PB-289737.

Thomson, D.H. and W.J. Richardson. 1987. Integration. p. 449-479 In: W. J. Richardson (ed.) Importance of the eastern Alaskan Beaufort Sea to feeding Bowhead whales, 1985-86. OCS Study MMS 87-0037. Rep. from LGL Ecological Research Associates, Inc., Bryan, TX, for U. S. Minerals Management Service. 547 p. NTIS PB88-150271.

Todd, S., P. Stevick, J. Lien, F. Marques, D. Ketten. 1996. Behavioral effects of exposure to underwater explosions in humpback whales (*Megaptera novaeangliae*). Can. J. Zool. 74:1661-1672.

Tomilin, A.G. 1957. Mammals of the U.S.S.R. and adjacent countries. Vol. 9. Cetaceans. Israel Progr. Sci. Transl. (1967), Jerusalem. 717 p. NTIS TT 65-50086.

Treacy, S.D. 1988. Aerial surveys of endangered whales in the Beaufort Sea, fall 1987. OCS Study MMS 88-0030. U.S. Minerals Manage. Serv., Anchorage, AK. 142 p. NTIS PB89-168785.

Treacy, S.D. 1989. Aerial surveys of endangered whales in the Beaufort Sea, fall 1988. OCS Study MMS 89-0033. U.S. Minerals Manage. Serv., Anchorage, AK. 102 p. NTIS PB90-161464.

Treacy, S.D. 1990. Aerial surveys of endangered whales in the Beaufort Sea, fall 1989. OCS Study MMS 90-0047. U.S. Minerals Manage. Serv., Anchorage, AK. 105 p. NTIS PB91-235218.

Treacy, S.D. 1991. Aerial surveys of endangered whales in the Beaufort Sea, fall 1990. OCS Study MMS 91-0055. U.S. Minerals Manage. Serv., Anchorage, AK. 108 p. NTIS PB92-176106.

Treacy, S.D. 1992. Aerial surveys of endangered whales in the Beaufort Sea, fall 1991. OCS Study MMS 92-0017. U.S. Minerals Manage. Serv., Anchorage, AK. 93 p.

Treacy, S.D. 1993. Aerial surveys of endangered whales in the Beaufort Sea, fall 1992. OCS Study MMS 93-0023. U.S. Minerals Manage. Serv., Anchorage, AK. 136 p.

Treacy, S.D. 1994. Aerial surveys of endangered whales in the Beaufort Sea, fall 1993. OCS Study MMS 94-0032. U.S. Minerals Manage. Serv., Anchorage, AK. 133 p.

Treacy, S.D. 1995. Aerial surveys of endangered whales in the Beaufort Sea, fall 1994. OCS Study MMS 95-0033. U.S. Minerals Manage. Serv., Anchorage, AK. 116 p.

Treacy, S.D. 1996. Aerial surveys of endangered whales in the Beaufort Sea, fall 1995. OCS Study MMS 96-0006. U.S. Minerals Manage. Serv., Anchorage, AK. 121 p. NTIS PB97-115752

Treacy, S.D. 1997. Aerial surveys of endangered whales in the Beaufort Sea, fall 1996. OCS Study MMS 97-0016. U.S. Minerals Manage. Serv., Anchorage, AK. 115 p. NTIS PB97-194690

Treacy, S.D. 1998. Aerial surveys of endangered whales in the Beaufort Sea, fall 1997. OCS Study MMS 98-0059. U.S. Minerals Manage. Serv., Anchorage, AK. 143 p. Published 1999.

Treacy, S.D. 2000. Aerial surveys of endangered whales in the Beaufort Sea, fall 1998-1999. OCS Study MMS 2000-066. U.S. Minerals Manage. Serv., Anchorage, AK. 135 p.

Treacy, S.D. 2002a. Aerial surveys of endangered whales in the Beaufort Sea, fall 2000. OCS Study MMS 2002-014. U.S. Minerals Manage. Serv., Anchorage, AK. 111 p.

Treacy, S.D. 2002b. Aerial surveys of endangered whales in the Beaufort Sea, fall 2001. OCS Study MMS 2002-061. U.S. Minerals Manage. Serv., Anchorage, AK. 117 p.

Treacy, S.D., Gleason, J.S., and Cowles, C.J. 2006. Offshore distances of bowhead whales (*Balaena mysticetus*) observed during fall in the Beaufort Sea, 1982–2000: An alternative interpretation. Arctic 59(1):83–90.

Tyack, P.L. and C.W. Clark. 1998. Quick look -- Playback of low frequency sound to gray whales migrating past the central California coast - January, 1998. Rep. from Woods Hole Oceanogr. Inst., Woods Hole, MA; and Bioacoustics Res. Prog., Cornell Univ., Ithaca, NY. 34 p. + Figures & Tables.

USACE. 1998a. Beaufort oil and gas development/Northstar Project: Environmental impact statement. Volume IV – Chapters 8-13. U.S. Army Corps of Engineers, Alaska. Anchorage AK.

USACE. 1998b. Beaufort oil and gas development/Northstar Project: Environmental impact statement. Appendix B - Biological Assessment. U.S. Army Corps of Engineers, Alaska. Anchorage AK.

von Ziegesar, O., E. Miller and M.E. Dahlheim. 1994. Impacts on humpback whales in Prince William Sound. p 173-191 In: T.R. Loughlin (ed.), Marine Mammals and the Exxon Valdez. Academic Press, San Diego.

Wacasey, J. W. 1975. Biological productivity of the southern Beaufort Sea: zoobenthic studies. Tech. Rep. 12b. Can. Dep. Environ., Beaufort Sea Proj. Victoria, B.C.

Wartzok, D., W.A. Watkins, B. Würsig and C.I. Malme. 1989. Movements and behaviors of bowhead whales in response to repeated exposures to noises associated with industrial activities in the Beaufort Sea. Rep. from Purdue Univ., Fort Wayne, IN, for Amoco Production Co., Anchorage, AK. 228 p.

White, M.J., Jr., J. Norris, D. Ljungblad, K. Baron and G. di Sciara. 1978. Auditory thresholds of two beluga whales (*Delphinapterus leucas*). HSWRI Tech. Rep. 78-109. Rep. from Hubbs/Sea World Res. Inst., San Diego, CA, for Naval Ocean Systems Center, San Diego, CA. 35 p.

Williams, T.M., G.A. Antonelis and J. Balke. 1994. Health evaluation, rehabilitation and release of oiled harbor seal pups. p 227-241 In: T.R. Loughlin (ed.), Marine Mammals and the Exxon Valdez. Academic Press, San Diego.

Williams, M.T. and J.A. Coltrane. (eds.). 2002. Marine mammal and acoustical monitoring of the Alaska Gas Producers Pipeline Team's open water pipeline route survey and shallow hazards program in the Alaskan Beaufort Sea, 2001. LGL Rep. 643. Rep. from LGL Alaska Res. Assoc. Inc. for BP Explor. (Alaska) Inc., ExxonMobil Production, a division of Exxon Mobil Corp., Phillips Alaska Inc. Anchorage, AK, and Nat. Mar. Fish. Serv., Anchorage, AK, and Silver Spring, MD. 103 p.

Williams, M.T., T.G. Smith and C.J. Perham. 2002. Ringed seal structures in sea ice near Northstar, winter and spring of 2000-2001. p. 4-1 to 4-33 In: W.J. Richardson and M.T. Williams (eds., 2001, q.v). LGL Rep. P485-2.

Williams, M.T., R. Rodrigues, V.D. Moulton, and S.B. Blackwell. 2006a. Summary of ringed seal responses during the break-up and open water period. P. 6-1 to 6-9 *In:* W.J. Richardson (ed., 2008, q.v.). LGL Rep. P1004.

Williams, M.T., V.D. Moulton, W.J. Richardson, and S.B. Blackwell. 2006b. Summary of results of overwintering ringed seals in relation to Northstar sounds P. 3-1 to 3-37 *In:* W.J. Richardson (ed., 2008, q.v.). LGL Rep. P1004.

Williams, M.T., C.S. Nations, T.G. Smith, V.D. Moulton and C. Perham. 2006c. Ringed seal (*Phoca hispida*) use of subnivean structures in the Alaskan Beaufort Sea during development of an oil production facility. **Aquatic Mammals** 32 (3): 311-324.

Woodby, D.A. and D.B. Botkin. 1993. Stock sizes prior to commercial whaling. p. 387-407 In: J.J. Burns, J.J. Montague and C.J. Cowles (eds.), The bowhead whale. Spec. Publ. 2. Soc. Mar. Mamm., Lawrence, KS. 787 p.

Woodward Clyde Consultants. 1995. Northstar Unit Beaufort Sea, Alaska: Literature Review.

Würsig, B. and C. Clark. 1993. Behavior. p. 157-199 In: J.J. Burns, J.J. Montague and C.J. Cowles (eds.), The bowhead whale. Spec. Publ. 2. Soc. Mar. Mamm., Lawrence, KS. 787 p.

Würsig, B., E.M. Dorsey, W.J. Richardson and R.S. Wells. 1989. Feeding, aerial and play behavior of the bowhead whale, *Balaena mysticetus*, summering in the Beaufort Sea. Aquat. Mamm. 15(1):27-37.

Würsig, B., E.M. Dorsey, M.A. Fraker, R.S. Payne, W.J. Richardson and R.S. Wells. 1984. Behavior of bowhead whales, *Balaena mysticetus*, summering in the Beaufort Sea: surfacing, respiration, and dive characteristics. Can. J. Zool. 62(10):1910-1921.

Zeh, J.E., C.W. Clark, J.C. George, D. Withrow, G.M. Carroll and W.R. Koski. 1993. Current population size and dynamics. p. 409-489 In: J.J. Burns, J.J. Montague and C.J. Cowles (eds.), The bowhead whale. Spec. Publ. 2. Soc. Mar. Mammal., Lawrence, KS. 787 p.

Zeh, J.E., A.E. Raftery, and A.A. Schaffner. 1996. Revised estimates of bowhead population size and rate of increase. Rep. Int. Whal. Comm. 46:670.