CHAPTER 9.0

EFFECTS OF NOISE ON THE BIOLOGICAL AND HUMAN ENVIRONMENTS

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9.1 INTRODUCTION

Chapter 9 provides background information on noise effects on marine mammals, fish, birds, terrestrial mammals, and subsistence harvesting. Reactions of project-related noise to wildlife and fish are described by animal group using information from Traditional Knowledge and data acquired from western science. Potential effects of project noise on subsistence species are addressed, largely through Traditional Knowledge, to identify potential impacts to subsistence harvesting.

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9.2 TRADITIONAL KNOWLEDGE

Traditional Knowledge is included in this Environmental Impact Statement (EIS) in acknowledgment of the vast, valuable body of information about the Arctic that the Inupiat people have accumulated over many generations. This knowledge contributes, along with western science, to a more complete understanding of the Arctic ecosystem. Although Traditional Knowledge has been accumulating for much longer than western science, it has been maintained orally and been recorded sporadically. While such transcriptions have occurred coincident to various research efforts, such efforts rarely have been focused directly on the topics of this EIS. Therefore, in this effort to collect references to Traditional Knowledge on specific topics such as likelihood of noise from the project displacing bowhead whales from traditional migration routes, the results are fragmentary and in no way represent the complete body of Traditional Knowledge on these topics.

Traditional Knowledge on the effects of noise was obtained from testimony by village elders, whaling captains, and other individuals from the villages of Barrow, Nuiqsut, and Kaktovik at the majority of hearings on North Slope oil and gas development projects held since 1979. Information also was obtained through personal interviews with interested individuals in and around the project area. Reviews of engineering studies and environmental reports associated with previous and ongoing oil and gas exploration and development activities provided a source of additional Traditional Knowledge. Published and unpublished scientific reports and data; and environmental reports and studies conducted by universities, the oil industry, federal and state agencies, and the North Slope Borough (NSB) also were used as sources for Traditional Knowledge.

Inupiat names are spelled according to the transcripts of the hearings, and some statements have been paraphrased to make the information readily understandable.

9.2.1 Introduction

The Inupiat Eskimos of northern Alaska have pursued the bowhead whale for generations during annual subsistence hunts. As a result, successive generations of Inupiat hunters have acquired an increasingly sophisticated knowledge of the ecology and behavior of these huge animals, particularly regarding the effects of noise on bowhead whale behavior. Hunters have observed the reaction of bowheads to noise, and have adapted hunting practices to minimize noise, particularly during the spring hunt. More recently, whaling captains and crews have observed the effects of seismic testing and associated noise on whale behavior and migration. Traditional and contemporary knowledge on noise and effects on whales are presented in this section.

9.2.2 Bowheads and Noise

It is well known among Inupiat hunters that bowhead whales are extremely sensitive to noise (H. Rexford in USDOI, MMS, 1979:13; R. Ahkivgak, H. Ahsogeak, and T. Brower in NSB, 1980:103, 104, 107; H. Brower in USDOI, MMS, 1990:10). Thomas Brower, Sr., a whaling captain from Barrow, testified that:

> *"In over thirty-six years of whaling I have seen how sensitive the bowhead whale is to noise and pollution .... whales are panicked by the sound [of an outboard motor] when I am as much as three miles away from them. I observe that in the fall migration the bowheads travel in pods of sixty to one hundred twenty whales. When they hear the sound of the motor, the whales scatter in groups of eight to ten .... in every direction"* (NSB, 1980:107).

John Craighead George, representing the NSB, pointed out, *"This is still a hunted animal, ... and animals that are hunted, ... are more shy and can be more easily frightened, particularly by marine boats, as they can't tell whether it's a hunting crew or just barge traffic."* (USDOI, MMS, 1983:57). Arnold Brower, of Barrow, noted: *"These whales communicate pretty much like any other animal communicates when there is an endangerment on their lives. [They] alert the other whales that there is an obstruction and noise or something in the area and abruptly there will not be any more migration of whales [in the area] for the duration of that particular time."* (USDOI, MMS, 1986:49). Thomas Napageak, a whaling captain and President of the Native Village of Nuiqsut, stated, *"... if the sound hurts the first whale, the leading whale* *in the migration ... will report to his fellow whales, and they will not be seen in their normal migration route."* (USDOI, MMS, 1995:13). Whaling crews have observed that after they make a strike, the resulting disturbance causes other whales to temporarily avoid the area, resulting in a small change in distribution of whales. *"Then everything goes quiet again and then the whales are distributed back to the way they were [prior to the strike]."* (J.C. George in USACE, 1996:64).

Effects from noise disturbances apparently continue even after the disturbance has subsided. Burton Rexford stated that it takes at least 2 weeks before the normal bowhead whale migration route is reestablished after such a disturbance (USACE, 1996:62). Noise from sources in the ice leads during the spring migration is apparently particularly disturbing (Worl, 1980:312).

Inupiat whalers have learned that bowheads will not tolerate short-term, high-stress disturbances; therefore, various precautions are taken prior to the start of the hunt, such as curtailment of noise from snowmachines, firearms, aircraft, and outboard motors and smoke-producing activities.

9.2.3 Short-Term Displacement of Bowheads Due to Noise Disturbance From Industry

Many Inupiat have observed that noise from oil and gas exploration and development adversely affects bowheads either by deflecting the fall migration or by causing the whales to become more wary. This displacement is a major cause of concern to Inupiat (G. Ahmaogak, 1995:4). A number of Inupiat men, with many years of experience hunting bowhead whales, have testified that short-term displacement and changes in behavior of bowheads is occurring as a result of noise disturbances. Frank Long, Jr., a whaling captain and President of Nuiqsut Whaling Captains Association, has been hunting bowhead whales since 1950. At the Minerals Management Service (MMS) Arctic Synthesis Meeting in Anchorage in 1995, he stated: *"I have been told from the time that I can remember that a whale will be startled or scared by a little sound. Even tapping on a boat will cause a whale not to surface. It will go farther out and leave you behind for sure."* (F. Long, Jr., 1996:73). He has also testified that: "*... during the fall when we're out on ice .... there are four leads that open up. And when the industry is heavy in their activity, we have to go all the way out to the fourth lead in order to meet our harvest .. quota."* (USDOI, MMS, 1995:24). However, bowhead whale harvest records indicate that three whales were landed at Nuiqsut during both 1992 and 1993, when offshore petroleum activities were occurring in the vicinity of the Kuvlum Prospect, 55 miles (88.5 kilometers [km]) to the east of Cross Island. The nature and duration of industry activity associated with Kuvlum, and the resultant effects on bowhead whale location and successful subsistence harvest during specific hunting periods is unclear. In 1995, Burton Rexford (MBC, 1996:80) stated, *"Throughout my 55 years of whaling ... I have observed ... the impact of underwater noise on bowhead whales."* In response to a statement in a draft EIS, that bowheads probably would avoid approaching within several kilometers of vessels attending a drilling unit, Arnold Brower testified that: *"The whale would not go out just several kilometers. It would go as far away as possible ... That's what we've encountered, and that happens over and over ever since offshore development began in Prudhoe Bay."* (USDOI, MMS, 1986:52).

Other Inupiat hunters with years of experience as members of whaling crews have also testified on the sensitivity of bowhead whales to noise. Jonas Ningeok of Kaktovik testified that, *"If the ships are* *around, [bowheads] don't come around at all, but if the ships are gone then they come back .... as long as there is noise they don't come around at all."* (USDOI, MMS, 1986:16). Frank Long, Jr., stated, *"Some years when there is a tremendous amount of activity in the Beaufort, especially ... [from] Prudhoe Bay all the way to Kuvlum . . ., it is very hard for us to harvest even one whale in a season, whereas when this activity is limited, it does not take us two weeks to ... meet our quota of four [bowhead whales]."* (USACE, 1996:34). Billy Oyagak, a whaler from Nuiqsut, stated that during fall 1985, interference from helicopters, ships, and drilling associated with Corona and Hammerhead drill sites made it difficult to find bowhead whales where they were normally found (USDOI, MMS, 1986:11). At the MMS Arctic Synthesis Meeting in Anchorage in 1995, Joseph Kaleak, a whaling captain from Kaktovik, stated: *"In 1985, no whales were landed [at Kaktovik]. That was due to the fact that there was a drill ship located about 18 miles east and ten miles offshore of Barter Island. So it was a bad year [for subsistence whaling at Kaktovik] because of that ship .... From 1992 to 1995 we had a very good whaling season, because there was no seismic survey activity and the whales were close to shore."* (MBC, 1996:69). Frank Long, Jr., (1996:73) has stated, *"It is very difficult to find even one bowhead whale when there is a lot of industrial activity."* Thomas Napageak testified that, *"We have ... never landed whales here in our community [Nuiqsut] ... when [offshore petroleum exploration] was underway."* (USDOI, MMS, 1995:13). However, bowhead whale harvest records indicate that three whales were landed at Nuiqsut during both 1992 and 1993, when offshore petroleum activities were occurring in the vicinity of the Kuvlum Prospect, 55 miles (88.5 km) to the east of Cross Island. The nature and duration of industry activity associated with Kuvlum, and the resultant effects on bowhead whale location and successful subsistence harvest during specific hunting periods is unclear. Noise and light from gas flaring at an oil rig, and light beams from the project may also disturb the migration, resulting in displacement of bowheads (L. Lampe in USACE, 1996:24).

Noise from seismic exploration is of special concern. Speaking on behalf of the Inupiat, Dr. Tom Albert, representing the NSB, stated, *"The noise that people are by far and away the most worried about is seismic marine exploration noise."* (USACE, 1996:70). Michael Pederson, of the Arctic Slope Native Association, concluded: *"Seismic noise from this proposed development [Northstar] will impact the migration route of the bowhead whale. The bowhead whale will be forced to swim further north, and most likely whaling crews ... will probably have to travel further out to sea to scout for bowhead whales."* (USACE, 1996:48).

Field observations by whaling crews support the notion that seismic noise displaces bowheads. During seismic exploration at Kuvlum in summer 1992, Inupiat whaling crews from Nuiqsut spotted no bowhead whales in the usual migration corridor, but observed that the main fall migration had shifted 40 miles (64 km) farther out to sea than during previous years (T. Napageak - Pers. Comm., Nuiqsut Whaling Captains Meeting, August 13, 1996:16). However, bowhead whale harvest records indicate that three whales were struck within 11 miles (17.7 km) of Cross Island during 1992. It is unclear whether industrial activities offshore may have caused temporary changes in normal migration patterns within the overall migration period. Billy Adams, a subsistence whaler born and raised in Barrow, stated: *"I can remember when a seismic ship was doing some work near Barrow during the fall whaling season. In that year [1986] we did not spot any whales, because the noise was disturbing the migration route of the bowhead whale."* (USDOI, MMS, 1995:26). Harry Brower, Jr., has stated, *"I've had personal observations [of] bowhead* *whales being diverted further out from shore due to seismic activity."* (USDOI, MMS, 1995:84). He used a Global Positioning System to record the position of locations where whaling crews had killed bowheads, and observed that when drill ships were around, whaling crews did not find bowheads where they normally occur, and crews had to travel farther offshore to hunt whales.

Eugene Brower, a whaling captain from Barrow and President of the Barrow Whalers, testified that:

> *"... not too long ago, we had that experience of the "Arctic Rose," a seismic boat that did a high frequency resolution study off Cooper Island. During that fall season, my fellow whalers had to go far out to go look for the bowhead whale. .... In the following year .. the platform drilling ship "Cabot" was put out there to do some drilling. Just from the noise from that drilling ship sitting idle, you could not find the bowhead whales where you normally find them. [The whalers] had to [go] farther and farther out, ... and the four whales that were caught, when the drilling platform was out there, were caught off Cape Simpson. That's almost 60 miles to the east of us ... When the seismic activity is going on to the east, ... the migration route off ... Barrow [is] farther out than the normal migration route"* (USDOI, MMS, 1995:29-30).

Herman Aishanna of Kaktovik, a representative of the Alaska Eskimo Whaling Commission (AEWC), stated: *".. we think [seismic activity] might be diverting the migration route of the bowhead ... I'm very opposed to the seismic boats at this time of the year when the bowheads are traveling back ..."* (USDOI, MMS, 1983:39). In 1995, Burton Rexford (MBC, 1996:80) stated: *"When the oil industry was doing seismic work during the fall migration, my two colleagues and their whaling crew members completely searched these above locations and beyond. The entire month of September was spent in our attempts to locate bowhead whales, resulting in nothing. Not only were there no bowheads, there also were no belukhas nor gray whales to be seen."*

Dr. Tom Albert, of the NSB, summarized the experiences of Inupiat hunters regarding the effects of seismic studies on bowhead whales by stating, *"The hunters that go out, feel that the reaction [of bowheads to seismic noise] is on the order of 10 miles or more."* (USDOI, MMS, 1995:41).

9.2.4 Long-Term Displacement of Bowheads Due to Noise Disturbance From Petroleum Exploration

Inupiat have repeatedly testified that long-term displacement of bowheads is occurring in response to industrial activity in the Alaskan Beaufort Sea. Inupiat whaling captain Patsy Tukle testified that: *"... the whales are going around the area [with offshore drilling]. They are not seen as they used to be any more. Helicopters are interfering and ... ships are [too]."* (USDOI, MMS, 1986:23). Joash Tukle, a whaling captain from Barrow, testified that: *"...since the offshore drilling started ... near Prudhoe or east of there ...during fall ... it would seem that the bowhead[s] [have] taken another route on the Arctic Ocean ... all this began to change as the offshore drilling started."* (USDOI, MMS, 1987:47). Eugene Brower, representing the Barrow Whaling Captains Association, stated, *"Bowhead[s] [will] be displaced from their route of migration from traffic and noise associated with the exploration and development of* *oil and gas."* (USDOI, MMS, 1987:15). Whaling crews are having to travel further distances out to sea to find bowhead whales, *"Leading to spoilage of meat because we have to go another 30 miles or 40 miles."* (D. Rexford in USACE, 1996:41). This increased distance also increases the risks to the whalers, and can contribute to spoilage of meat before the whale can be butchered.

John Craighead George, representing the NSB, has stated: *"For years I have heard whalers say that industrial noise displaces bowheads in the fall migration ... and I am more and more convinced that there is a big difference between a short-term strong disturbance [from the hunt] and a long-term continuous low-level disturbance [from industrial activity]."* (USACE, 1996:63). George Ahmaogak Sr. (1989:595-596), former Mayor of the NSB, stated that, *"We [Inupiat] feel that industrial noise, especially noise due to seismic exploration, has already displaced the fall migrants seaward and is thereby interfering with the subsistence hunt at Barrow."*

Loren Ailers of Kaktovik, representing the City Council, summarized the feelings of many Inupiat who have been testifying at hearings since 1979 by stating that oil and gas exploration would, *" ... have long-term and possibly devastating effects on the bowhead whale."* (USDOI, MMS, 1982:8).

9.3 INTRODUCTION TO SOUND

The effect of industrial noise associated with the project on marine mammals, terrestrial mammals, and birds was a concern raised during the scoping process. A general discussion of noise is provided in this section to assist the reader in understanding potential effects which may result from this noise.

Sound generally is characterized by a number of variables including frequency and intensity. Frequency describes a sound's pitch and is measured in Hertz (Hz), while intensity describes a sound's loudness and is measured in decibels (dB). Hertz is a measure of how many times each second the crest of a sound pressure wave passes a fixed point. For example, when a drummer beats a drum, the skin of the drum vibrates a number of times per second. A particular tone which makes the drum skin vibrate 100 times per second generates a sound pressure wave that is oscillating at 100 Hz, and this pressure oscillation is perceived as a tonal pitch of 100 Hz. Sound frequencies between 20 and 20,000 Hz are within the range of sensitivity of the best human ear, and the decibel level measured is called the A-weighted sound level (dBA).

Sounds from a tuning fork (a pure tone) contain a single frequency, but most sound sources contain a mixture of many different frequencies. For noisy industrial sources, sound energy usually is distributed across a wide spectrum of frequencies.

Decibels are measured using a logarithmic scale such that an increase of 3 dB represents a doubling of noise intensity. The decibel is a relative measure of intensity, and it is always referenced to a standard level. Sound intensity measured in air uses a standard level of 20 microPascal (μPa), while sound intensity measured in water uses a standard level of 1 μPa. The distinction between in-air and in-water reference levels is important since sound intensity in water would appear extremely high compared to values in air. Values of sound intensity are always specified in terms of their reference level. For example, one might read that the in-air intensity of a fog horn was 130 dB relative to 20 μPa, while the in-water intensity of a boat was 142 dB relative to 1 μPa. The actual in-air equivalent of the ship's intensity, given the differences in reference levels and in the densities of air and water, would be 80 dB. Using the in-air standard, 120 dB is the threshold of pain for humans, and the equivalent sound energy level in water (but not necessarily the threshold of pain) would be 182 dB. The relationship between sound pressure level (SPL), in dB, and sound pressure, in μPa, is a relatively simple one. SPL equals 20 times the logarithm (base 10) of a given SPL (P) divided by the reference pressure (Po):

SPL = 20 log (P/Po) (Richardson et al., 1995a:19).

Sound levels for noise sources are usually reported as the sound level at 3 feet (ft) (0.9 meters [m]) from the source, referred to as the “source level,” or the sound level at a known distance from the source, referred to as the “received level.” Source levels usually are estimated rather than measured, using a measured received level at a known distance from the source. Source level estimation relies on using some model of reduction of sound (attenuation) as a function of distance from the source. For low frequency sounds in shallow water, such as the nearshore Alaskan Beaufort Sea, sound attenuation is complex and best determined from empirical measurements.

Most environmental noise includes a conglomeration of noise from distant sources that create a relatively steady background noise in which no particular source is identifiable. A single descriptor called the “equivalent sound level” is used. Equivalent sound level is the energy-mean sound level during a measured time interval. It is the 'equivalent' constant sound level that would have to be produced by a given source to equal the fluctuating level measured.

9.4 EXISTING NOISE ENVIRONMENT (AMBIENT NOISE)

Ambient noise is background noise that clutters, masks, or otherwise interferes with sounds of interest. Ambient noise is a key element in the analysis of the effects of petroleum development on marine mammals because, in both air and water, natural and human made sound sources contribute to the ambient noise field. Most of these sounds are continuous and fluctuating, but some are short-term. For an animal attempting to use sound for a purpose, for example, one whale trying to hear the calls of a distant whale, ambient noise in the marine environment is the background over which an animal must hear sounds of interest.

Naturally-occurring ambient noise consists of sounds from sources such as wind, rain, breaking waves, bubbles, earthquakes, turbulence from currents, certain types of marine life and, in the Arctic, ice (moving and breaking). Surf noise in nearshore areas may contribute to increased ambient noise levels, but few data have been collected to document this. Marine life also contributes to ambient noise, since many species, such as snapping shrimp, seals, and whales, produce underwater noise. Ambient noise sources in the Arctic are variable depending on season, primarily waves and marine life during summer and grinding ice and blowing snow during winter.

The ambient noise environment onshore would vary with location and is dependent on the type of noise source, distance to a source, meteorological conditions, and ice/snow cover. Ambient noise levels in remote areas without manmade sources may be less than 40 dBA. Processing and compressor equipment, separators, pumps, generators, and vehicles within the Prudhoe Bay industrial complex are dominant noise sources throughout much of the area, and noise levels are dependent upon the mix of equipment types, local meteorological conditions, equipment operating conditions, and receptor locations. Locations near processing and compressor facilities, such as the Central Compressor Plant and activities in the vicinity of field operations or administration centers, would have consistently higher ambient noise levels than those of undeveloped areas, such as Point Storkersen and the Kuparuk River delta.

Underwater ambient noise levels at and near the vicinity of the Northstar Unit have been documented. In September 1984, hydrophones were placed in three different locations on the seafloor at distances of 1 to 1.5 miles (1.6 to 2.6 km) north and east of Seal Island and monitored hourly for a 9-day period (Davis et al., 1985:4). Activity in the vicinity of Seal Island and Prudhoe Bay during the monitoring period was limited to occasional boat traffic. No drilling or other operations were occurring in the area. In absence of boat traffic, sound levels tended to reflect wind speed. As wind speed increased, underwater noise levels increased (Davis et al., 1985:28). Ambient noise levels ranged from 79 to 123 dB, with 50 percent (%) of the measured values in the 20 to 1,000 Hz band occurring at 95 dB or less (Davis et al., 1985:32).

A second ambient noise study was conducted in September 1985 near the newly constructed Sandpiper Island and approximately 10.5 miles (17 km) north-northwest of Seal Island. Hydrophone data was collected at 0.6 miles (1 km) and at 0.3 miles (0.5 km) northeast of Sandpiper Island (Johnson et al., 1986:6). Because of industrial noise emanating from nearby Seal Island, ambient noise levels did not decrease much below 86 to 90 dB even under calm conditions, and when operations on the island were limited to the use of power generators, twice daily helicopter flights, occasional construction activities, and occasional tug-propelled barge traffic (Johnson et al., 1986:45). Ambient noise levels were between 83 and 115 dB, and 50% of the noise levels were at or less than 95 dB in the 20 to 1,000 Hz band. Wind speed during the period ranged from 20 to 40 knots (37 to 44 km/hour), thus accounting for some wave-generated noise at the site.

A third study of ambient noise was conducted in September 1985 at a site 1.5 miles (2.4 km) southeast of Sandpiper Island. Of the ambient noise levels recorded in the 100 to 1,000 Hz band using two hydrophones, 50% were below 76 and 83 dB at the 10 and 33 ft (3 and 10 m) depths, respectively (Miles et al., 1987:286-287). During the monitoring period, ambient noise levels were not influenced by industrial activity (Miles et al., 1987:81); however, wind speed averaged 10 to 15 knots (18.5 to 28 km/hour).

In the shallow arctic environment, received levels for seismic pulses are highly dependent on sound transmission (propagation) conditions, depth of water at the seismic source, depth of water at the receiver, depth of the receiver, and ambient noise level (Greene et al., 1998:3-61). Received levels at ranges beyond approximately 12.4 miles (20 km) were difficult to predict and there was no obvious dependence of received level on distance (Greene et al., 1998:3-19 to 3-20). Received levels for seismic pulses have been recorded above background noise at ranges of 74.5 to 84 miles (120 to 135 km) (LGL and Greeneridge, 1987:109; Hall et al., 1994:149-150). Around the Northstar Unit, received levels for distances greater than 6.2 to 10 miles (10 to 16 km) were highly variable. In 1996, received levels for seismic pulses at 41 miles (67 km) from an 11-airgun array were around 77 dB, but these pulses were detectable only on days with low ambient noise levels (Greene, 1997: 3-38 to 3-41). In 1997, the received levels of seismic pulses at 31 miles (50 km) from a smaller array were 80 to 115 dB (Greene et al., 1998:3-15 to 3-19, 3-62).

Noise at frequencies between 20 and 1,000 Hz is of special interest for this project because many sounds produced by arctic marine mammals are in this frequency range. Bowhead whale calls occur mostly between 80 and 400 Hz (Clark and Johnson, 1984:1437-1439; Würsig and Clark, 1993:664). Frequencies in the 50 to 500 Hz band have better than average transmission in shallow arctic waters and could affect a larger area than sounds in other frequencies.

Many mammals are unable to detect sounds of interest (e.g., calls from other animals) if strong background noise is present and contains frequencies near those of the sound of interest. This phenomenon is referred to as "masking." An example of masking is noise from a refrigerator making it more difficult to hear someone talking in an adjacent room. The masking band width is approximately 23% of the center frequency of a sound, and is typically referred to as the "1/3 octave band". Background noise within 23 Hz of the 100 Hz frequency could interfere with a whale's ability to detect the call of a distant whale in the band centered at 100 Hz.

The noise level from a source when measured within a few feet of the surface is 15 to 30 dB lower than the noise level when measured at water depths of 16 to 33 ft (4.9 to 10 m) (Jensen, 1981:1397). This indicates that exposure to noise would occur at the highest levels when an animal is well below the surface.

An acoustical monitoring program that evaluated noise transmission loss in the water near Seal Island was conducted during the 1996 Northstar seismic program. Resulting data were analyzed and it was concluded that the relatively shallow water surrounding Seal Island has a substantial reducing effect on received noise level (Greene, 1997:3-29).

9.5 AFFECTED BIOLOGICAL NOISE RECEPTORS

This section discusses reaction to noise by marine mammals, marine and freshwater fish, birds, and terrestrial mammals which may be in the project area.

9.5.1 Marine Mammals

The evaluation of impacts on animals requires interpretation and integration of results from many disciplines, including the study of sound wave interaction with the environment; how animals hear sounds; and how animals use sounds for communicating, navigating, and finding food. The evaluation and prediction of noise impacts on marine mammals is particularly difficult due to complications from unpredictable animal behavioral responses (Green et al., 1994:17-18). Therefore, information presented in this section is based on available western science data which is limited to discrete studies, and

Traditional Knowledge that has been gained by the Inupiat over generations.

9.5.1.1 Bowhead Whale - Responses to Noise

It is well known among Inupiat hunters that bowhead whales are extremely sensitive to noise (H. Rexford in USDOI, MMS, 1979:13; R. Ahkivgak, H. Ahsogeak, T. Brower, Sr. in NSB, 1980:103, 104, 107; H. Brower in USDOI, MMS, 1990:10). The bowheads sensitivity to noise has been attributed to hunting pressures from subsistence harvesting, as well as industrial noise (J. Craighead George in USDOI, 1983:57). Noise from an outboard motor at a distance of 3 miles (4.8 km) has been found to cause pods of whales to scatter and small sounds such as tapping on a boat can cause diving and avoidance reactions (T. Brower, Sr. in NSB, 1980:107; F. Long, Jr., 1996:73).

The potential impact of industrial noise on bowhead whales comes from the assumption that these animals rely heavily on sound as a means of communicating and navigating in the Arctic. Bowheads produce most of their vocalizations in the 50 to 400 Hz band, and there is circumstantial scientific evidence demonstrating that bowheads use sounds for communicating and navigating (Clark et al., 1986:345-346; Clark, 1991:578-579; George et al., 1989:24; Ellison et al., 1987:329; Würsig and Clark, 1993:192). Underwater sounds from industry are predominantly in the 50 to 1,000 Hz frequency band, and lower frequencies, especially those in the 100 to 400 Hz band, propagate efficiently in the shallow water, arctic environment (Greene, 1997:3-12 to 3-41). There is no direct evidence of bowhead auditory abilities; however, indirect evidence of auditory ability comes from studies of vocalizations (Clark and Johnson, 1984:1437-1439) and ear anatomy of large whales (Ketten, 1992:727-738). This evidence strongly supports the conclusion that bowheads have very good hearing for frequencies below approximately 400 Hz and, therefore, could be disturbed by industrial noise sources.

The response of a bowhead whale to acoustic disturbances is quite variable and depends on a number of biological factors, including the activity that the whale is engaged in at the time of the exposure to the noise. This dependency of behavioral response on the social activity of the animal is important since bowheads will be migrating past, but well offshore of, the project area in the spring and past, but closer to, the project area in the fall. Communications among whales during migration and in response to danger also has been observed to alter migration patterns (A. Brower in USDOI, MMS, 1986:49; T. Napageak in USDOI, MMS, 1995:13). Whaling crews have observed that disturbances to migration as a result of a strike, a short-term event, are temporary (J.C. George in USACE, 1996:64); however, industrial noise from the project would be continuous and long-term.

Two other behavioral responses, habituation and sensitization, also are important when discussing the potential reactions of bowheads to multiple exposures to a noise stimulus. Habituation refers to the condition in which repeated experiences with a stimulus that has no important consequence for the animal leads to a gradual decrease in response. Sensitization refers to the situation in which the animal shows an increased behavioral response over time to a stimulus associated with something that has an important consequence for the animal (Walker, 1949 as cited from Richardson et al., 1995a:250).

Seismic survey activities are not part of the project. They are, however, among the loudest noises in the region and are of concern to local residents and governmental agencies. Therefore, information related to seismic survey activities and their impacts to marine mammals are included in this chapter.

Seismic surveys can be conducted using either a hydraulic vibrator system (vibroseis) for on-ice seismic exploration, or a ship-based systems. Both systems generate short, intense bursts of underwater energy which may propagate for great distances.

The vibroseis system for seismic exploration operates from trucks driven over the ice. The system has a source level in water exceeding 184 dB (Cummings et al., 1983:419) and uses a slow sweep of frequencies to change the vibration rate, in contrast to the rapid explosion of ship-based systems described below (Richardson et al., 1995a:143).

Ship based systems for seismic exploration include sleeve exploders, open-bottom gas guns, and airguns, with airguns being the most common type of high energy source used in geophysical surveys (Richardson et al., 1995a:136-144). Sleeve exploders are cylindrical devices deployed under the water surface behind the ship. The cylinders contain a mixture of propane and oxygen which is exploded to produce a strong signal focused downward. Received sound levels of 148 to 153 dB have been recorded at 5 miles (8 km) and 115 to 117 dB at 16 to 18 miles (26 to 29 km) from a sleeve exploder (Greene and Richardson, 1988:2249). Propagation of seismic acoustic energy through the water depends on a number of variables, including sound velocity profile, water depth, and bottom composition. The maximum range out to which seismic noise is detectable is a function of source level (e.g., number of guns in the array), frequency, and ambient noise level at the location of the receiver. Open-bottom gas guns produce received levels of 177 dB at a distance of 0.5 miles (0.8 km) and 123 dB at a range of 9 miles (14.5 km) (Greene and Richardson, 1988:2250). A third type of device used for seismic studies is the air gun. Airgun arrays have a variety of source levels, depending primarily on the number of airguns in the array and the total volume of each airgun (Richardson et al., 1995a:137). Airgun arrays are designed so that most of the energy propagates downward, so there is a difference in the vertical and horizontal characteristics of the sound field generated by an airgun array. Richardson et al. (1995:136) provides an equation for calculating source levels (Ls) based on peak-to-peak pressure (Pa):

$$Ls\ (\text{dB re } 1\ \mu\text{Pa-m}) = 20\ \text{Log}\ (Pa) + 220$$

In general, peak-to-peak pressure is directly proportional to total volume of the array, for example, a 1,000 in 3 airgun has a level that is 6 dB greater than a 500 in 3 airgun.

With respect to the potential effects of seismic impulses on bowhead whales, the characteristics of the seismic sound as received by the whale are of greater importance than the airgun array's source level. For seismic sources, received level, frequency content, and signal-to-noise level (ratio of seismic received level to ambient noise level) have been the acoustic characteristics of greatest interest. Single airguns have lower source levels than most arrays, producing levels of 129 dB at a distance of 3 miles (4.8 km). Received levels of 148 to 179 dB have been measured from airgun arrays at distances of 1.2 to 7 miles (1.2 to 11.3 km) (Greene, 1988:2252).

Recent analysis of empirical data collected during seismic operations in the project area provide the most appropriate information on estimating the propagation ranges for seismic pulses (Greene, 1997:3-12 to 3-41). An important conclusion was that both the frequency content of the propagating airgun signals and the rate of fall-off with range were substantially affected by the water depth in the shallow waters of the survey area (Greene, 1997:3-26). Using an empirically verified model, the estimated received levels at 2.6 miles (4.2 km) for an array of 11 airguns operating at a source level of 222 dB was 160 dB (Greene, 1997: 3-37).

As discussed previously in Section 9.4, received levels for airgun arrays have been difficult to predict at ranges beyond 6.2 miles (10 km). In 1996 and 1997, Greeneridge Sciences, Inc. collected extensive field measurements in the Northstar Unit area and documented the characteristics of seismic pulses as a function of distance from the airgun array (Greene et al., 1998). They also measured ambient noise to help predict the percentage of time that seismic pulses would be greater than ambient noise levels at different ranges. They concluded that received levels were highly variable, especially at distances greater than 6.2 miles (10 km) and that detection of the seismic pulses was even more variable because of the high variability in ambient noise (Greene et al., 1998:3-61). For both years, although different airgun systems were used and water depths varied, there was generally good agreement between the received level at different ranges as estimated from a least squares fit to the empirical data. The received levels of the best fit at different ranges were as follows:

- At 6.2 miles (10 km) - 127 to 132 dB with a range of 110 to 144 dB.
- At 12.4 miles (20 km) - 114 to 116 dB with a range of 96 to 131 dB.

- At 18.6 miles (30 km) - 105 to 106 dB with a range of 86 to 123 dB.
- At 24.8 miles (40 km) - 97 dB with a range of 78 to 116 dB.
- At 31 miles (50 km) - 90 to 91 dB with a range of 72 to 110 dB.

For bowheads, as with most animals, there is a general tendency for the level of response to manmade noises to match the level of variability and unpredictability in the sound source. Animals will show little to no response to a noise source with a relatively constant intensity level and frequency spectrum (e.g., a humming generator, operational drilling platform) but will react to a noise source that is rapidly changing in intensity or in frequency content (e.g., an exploration drilling platform, icebreaking activity).

Drilling Noise: Bowhead whale responses to noises from drilling activities are expected to depend on the type of activity and its location relative to the whales' normal migration corridors. Noise levels from a gravel drilling island are expected to be low (Richardson et al., 1995a:127). Measured noise levels in the 20 to 1,000 Hz band have been less than 109 dB, with highest noise level components below 200 Hz, and detectable under very quiet conditions only out to ranges of less than 0.6 to 6.2 miles (1 to 10 km) (Johnson et al., 1986:49; Malme and Mlawski, 1979:1). Noise source levels of top-drive rigs operating on gravel islands seem lower than for other types of equipment (Richardson and Malme, 1993:647). There are too few observations of whales near drilling islands to reach a conclusion based on direct evidence. Between September 24 and 26, 1984, three bowheads were reported 3.1 miles (5 km) east-southeast of Seal Island, more than a week after termination of exploratory drilling and during a period with only maintenance activities (Davis et al., 1985:1, 64). The study concluded that the bowhead migration pattern had not been altered as a result of drilling noise or the presence of maintenance activities; however, only a small number of whales were observed in the study and the observation of whales near the drill site was made a week after drilling activities stopped.

Bowheads will tolerate high noise levels when there are no alternatives to avoiding the high noise level (for example, when heavy ice constrains their ability to move into lower noise areas). However, when noise levels become too high or the noise is highly variable and unpredictable and other routes are available, whales will avoid moving through noisy areas. Inupiat hunters have reported that bowheads have been displaced offshore by drilling and seismic activity and avoid areas of high noise created by these activities (G. Ahmaogak, 1985:29; 1989:595-596; 1995:4; D. Rexford in USACE, 1996:41). These observations have been supported in some cases by aerial and acoustic survey results (LGL and Greeneridge, 1987:12; Miller et al., 1997:5-107).

There are no conclusive empirical data for directly evaluating the potential impact of BP Exploration (Alaska) Inc.'s (BPXA's) proposed drilling program on bowhead whales. A partial study was conducted in 1984 off Seal Island during and after drilling and well-logging operations, but sample sizes were too small to draw firm conclusions about either changes in bowhead distribution or behavioral responses (Davis et al., 1985:62-64). Studies have been conducted evaluating the potential impact of other types of drilling activity, including an offshore drillships (LGL and Greeneridge, 1987) and the floating drill rig Kulluk (Hall et al., 1994). Conclusions from these studies, although not directly applicable to the drilling program for BPXA's proposed project, provide some general insight into the impacts of offshore drilling operations on bowheads. For BPXA's proposed project, noise levels are expected to be much lower than those from offshore drillships or floating rigs operations and, therefore, potential impacts are expected to be less.

An obvious response of bowhead whales to noise from drillship drilling operations was observed in 1986 at the Corona and Hammerhead sites, approximately 60 miles (97 km) east of the project site, when monitoring was conducted up to 18.6 miles (30 km) from the drill site (LGL and Greeneridge, 1987:41). One whale appeared to avoid an active drill ship by moving in an arc around it, maintaining a distance of 13 to 15 miles (21 to 24 km). No bowheads were observed closer than 6 miles (9.7 km) from the drillship; a few were observed within 9 miles (14.5 km). Overall, the study concluded that migrating bowheads appeared to avoid the offshore drilling operation (LGL and Greeneridge, 1987:47).

Apparent avoidance reaction of bowheads to drilling operations was noted during the 1992 Kuvlum drilling project. None of the 49 whales seen during 141 hours of aerial survey were within 18.6 miles (30 km) of the drilling site, and the average distance was about 24.8 miles (40 km) (Hall et al., 1993:2-3). The whales also moved past the area of industrial activity in a narrow corridor to the north of the drilling location (Hall et al., 1993:66). Bowhead calling rates peaked at 20 miles (32 km) from the drilling area. This distance was close to the range at which the observed whales started deviating in an arc north of the drilling unit, suggesting that the whales were attempting to maintain social cohesion and group coordination before initiating the deviation (Hall et al., 1993:68). This apparent displacement continued until about 18.6 miles (30 km) west of the industrial activity, where migrating bowhead whales again formed a dispersed pattern (Hall et al., 1993:67). Although interpretation of these results was confounded by heavy ice conditions, the authors concluded that floating drilling units may cause bowheads to shift their migration distribution (Hall et al., 1993:46-48).

Bowhead whales showed no avoidance of an idle bottom-founded drilling platform during monitoring of the Fireweed prospect (Hall et al., 1991:33-38). Results from a second study with the same platform during a period when generators and pumps were running but drilling was not underway showed no obvious avoidance of the platform (Gallagher et al., 1992:41-72).

Aircraft Noise: Bowhead response to helicopters and airplanes varies with social context, distance from the aircraft, and aircraft altitude. Whales often react to an aircraft as though startled, turning or diving abruptly when the aircraft is overhead. Bowheads seem particularly responsive when they are in shallow water, which may be a result of the efficient generation of aircraft sounds in shallow water (Richardson et al., 1995a:249). Bowheads sometimes seem startled by the shadow of a plane rather than its noise. When whales are at the surface, they may detect the sound of an aircraft in the air rather than the water.

Bowhead whales reacted to a circling piston-engine aircraft frequently when it was less than 1,000 ft (305 m) altitude, infrequently when it was at 1,500 ft (457 m), and rarely when it was at greater than 2,000 ft (610 m) (Richardson et al., 1995a:249). Bowheads in shallow water were reported to be especially responsive to airplane noise, with the most obvious response being a rapid dive. Bowheads seem less responsive to helicopters, even at altitudes as low as 500 to 750 ft (150 to 230 m) (Richardson and Malme, 1993:668).

Vessel Noise: Avoidance reactions of bowhead to small boats have been observed at distances up to 2.5 miles (4 km), but most reactions have been observed at ranges of less than 1.2 mile (2 km), often when measured levels of underwater noise were less than 90 dB in the 1/3 octave band of maximum noise (Richardson et al., 1985 as cited from Richardson et al., 1995a:268). The strongest responses are for whales observed within 0.6 miles (1 km) of an approaching vessel.

Inupiat hunters have reported that bowheads are frightened by vessel noise and that bowheads would avoid approaching vessels that are attending a drilling vessel. Furthermore, hunters have noticed that whales are not present when vessels are present, but return in the absence of vessel operations. Hunters also believe that whales will avoid areas with ship activity by traveling as far as possible from the activity (A. Brower in USDOI, MMS, 1986:52; J. Ningeok in USDOI, MMS, 1986:16).

Bowheads respond to boats by spending less time at the surface, taking fewer breaths when surfacing, and changing swimming speed and direction at distances of at least 2.5 miles (4 km) from the vessel (Richardson et al., 1995a:116; Koski and Johnson, 1987:59-61). In one case a mother and calf reacted when the nearest approaching vessel was approximately 9.3 miles (15 km) away. Operating icebreakers appear to elicit the strongest avoidance responses from bowheads compared to other manmade noise sources (icebreaking barge/tug combinations make less noise than traditional icebreaking vessels; Section 9.7.4). Of 49 bowhead whales observed during the 1992 Kuvlum drilling operations, none were observed closer than 14 miles (22.5 km) from an icebreaker operating at the site, and bowhead calling rates peaked at 20 miles (32 km) from the drilling area (Hall et al., 1993:66-69). This distance was close to the range at which the observed whales started deviating in an arc north of the drilling unit (Hall et al., 1993:68). It should be noted that the year the field work was carried out (1992) was a very heavy ice year, and ice floes several miles across surrounded the icebreaker. Because of the complicating factors of ice and industrial activity, the authors of the report were unable to determine whether ice or industrial activity caused the whales to migrate to the north of the project site. They did, however, state that ice alone was unlikely to have caused the whales to arc north of the site.

Whales usually avoid an approaching vessel by trying to outswim it, and response is probably mediated more by the rate of increase in the noise level than by the absolute received level. If overtaken, the whale will turn to swim away from the path of the vessel. Bowheads seem to respond differently to a vessel depending on whether it is approaching, moving slowly, or stationary (Richardson et al., 1995a:268-270). Overall, bowheads seem to consistently stop whatever they are doing and flee from approaching vessels of all types and sizes. In contrast, vessels that are idling, moving slowly, or not approaching in the direction of a whale do not cause this flight response (Richardson et al., 1995a:268-270).

Seismic Survey Noise: Although quantitative estimates are not available, in all likelihood seismic survey sounds are among the loudest and most prevalent of any industrial noise source, are the most ubiquitous industrial noise source, and introduce more total sound energy into the arctic water than any other industrial noise source. Furthermore, a seismic survey impulse is a sound with enough acoustic energy to cause physical harm to a nearby marine mammal ear (Ketten, 1992; Ketten et al., 1993). Bowhead whales are possibly the most sensitive marine mammal to seismic survey sounds because their hearing is expected to be the most sensitive to low frequency noise (i.e., 100 to 400 Hz) that can propagate over long distances. However, this does not necessarily mean that bowheads are the species most susceptible to biological impact.

Although BPXA's proposed project does not include seismic surveys, information on whale reactions to seismic survey noise could be relevant. Recent data on seismic noise transmission and bowhead responses to seismic operations in the Northstar Unit have come from monitoring efforts carried out as part of the 1996 and 1997 BPXA Seismic Survey project (Richardson, 1997, 1998). These results show that no whales were seen within 13 miles (21 km) of the seismic site during active seismic periods, but numerous whales were seen within 1.2 to 12.4 miles (2 to 20 km) of the site during periods without active seismic operations (Richardson, 1998:5-60 to 5-62). Richardson (1998) concluded that these "results suggest that bowheads avoid waters near seismic operations." Traditional Knowledge of bowhead hunters includes strong impressions about the reactions of bowheads to seismic survey activities (T. Napageak in USDOI, MMS, 1995:13; B. Adams in USDOI, MMS, 1995:26; H. Brower, Jr. in USDOI, MMS, 1995:84; B. Rexford in MBC, 1996:80; E. Brower in USDOI, MMS, 1995:41; 17 Whalers in MBC, 1997:Attachment C).

There have been various efforts to document the type and level of responses that bowheads have to seismic survey noise. Some have relied on visual observations from an airplane or vessel to look for avoidance response or changes in distribution, and some have included acoustic monitoring to document changes in vocal behavior, as well as to measure sound levels at known distances from the seismic activity.

In 1984, the MMS supported a study during which bowhead groups were observed for up to several hours prior to the operation of a seismic vessel and then during the approach of that vessel while operating its seismic array. Obvious responses were noted. Some animals responded when the vessel was less than 6 miles (9.7 km) away, and one group showed strong avoidance at a distance of 3.1 miles (5 km) from the operating seismic vessel (Ljungblad et al., 1985:45). The most obvious responses of bowheads to the approach of the vessel were changes in dive and surface behaviors, which occurred at ranges of up to 6 miles (9.7 km). When seismic operations were within 1 mile (1.6 km) of the whales, they swam rapidly away from the vessel. Interpretation of these results, in terms of bowhead response range to seismic vessels when surveys were being conducted, is complicated by a lack of control data since other seismic vessels were operating during all phases of the experiments. Therefore, the maximum distance out to which whales were observed consistently responding should be considered the minimum range within which responses occur. Results of the study were presented to the International Whaling Commission Scientific Committee in 1984. After review, the committee recommended that additional research be conducted and the results of the 1984 study be subjected to rigorous re-analysis.

There are important recent results indicating that bowheads respond to seismic operations. Acoustic call counts from bottom-mounted recorders operating during 1996 seismic survey operations, indicate that bowhead call rates change depending upon the range from the seismic operation and whether seismic activities were occurring or not occurring. Bowhead call rates from the bottom-mounted recorder operating closest to the seismic operation were lower during hours with seismic operations than during hours without seismic operations, while call rates from the recorder furthest from the seismic activity were more than twice as high when seismic operations occurred than when it did not occur (Greene et al., 1998:3-57). These results suggest that some bowheads diverted offshore when passing the Northstar area during seismic activity or that some bowheads decreased their calling rates. Aerial survey data from 1996 and 1997 further suggest that bowhead whales avoid areas with seismic operations (Miller et al., 1998:5-59 to 5-63). When the 1996 and 1997 aerial data were combined, all 52 sightings noted during periods of seismic activity, and within 3.5 hours following seismic operations, were greater than 12 miles (20 km) from the source. The consistency between these results based on two different methods (acoustic and aerial survey) lend strong credibility to the conclusion that whales are displaced by seismic activity.

Whaling crews have noted that seismic surveys conducted near Barrow, Cross Island, and Kaktovik have been responsible for altering migration patterns and for failures in harvesting success. Unsuccessful harvesting seasons have been found to closely correlate with seismic survey activities (T. Napageak in USDOI, MMS, 1995:13; B. Adams in USDOI, MMS, 1995:26; H. Brower, Jr. in USDOI, MMS, 1995:84; B. Rexford in MBC, 1996:80). Harvest success and whaling quotas are presented in Tables 7.3.2 and 7.3.3 respectively. The extent of the migration pattern displacement has required hunting to be performed further offshore than otherwise would be the case (E. Brower in USDOI, MMS, 1995:29-30). The displacement has required whaling to be performed at least 10 miles (16 km) further offshore than would be the case without seismic survey activities (T. Albert in USDOI, MMS, 1995:41); however, migration patterns are believed to change at distances of 35 miles (56 km) from seismic source vessels and to shift the migration path as much as 30 miles (48 km) from the normal migratory path (17 Whalers in MBC, 1997:Attachment C). During the last several years, seismic and other oil exploration activities have been coordinated with the AEWC to minimize adverse effects on subsistence whaling, and have lead to stipulations in agreements with the AEWC.

Analysis of the bowhead sightings (179 whales) from the aerial surveys during BPXA's 1996 and 1997 seismic programs indicate that those programs did not greatly influence the position of the migration corridor (Miller et al., 1998:5-58). However, the power of this conclusion is limited by the small number of bowhead sightings during seismic activity (8 whales) or within 3.5 hours of seismic activity (13 whales).

9.5.1.2 Beluga Whale - Responses to Noise

Beluga whale hearing is poor below 1,000 Hz, and their best sensitivity is in the 10,000 to 100,000 Hz (10 to 100 kilohertz [kHz]) band (Awbrey et al., 1988:2274; Johnson et al., 1989:2653). This range of sensitivity is indicative of the beluga's use of high frequency sounds for echolocation (locating objects by emitting high-pitched sounds). Low frequency hearing tests by Johnson et al. (1989:2651) on one beluga did indicate it could respond to sounds as low as 40 to 75 Hz. However, more recent experiments suggest that at these low frequencies the animal is not necessarily responding to sound but may instead be responding to particle motion in the near-field of the loudspeaker (Turl, 1993:3006-3008).

Belugas are known to produce a wide variety of sounds, some of which are audible to humans and some of which are ultrasonic. Beluga whistles are in the 2 to 6 kHz range, but some are as low as 260 Hz (Schevill and Lawrence, 1949:143-144). Recent studies further described an extensive repertoire of free-ranging beluga sounds in the frequency range below 16 kHz produced during a variety of activities (Sjare and Smith, 1986:408-413).

Beluga responses to acoustic disturbances are quite variable and depend upon a number of biological factors, including the activity of the animal when exposed to the noise (Richardson et al., 1995a:247). Habituation and sensitization also are important when discussing potential reactions of belugas to multiple exposures of a noise stimulus. Belugas have often shown little to no response to loud sounds and avoidance reactions to very faint sounds. Belugas showed no responses to recorded playback of loud fishing boats or exposure to high sound levels at close range, while others showed avoidance reactions to icebreaking ships at ranges of up to 50 miles (80 km) (Cosens and Dueck, 1988:52; Richardson et al., 1995a:257-259). This may be interpreted as an example of how belugas habituate to human made noises depending on their experiences (Richardson et al., 1995a:282-283).

Construction Noise: There have been no observations made that would provide information about belugas' reaction to on-ice construction traffic, trench digging, and island construction as proposed for Northstar development. The closest similar activity may be a stationary dredging operation where belugas showed little reaction and approached to within 1,312 ft (400 m). Moving barges caused a greater reaction (Ford, 1977; Fraker, 1977 as cited from Richardson et al., 1995a:279). Interpretation of the stronger reactions to moving barges was that the moving barges blocked the free movements of the whales along a shoreline.

Belugas have been observed in close proximity to drilling operations on an artificial island, where they were seen regularly within 328 to 492 ft (100 to 150 m) of the island (Fraker, 1977 and Fraker and Fraker, 1979 as cited from Richardson et al., 1995a:282).

Beluga responses to aircraft can depend on the social context, environmental conditions, and aircraft altitude (Richardson et al., 1995a:247-248). For example, feeding belugas appeared undisturbed by an aircraft at 1,500 ft (457 m), while lone animals dived in response (Bel'kovich, 1960 as cited from Richardson et al., 1995a:247). Some belugas have been observed reacting to aircraft by swimming away or diving, but this reaction is variable and usually occurs when the aircraft is below 1,500 ft (457 m) (Finley, 1982:4-5). Inupiat hunters suspected low-flying aircraft were responsible for preventing belugas from entering a bay along the Alaskan Beaufort Sea coast (Burns and Seaman, 1985:108).

Reactions to vessels are variable depending on social context, habitat, vessel type, and movements. Some of these reactions are learned through repeated negative associations with certain types of vessel noises and movement patterns when the belugas are being hunted. Belugas migrate back to traditional areas each spring, even in areas where hunting is extensive, despite the negative association (Fraker and Fraker, 1979:4-5). Similarly, belugas can be very tolerant of disturbance when the vessels operate predictably and consistently (Fraker, 1977 as cited from Richardson et al., 1995a:256). Belugas feeding or traveling are not as likely to react to fishing boats as they are to boats with outboard motors (Frost et al., 1984). This may be because outboards produce more high frequency sound than fishing boats, and beluga hearing sensitivity improves with higher frequencies (Richardson et al., 1995a:257).

In contrast to the varied reactions of belugas to small vessels and boats, belugas have been observed responding strongly to icebreaker vessel noises at ranges of up to 31 miles (50 km) (Cosens and Dueck, 1988:52). Belugas responded at long ranges by swimming rapidly away from the approaching icebreaker vessel, changing the types of calls produced, and changing their diving behaviors. Belugas also avoided the area for up to 1 to 2 days after the vessel activity ceased. These strong reactions are unusual and are probably the result of the whales being confined by heavy ice; large ships of this type are rare in the high Arctic in the spring, and conditions were such that the ship sounds propagated a long distance (Richardson et al., 1995a:257). Estimates indicate that belugas may hear sounds in the 5 kHz band at 16 to 19 miles (25 to 30 km), whereas hearing thresholds limited the range of detection for lower frequencies and ambient noise limited the range of detection for higher frequencies (Cosens and Dueck, 1988:296).

Seismic Survey Noise: The effects of seismic survey activities on beluga whales and other marine mammals are a concern to North Slope residents (including subsistence harvesters), agencies, and industry. Although the level of concern is similar to that of the bowhead, belugas are less frequently taken in the project area as part of subsistence harvesting. The overall migration pattern of the species is similar to that of the bowhead; however, the main body of the migration pattern typically is further offshore in the project area than that of the bowhead and, therefore, less accessible to hunters.

Studies documenting reactions of beluga whales to seismic survey activities are limited to a monitoring program that was carried out as part of a fall 1996 BPXA seismic survey, which included waters from the West Dock causeway to about 28 miles (45 km) northwest of West Dock and approximately 8 miles (13 km) offshore from the barrier islands. The northern margin of the area surveyed bordered the southern margin of the usual beluga migration pattern.

Marine mammal monitoring during the seismic survey indicated that no reactions to seismic activity (including vessel movement) were noted (Miller et al., 1997:5-5 to 5-109). However, due to the relatively few whales observed and their distance from the source vessel, a conclusion regarding impacts from seismic activities on beluga whales cannot be made.

9.5.1.3 Ringed Seal - Responses to Noise

Ringed seal are sensitive to underwater sounds in the 1,000 to 60,000 Hz band; however, there are no data on hearing thresholds below 1,000 Hz (Terhune and Ronald, 1975:230). Most observations of ringed seals have been on animals hauled out on ice or inside their subnivean (under ice) lairs, as determined by radio telemetry (Kelly et al., 1986; Kelly, 1988). No data are available on their reactions to underwater sounds because of the difficulty of observing these small animals in water.

Ringed seals produce relatively low intensity sounds that are mostly calls below 5 kHz (Schevill et al., 1963:51-52; Stirling, 1973:1594). Nothing is known of the biological functions for these sounds; however, given that the calls are low intensity, in the mid-frequency range, and are not songs, they presumably are used for communication over short ranges in association with reproduction and territorial identification.

Construction Noise: Some localized displacement of ringed seals probably occurs around areas with intensive on-ice traffic and construction (Green and Johnson, 1983:22). Studies suggest that ringed seals avoid the immediate vicinity of industrial activity areas. In a study conducted by Frost and Lowry (1988:22), ringed seals were found to be less abundant within 2 nautical miles (5.9 km) of artificial islands in the central Beaufort Sea than within areas 2 to 4 nautical miles (5.9 to 11.9 km) from the islands, regardless of the level of industrial activity at the islands. However, in a similar study, Frost et al. (1988:92) found that seal density was greater within "industrial blocks" of the Beaufort Sea than within areas that are not used by industry. The higher overall concentration of seals in the industrial block suggests that some characteristics other than the presence or absence of industrial activity was responsible for the difference. The extent to which displacement occurs in response to localized industrial activity has not been determined, and there is no clear evidence that seals leave the area of disturbance or redistribute themselves permanently elsewhere (Calvert and Stirling, 1985:1241-1242).

Ringed seals, when hauled out onto the ice, sometimes react to low-flying airplanes and helicopters by diving (Burns and Harbo, 1972:283). There are no systematic observations on these responses to determine in-air noise levels. Calvert and Stirling (1985:1240) showed that ringed seal vocal activity levels were similar in areas with low-flying aircraft and undisturbed areas, suggesting that the aircraft disturbance did not affect the general distribution and density of animals. However, other evidence indicates that reactions by seals inside their subnivean dens vary as a function of aircraft altitude and distance (Kelly et al., 1986:ii).

There are no observations of ringed seal reactions when exposed to the underwater sounds of ships, boats, or dredging operations. There are some observations of short-term ringed seal reactions to ships and icebreakers (Brueggeman et al., 1992 as cited from Richardson et al., 1995a:255) showing that animals hauled out on the ice tended not to respond at ranges of several kilometers, but did respond by diving into the water at closer ranges.

There are no systematic studies documenting ringed seal reactions to drilling and related activities. Some reduction in seal density was noted within 2.3 miles (3.7 km) when drilling was underway on an artificial island (Frost and Lowry, 1988:20).

Seismic Survey Noise: Reactions of seals were recorded as part of marine mammal monitoring for the BPXA fall 1996 seismic survey. Results indicate that approximately 189 seals were within 820 ft (250 m) of the seismic array during the monitoring period, of which ringed seals comprised the majority of those counted; bearded seals and spotted seals comprised relatively small numbers, proportionally.

Studies on effects of noise disturbance on ringed seals from on-ice seismic profiling, using the Vibroseis method, have been conducted in the vicinity of Seal Island (Burns et al., 1982; Kelly et al., 1986). The noise levels were sufficient to cause seals to abandon breathing holes and lairs at a greater than normal rate (Kelly et al., 1986:530). However, the reaction of ringed seals to disturbance from these activities was found to be highly variable. Some seals' breathing holes and lairs remained active despite close proximity to seismic survey lines and helicopter and small plane flight paths, while other seals abandoned areas at greater distances from the noise (Kelly et al., 1986:531).

Most seals (all species) exposed to seismic activities reacted by either diving (36%) or avoidance (39%); approximately 18% reacted by "looking;" 5% swam parallel to the vessel; and 2% approached the vessel. During full-array seismic, most seals within 492 ft (150 m) of the source vessel dove, whereas those encountered at distances between 492 and 820 ft (150 and 250 m) avoided the source vessel. The 1996 seismic operations apparently caused some small scale displacement of seals, as indicated by the lower sighting rates within 492 ft (150 m) of the source vessel during airgun array operations. However the overall sighting rates for seals seen within a few hundred meters of the source vessel were almost identical during periods with no airguns, one airgun, and a "full array" of 8 to 11 airguns. Although Harris et al., (1997:4-37) states that there was no indication that the seismic operation caused displacement of seals on a scale that could affect accessibility to subsistence hunters, it is apparent that increased vessel movement attributable to seismic operations would result in a temporary displacement of some individuals. The duration of displacement was not observed; however, the seismic array, which was towed at 4 to 5 knots (7.4 to 9.3 km/hour), would traverse a 1,640-ft (500 m) portion of the seismic transect in 15 to 19 minutes.

9.5.1.4 Bearded Seal - Responses to Noise

Comparative data from other seals (e.g., ringed, harp, and harbor seals) suggest that bearded seals would be sensitive in the 1,000 to 40,000 Hz band, with the further suggestion that hearing would still be good down to 200 to 500 Hz (Møhl, 1986:34; Terhune and Ronald, 1972:567-568; Terhune and Turnbull, 1995:85-92).

Bearded seals are well known for their loud, unique songs in the 300 to 400 Hz tone (Ray et al., 1969:80-81; Budelsky, 1993:86-89). Aggregations of singing bearded seals can be heard at distances greater than 10 miles (16 km) (Cleator et al., 1989:1906). These songs are presumed to be a very important part of the breeding ecology for these animals due to high vocal activity, and underscore the importance of sound production and perception for their survival.

Most observations of bearded seals have been on animals hauled out on ice. There are few observations on bearded seals' reactions to underwater sounds because of the difficulty observing these animals in water.

There are no data available on the reactions of bearded seals when exposed to underwater sounds from on-ice construction activities, drilling, or vessels. There are some observations showing that animals on pack ice dove into the water when an icebreaker was working at ranges of less than 0.6 miles (1 km); however, animals seemed to be less responsive to the icebreaker when it was in transit in open water (Richardson et al., 1995a:275). Bearded seals, when hauled out on the ice, sometimes react to low-flying airplanes and helicopters by diving, and helicopters seem to be more disturbing than other types of aircraft (Burns and Frost, 1979 as cited from Richardson et al., 1995a:244).

Seismic Survey Noise: Reactions of seals were recorded during marine mammal monitoring for the BPXA 1996 seismic survey. Approximately 189 seals were identified as being within 820 ft (250 m) of the seismic array during the survey, of which bearded seals comprised approximately 4% of the population; however, the survey did not make a distinction between the reactions of bearded seals from those of ringed or spotted seals. The general reaction of seals to seismic activity is described in Section 9.5.1.3, which included diving and avoidance, followed by "looking" and swimming parallel to the source vessel.

9.5.1.5 Polar Bear - Responses to Noise

Little is known about the types of sounds produced by and the hearing abilities of polar bears. However, polar bears often react to low flying aircraft by running away. Helicopters are sometimes used to scare bears away from human habitation (Richardson et al., 1995a:252). Polar bears react inconsistently to the approach of vessels (Richardson et al., 1995a:273). There are limited data on reactions of bears to construction, offshore drilling, or production operations. However, polar bears have been known to approach stationary drill ships and drill sites on caissons and artificial islands when ice is present nearby (Richardson et al., 1995a:289).

Polar bear reactions to seismic survey activities has been documented as part of the BPXA fall 1996 seismic survey (Richardson, 1997:Appendix 1). Two adult bears were observed approximately 984 ft (300 m) from a support tug that was used to move the cable barge. When the bears were spotted, the vessel came to a stop and the bears were observed both on the ice and swimming away from the vessel. At the time, the source vessel was operating approximately 6.2 miles (10 km) from the site. A sow and cub also were observed from a jet-driven aluminum landing craft that was used to deploy, retrieve, and charge batteries and to assist in cable deployment and interconnection. The pair was observed climbing into a large ice pan as buoys were being picked up on either side of the ice pan. The bears were estimated to be about 656 ft (200 m) from the vessel and the encounter lasted about 10 minutes. Full-array seismic was ongoing approximately 2.5 miles (4 km) from the siting. Eight additional sightings, totaling 13 polar bears, were reported from monitoring aircraft; however, seismic shooting was not taking place at the time and no reactions to aircraft were observed. Seismic survey activity also was found to have minor effect on denning polar bears, largely because dry, cold snow absorbs vibrations very effectively (Blix and Lentfer, 1992:23).

Stirling (1988:6) and Shideler (1993:17-18) indicate that polar bears are attracted to drilling and similar activities for a number of reasons, including curiosity, food, scent, and potential predation of drilling personnel. Although noise was not identified as a factor in attraction, it is likely that it is a contributor.

Denning polar bears prefer to seek den sites free of disturbance (Amstrup, 1995:292). However, other studies of polar bears found them to be tolerant of some human activity (Stirling, 1988:6). If an active polar bear den was located near the mine site in the Kuparuk delta, disturbance of the den would be considered a minor impact. However, the U.S. Fish and Wildlife Service would recommend appropriate measures to avoid or minimize potential effects.

9.5.2 Marine and Freshwater Fish - Responses to Noise

There are no data documenting noise effects on fish in the project vicinity. Noise studies have been limited to the analysis of fish communication and not on noise impacts on fish. However, a 4-month pilot project in Bodega Bay, California, designed to establish collection and husbandry protocols, map the sound field of the enclosure, and conduct and analyze preliminary playback experiments for the purpose of refining future experimental protocols, has released a bi-monthly progress report (Klimley and Beavers, 1997:1). Thirteen rockfish were tested individually in an enclosure using a tape recorder, amplifier, and underwater transducer. The SPL was 145.1 dB at 3.2 ft (1 m) and 109.5 dB at 39.4 ft (12 m) from the speaker. The researchers observed little movement by the fish in the enclosure in response to the signal and little difference existed in the behavior of the fish during sound playback and “silent” control period.

Had the SPLs used in the experiments been higher, they may have elicited an alarm response among the rockfish. The general threshold of rockfish to impulsive sounds made by an air gun used in geophysical surveys was 180 dB (Klimley and Beavers, 1997:1). At this level, blue rockfish milled in tighter circles and black rockfish moved to the bottom. Olive rockfish either moved up in the water column or descended to the bottom where they became immobilized. Responses were detected in some fishes at levels as low as 161 dB.

Additional research and analysis is necessary to definitively determine the effects of noise on Alaskan Beaufort Sea fish species. Although rockfish are not present in the project area, the study provides baseline information about fish response to noise (Klimley and Beavers, 1997:1). Different fish species, however, may respond differently to noise and effects on Alaskan Beaufort Sea fish species may vary from those displayed by the various species of rockfish.

9.5.3 Avian Species - Responses to Noise

Many bird species are found in the project area; however, nearly all species are migratory and occur from May through September. Fixed-wing aircraft and helicopter traffic is expected to be the major source of noise affecting birds, but the impacts of aircraft overflights on birds are difficult to assess. Responses among birds may vary among species, populations, flocks, and individuals, as well as between different habitats and times of the year. Characteristics of overflights, such as altitude, horizontal distance, type of aircraft, duration of disturbance, engine sound level, and frequency, affect the response.

The reaction of birds to exploratory drilling activity near the MacKenzie River Delta found that 43% of common bird species were less numerous within 1.6 miles (2.6 km) of the drilling rig during drilling operations, 52% of the species were not affected by rig activity, and 5% of the species were more abundant (Hanley et al., 1981:158).

Snow geese, which are susceptible to disturbance by low flying aircraft, return to feeding within a relatively short time (Belanger and Bedard, 1989:717-718). Birds that were disturbed during the spring returned to feeding more quickly than those disturbed during the fall. The mean time to resume feeding after disturbance was about 2 minutes during the spring and 12 minutes during the fall. Reasons for the differing return times is likely related to energy reserves that differ by season. The study also found that geese habituate to reoccurring aircraft and gunfire noise, which resulted in reduced disturbance rates.

In similar studies, Wright and Fancy (1980:31 and 36) found that disturbance to oldsquaw from helicopter noise resulted in displacement of flocks. The average time of displacement was about 10 minutes.

Aircraft flying overhead at low altitudes have a greater potential to create an impact than at a greater distance and high altitude. In one study, nesting common eiders (the major nesting species on the barrier islands) showed some tolerance to helicopter overflights (Gollop et al., 1974). Based on a 2-day experimental study, the eiders appeared to be undisturbed and remained on their nests. The duration and small sample size, however, limit the applicability of the study. Aircraft or helicopter-induced stress and its affects on the energetics of incubation, is an important factor not addressed in the study (Gollop et al., 1974:193). The effect of multiple overflights in either sensitizing or habituating birds is not well understood, but there is some evidence that once exposed to disturbance, birds may be more easily disturbed subsequently (Gollop et al., 1974:189). Birds that are molting or caring for broods are most likely to react negatively to aircraft because of their vulnerability. Several studies have evaluated the behavioral reaction of birds from aircraft overflights. Brant and other geese reacted to approaching aircraft by raising their head, calling, walking, or swimming together in a group, and eventually flying away from the noise (Ward and Stehn, 1989:101).

In general, researchers have found that the response by waterfowl is related to the altitude and/or horizontal distance to aircraft. Typically, the lower and closer the aircraft, the greater the disturbance response. However, it is difficult to determine a minimum altitude that will eliminate or minimize the disturbance. Overflights at Izembek Lagoon, east of the project area, were permitted at a minimum 1,500-ft (457 m) elevation, which was sufficient to avoid disturbing black brant staging at the lagoon.

Generally, the intensity of the disturbance decreases with increased horizontal distance of aircraft to waterfowl. However, a high degree of variability has been observed.

9.5.4 Terrestrial Mammals - Responses to Noise

Caribou: Information about the effects of noise on caribou is limited to fixed-wing military aircraft which are likely to produce noise levels that are higher than those of aircraft (fixed- or rotary-wing) that would be in use in the project area. A study was conducted to evaluate behavioral responses of free-ranging caribou to low-level, subsonic jet aircraft overflights in 1991. Overflights were conducted by the U.S. Air Force during late winter (April), post-calving (June), and the insect season (July to August). The aircraft overflights consisted of A-10, F-15, and F16 jet aircraft, which emit higher noise levels than those used during project construction and operation. Approximately 50% of the caribou showed some degree of overt behavioral response to the overflights, but only 13% of the overflights caused the animals to move (Armstrong Laboratory, 1993:33-40). Activity budgets and daily distance traveled were compared between disturbed and undisturbed groups of caribou. No differences were evident in late-winter activity budgets; however, animals spent less time lying and more time either feeding or walking during post-calving and the insect seasons than at times when overflights did not take place. No differences in daily distance traveled were evident during late winter and the insect season, but disturbed caribou traveled farther than did undisturbed caribou during post-calving. The study concluded that behavioral impacts were generally mild, but that female caribou reacted to jet aircraft overflights by lying less and moving more, and these responses were most prevalent in June when newborn calves were present.

Other studies found that caribou in large numbers (greater than 20 animals) tend to be more responsive to noise than animals in small groups, particularly when calves are present (Miller and Gunn, 1981:70). Studies of animal movement found that caribou avoid or move more rapidly through areas with ongoing industrial noise than those without industrial noise. Avoidance reaction was noted at an average distance of 650 ft (198 m) from an operating gasoline compressor sound simulator; the migration patterns of post-calving herds were found to deflect from the sound simulator at an average distance of 920 ft (280 m) (Wright and Fancy, 1980:38 and 49-50).

Observations of caribou reaction to railroad and highway noise, and noise from chain saw operations and dynamite blasts indicate that caribou herds tend to habituate to such noise sources. Bergerud (1974:579), states that herds in Newfoundland wintering within 1 mile (1.6 km) of the Canadian National Railway and 2 miles (3.2 km) from the related noise sources were not affected.

A direct inverse correlation was found between jet aircraft overflights and calf survival (Harrington and Veitch 1992:213). Although there are differing opinions regarding distances from aircraft that are considered to be adequate to avoid disruption to caribou, tolerance levels appear to range from 300 to 500 ft (91.4 to 152.4 m) during rut and calving, and to 500 ft (152.4 m) at other times, including migration (Calef et al., 1976:210; Harrington and Veitch, 1991:325). Minimum "safe distances" were reported by Harrington and Veitch (1991:325) to be 1,000 ft (304.8 m).

Other Terrestrial Mammals: Very little information is available regarding the effects of noise on Arctic fox and other terrestrial species; however, Eberhardt et al. (1982:188) found that petroleum development activities do not adversely affect Arctic fox and that these foxes do not necessarily attempt to avoid areas of human activity.

Grizzly bears are present within the Prudhoe Bay industrial complex and in 1994, a total of 28 bears were estimated to occupy the area from the Colville River east to the Shaviorik River and inland to the White Hills (Shideler and Hechtel, 1995:32). Although the species typically feeds on tundra vegetation, they are attracted to the oil fields and communities to feed on human refuse found in trash containers and landfills. Bears also have been found to adapt to human activities, including learned avoidance of baited traps and the presence of helicopter traffic (Pearson, 1975:43).

9.6 EFFECTS OF NOISE ON THE HUMAN ENVIRONMENT

Industrial noise associated with oil field activity has increased ambient levels throughout a large portion of the Prudhoe Bay area over pre-industry levels. Processing and compressor equipment, separators, pumps, generators, and vehicles are common noise sources within many areas, and common underwater noise sources emanate from vessel traffic, offshore exploratory drilling, and seismic survey activity. Onshore noise potentially could affect the human environment as well as terrestrial mammals that are relied upon for subsistence harvesting. Underwater noise could affect marine mammals and subsistence harvesting success.

9.6.1 Onshore Sensitive Receptors

Onshore receptors that are sensitive to noise typically include residential areas, hospitals, nursing homes, parks, and public meeting halls. Locations of such facilities in the Prudhoe Bay area are limited to the Deadhorse community and camp facilities within the Eastern and Western Operating Areas, and residences in Nuiqsut are located farther from the project area. Although project operations and maintenance would result in increased noise levels at Seal Island, distances to sensitive receptors that are located onshore would be sufficient to preclude effects on the human population. Operations and maintenance noise at onshore locations would be limited to regular helicopter traffic between the Deadhorse Airport and Seal Island for personnel changes, materials shipments, and low-elevation helicopter overflights along the onshore pipeline corridor as part of routine inspection. Due to distances between such noise sources and sensitive receptors, noise-related impacts to onshore receptors are not anticipated.

9.6.2 Subsistence Harvesting

Subsistence harvest resources within the project area that could be affected by noise are limited to the bowhead whale and caribou (Section 7.3). Although other resources (waterfowl, fish and other marine and terrestrial mammals) are harvested by North Slope residents, they would not be affected by noise associated with construction, operations, maintenance, or abandonment of the project.

Bowhead whales are traditionally harvested by residents of Barrow, Nuiqsut, and Kaktovik; however, noise-related impacts would be limited to the fall harvest that is conducted from Cross Island by Nuiqsut whalers. Studies of bowhead whales indicate that industrial noise may cause behavioral changes at distances of as much as 62 miles (100 km), and deflection behavior at ranges of 0.5 to 14 miles (1 to 24 km), although most deflections occur at less than 6.2 miles (10 km) (George et al., 1996:5). Other studies have found avoidance behavior at a range of 1 to 9 miles (1.6 to 14.5 km) from small boats (Richardson et al., 1995a:268; Richardson et al., 1985a:116; Koski and Johnson, 1987:59-61; LGL and Greenridge, 1987:47; and Ljungblad et al., 1985:45) which is consistent with observations by whaling captains that avoidance behavior from the noise of an outboard motor occurs within 3 miles (4.8 km) of the source (T. Brower, Sr. in NSB, 1980:107). Whalers also have noted that when industrial activity is high in the Alaskan Beaufort Sea, harvest success is low and quotas are not easily met (J. Ningeok in USDOI, MMS, 1986:11; F. Long, Jr. in USACE, 1996:34; B. Oyagak in USDOI, MMS, 1986:11; J. Kaleak in MBC, 1996:69; T. Napageak in USDOI, MMS, 1995:8). Although the range of distances in which migratory deflection and avoidance reaction is highly variable, subsistence harvesting could be affected. If the fall migration pattern within traditionally used hunting areas were altered as a result of project noise and/or activity, harvest success could be reduced or harvest failure may result. Impacts to subsistence harvesting are addressed in Section 9.8.2.2.

Caribou winter in the foothills of the Brooks Mountain Range and move to calving grounds on the open tundra in areas of the Kuparuk River Delta and near the Canning River Delta in late April and early June. During early summer, the herds move to the coast to avoid insect harassment and return inland with the abatement of the insect season. If noise from industrial activity (i.e., helicopter overflights) is sufficient to displace caribou herds, subsistence harvesting could be affected. Impacts to subsistence harvesting are addressed in Section 9.8.2.2.

9.7 PROJECT NOISE SOURCES

Noise studies in waters off the North Slope conclude that, under certain conditions, industrial sources can generate high levels of low-frequency noise which can be transmitted under water over long distances (LGL and Greeneridge, 1987:43-44; Miller et al., 1997:5-5 to 5-107). Common types of industry-related noises and documented noise levels for the project area are discussed below.

9.7.1 Transportation Activities

Vessel Movement: Ships and boats create high levels of noise both in frequency content and intensity level. Ship traffic noise can, in some circumstances, be detected at distances of over 1,150 miles (1,851 km) in deep water and is a combination of narrowband tones and broadband noise (Wenz, 1962:1949). Ice breaking vessels have source levels of 165 to 175 dB, while vessels under 98 ft (30 m) long typically have levels less than 165 dB (Richardson and Malme, 1993:637). Icebreaking activities can generate some of the highest measured levels of vessel noise (below 500 Hz) as a result of the ship's higher power levels, when the ship is pushing slowly against ice.

Tugs can emit high levels of underwater noise at low frequencies. In August 1985, underwater noise was recorded from two tugs that were keeping a barge pressed against a loading ramp at Sandpiper Island. An underwater sound level of 163 dB in the 20 to 1000 Hz band was recorded at a distance of 0.3 miles (0.5 km). Peak noise levels of 118 dB in the 20 to 1,000 Hz band were noted at a range of 1 mile (1.6 km) when tugs and barges were present at Seal Island (Davis et al., 1985:61).

Aircraft Movement: Noise effects from aircraft (helicopters and fixed-winged planes) in air and water have been reviewed earlier in this chapter. The duration of aircraft sound in water is short, and underwater sound levels are much lower than sound levels in air. Comparisons of aircraft noise levels are complicated by analysis using differing averaging times, aircraft, and flight altitudes. However, aircraft sound levels generally range from 95 to 130 dB (Richardson et al., 1995a:350). An average level of 113 dB at an altitude of 1,017 ft (310 m) was reported in a more recent study (Greene, 1997:3-48 to 3-49, Fig. 3.25).

Vehicular Movement: Sounds from vehicles such as automobiles, buses, and trucks typical range from 60 to 85 dBA at 50 ft (15.2 m) from the source in air. Frequency ranges from approximately 250 to 1,000 Hz. Noise from vehicular traffic attenuates at approximately 3 to 4.5 dBA per doubling of distance.

9.7.2 Gravel Mining Activities

Gravel mining and reclamation of the pit would be conducted during winter months. Noise from gravel mining is primarily emitted by compressors, drills, blasting operations, rock crushers, bulldozers, loaders, and miscellaneous trucks. Noise reduction of construction equipment as a function of distance may be difficult to predict in the project area; however, noise from this type of equipment decays at a rate of 6 dBA per doubling of distance from the source to receiver. This is a logarithmic relationship describing the acoustical spreading of a pure undisturbed spherical wave in air. Although construction noise may be audible for a long distance in remote areas that have low ambient noise levels, substantially higher noise levels from equipment would be limited to a relatively confined area totaling approximately 35 acres (14 hectares) at the mine site.

9.7.3 Construction Activities

Sounds from construction typically consist of noise emanating from equipment such as diesel generators, bulldozers, backhoes, and compressors, plus from activities such as pile-driving using an impact hammer. In-air noise levels from generators range between 70 and 82 dBA at 50 ft (15.2 m) from the source, and in-air noise levels from bulldozers, backhoes, and compressors range between 72 and 96 dBA (Spencer, 1996:18). Sounds generated from pile-driving or hammering are short duration, rapid onset, and high peak pressure level signals that are most like seismic survey pulses. Typically, hammering impulses occur 1 to 3 seconds apart. In the fall of 1985, hammering sounds from pile-driving were recorded near Sandpiper Island. At a range of 0.6 miles (1 km) from the hammering activity, sounds levels of 131 to 135 dB in the 25 to 125 Hz frequency range were recorded when the pipe was between 65 and 80 ft (20 to 24.4 m) deep (Johnson et al., 1986:47). Pile-driving sounds detected at a range of 0.6 miles (1 km) from an island were 25 to 35 dB above the ambient noise level in the 50 to 200 Hz frequency band (Moore et al., 1984:543-52). Results of a theoretical study to estimate the level of noise generated during construction pile-driving activity on Seal Island agree with these empirical data. In the theoretical study, the underwater sound level from pile-driving in shallow water every 1.3 to 1.7 seconds at a distance of 0.6 miles (1 km) was estimated to be 138 dB (Spencer, 1996:15). An alternative method, the vibratory hammer, would theoretically generate an underwater sound level of 119 dB at a distance of 0.6 miles (1 km) (Spencer, 1996:16).

The distance out to which impulsive construction sounds could be detected depends primarily on the source level, the local propagation conditions around the Seal Island construction site, and the ambient noise level in the low-frequency band. The median ambient noise level in the 20 to 1,000 Hz band from a shallow water site near the Northstar Unit was reported as 95 dB (Richardson et al., 1998:3-54). Using this ambient noise level data, empirical propagation data (Richardson et al., 1998:3-62), and a noise level of 138 dB at 0.6 miles (1 km), pile-driving sounds are expected to be detected out to ranges of 2.5 to 12.4 miles (4 to 20 km).

Two studies have investigated noise characteristics of construction at Seal Island. In the first study, under-ice noise levels during ice road construction in the 0 to 500 Hz band were less than 80 dB at ranges between 0.2 to 1 mile (0.3 and 1.6 km) (Greene, 1983:129). Under-ice noise levels were below 80 dB at distances of 0.5 to 2 miles (0.8 to 3.2 km) when a ditchwitch, backhoe, dump truck, D-7 Caterpillar, and gravel trucks were operating. In the second study, received levels up to 135 dB were recorded at a distance of 0.6 miles (1 km) (Spencer, 1996;18). The loudest noise was caused by a 20.9 ton impact hammer driving piles and a vibratory hammer driving sheet piling for island protection.

Noise radiating from pipeline construction and installation activities would be similar to island construction noise (Section 9.7.3). Noise sources include trucks, cranes, bulldozers, backhoes, and compactors. In air, noise from these sources emit levels ranging from 70 to 82 dBA at 50 ft (15.2 m).

9.7.4 Operation and Maintenance Activities

Drilling is expected to be one of the loudest noise sources during operation and maintenance activities. Wells would be drilled through the mass of the island which would act as an acoustic buffer, absorbing and filtering most of the acoustic energy generated by the operation before it can radiate into the water. Absorption lessens the overall level of sound energy entering the water, while filtering restricts the propagation of sound frequencies above several hundred Hz.

Estimates of expected noise levels and variability of noises from drilling activities are expected to be less than levels measured from non-island type drilling operations (i.e., drill ships and bottom-founded structures). Underwater noise levels from drill sites on manmade islands usually have been less than 109 dB, concentrated below 200 Hz, and detected at distances between 1 and 11 miles (1.6 and 17.7 km) depending on the ambient noise conditions (Malme and Mlawski, 1979:11; Johnson et al., 1986:45; Miles et al., 1987:183). Drilling noise levels measured at 40 Hz were often 10 to 20 dB greater than ambient noise levels at 0.6 miles (1 km) from Seal Island (Johnson et al., 1986:49). Source levels of top-drive rigs (such as that to be used for the project) operating on gravel islands seem lower than for other types of equipment (Richardson and Malme, 1993:647).

During fall and spring broken/thin ice conditions, icebreaking barges would periodically travel between Seal Island and West Dock in order to maintain a corridor that might be required in the event of an oil spill. These icebreaking barges would be propelled by marine tugs. Noise levels from an icebreaking barge/tug combination is not as high as those from a traditional icebreaker. Noise sources from the tugs themselves are primarily due to propulsion, namely propeller and engine. In addition, the icebreaking barge being pushed by the tug will be a noise source as it breaks and pushes aside thin ice.

In summary, construction, operation, and maintenance activities would generate noise from multiple sources within a variety of locations in the project area. Gravel mining and hauling would generate noise within the vicinity of the Kuparuk River Delta and along the ice road to Seal Island. Noise sources from the vicinity of Seal Island would result from the use of heavy machinery for pile driving, drilling, drill waste disposal, production equipment, and marine vessel traffic.

9.8 ENVIRONMENTAL CONSEQUENCES

The effects of noise on marine mammals, fish, birds, and terrestrial mammals are described for the No Action Alternative and for project construction. Due to similarities in project alternatives, noise impacts related to Alternatives 2, 3, 4, and 5 are identical; therefore, potential impacts to biological resources from these alternatives are discussed together.

9.8.1 Alternative 1 - No Action Alternative

Marine mammals, fish, birds, and terrestrial mammals currently are impacted by noise from oil field operations on the North Slope and it is likely that the current level and frequency of impacts will continue into the foreseeable future. Noise sources are likely to shift from location to location as producing reservoirs become depleted and facilities are decommissioned and as new fields are developed and new facilities become operational. Increased onshore development potentially could generate noise that would affect nesting birds and displace caribou and other mammals from important habitat; noise from new offshore development is likely to affect marine mammals, including the bowhead whale, regardless of development of the Northstar Unit.

Ambient noise levels are likely to be less than 40 dBA in undeveloped areas without manmade noise. In the vicinity of Seal Island, noise levels below the water surface would be expected to range from 79 to 123 dB, with 50% of the values in the 20 to 1,000 Hz band at 95 dB or less when no human activity is present. However, the variability of actual ambient noise levels would be dependent upon a variety of factors, including meteorological conditions, wave action, and the presence of ice.

9.8.2 Alternatives 2, 3, 4, and 5

Impacts of noise to biological resources from Alternatives 2, 3, 4, and 5 are presented in Table 9-1. Project-related impacts to subsistence resources and harvesting are addressed as part of Chapter 7 (Affected Human Environment and Impacts).

9.8.2.1 Construction Noise Impacts

Construction noise would originate from gravel mining, ice road construction, the reconstruction of Seal Island, and pipeline installation.

Bowhead Whale:

Ice Road Construction and Operation and Offshore Pipeline Installation: Bowhead whales would not be present in the area during ice road construction or operation or during offshore pipeline installation. Therefore, impacts from such activities are not anticipated.

Island Construction Noise: No studies have been conducted on the responses of bowheads to offshore island construction activities (Richardson et al., 1995a: 276-281); however, construction during winter will eliminate biological impact on bowhead whales because none would be present in the area (Section 6.9).

Scheduling construction activities during periods when whales are not expected to be in the region greatly reduces the chances that bowheads will be exposed to levels of island construction noise to which they will respond. Tables 4-7 and 4-8 provide a listing of project activities; including island construction, barge and vessel traffic, offshore pipelines, and drilling operations. It indicates that many of the activities expected to have the greatest possible impact (e.g., island construction, vessel traffic) are scheduled to occur either in the winter or early summer when whales are not in the area, or during the spring when whales are migrating past the project site, but at ranges of greater than 44 miles (70 km) (Miller et al., 1996:18-35). This schedule dramatically reduces the chances of whales being exposed to project activity noises so that whales will not be effected by project activities.

Pile-driving for the installation of island slope protection would represent one of the greatest noise impacts to bowhead whales, if it were to occur during the migration period. However, pile-driving is scheduled to be completed approximately 2 weeks prior to the fall migration period in the vicinity of Seal Island, and impacts

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related to pile driving noise are not anticipated. However, if this high noise level activity was to coincide with fall migration and subsistence harvest activities, and if the harvest success was reduced, the impact could be significant to subsistence.

Other construction activities at Seal Island that could affect bowhead whales are barge traffic associated with module and drilling rig movement to the island. The modules for Northstar will be placed on the island during 1999/2000. Barges will arrive during summer from the west ahead of the bowhead migration, and will move directly to Seal Island inshore of the main bowhead migration corridor (and before many bowheads are present). Offloading will be completed before early September. There will be no travel along or across the bowhead migration route or near subsistence whaling activities. A drill rig will be moved from West Dock to the island during the first summer after island construction. Rig movement will only occur in the nearshore shallow water zone and will not go along or across the whale migration corridor. If barge offloading was to extend into fall migration and subsistence harvest activities, and if the harvest success was reduced, the impact could be significant to subsistence.

Whales react most noticeably to erratically moving vessels with varying engine speeds and gear changes, and to vessels in active pursuit (Richardson et al., 1985; Richardson and Malme, 1993). During this project, however, most operations by support vessels and sea lifts of process modules and a drill rig will be by slow-moving vessels. Bowhead reactions to slow-moving vessels are much less dramatic. Bowheads often tolerated the approach of slow-moving vessels to within a few hundred meters, especially when the vessel is not directed toward the whale and when there are no sudden changes in direction or engine speed (Richardson et al., 1995a:269). Vessel traffic supporting Northstar construction and operations will largely occur between Seal Island and the mainland, and would not approach or pursue whales. Any vessel impacts would be restricted to an area close to or inshore of Seal Island; since bowhead whales only occasionally occur that close to shore, any impacts of this vessel traffic to bowhead whales would be minor.

Although barge activity for the transport of major components is scheduled to be completed in the vicinity of Seal Island prior to the arrival of the fall bowhead migration, work boat traffic may be ongoing. The reaction of bowhead whales to vessel noise is well documented through observations from Inupiat hunters and from marine mammal surveys. Although avoidance reaction due to noise from a small boat has been noted at distances as small as 1.2 to 2.5 miles (1.9 to 4.0 km) (Richardson et al., 1995a:268), observations related to outboard motor operations noted avoidance reactions at approximately 3 miles (4.8 km) (T. Brower, Sr. in NSB, 1980:107) and reactions to other vessels have ranged from 6 miles (9.7 km) (Ljungblad et al., 1985:45, 509) to 9.3 miles (15 km) (Richardson et al., 1985a:116; Koski and Johnson, 1987:59-61). Therefore, although a few bowheads might avoid vessel traffic at ranges of up to 10 miles (16 km), most will avoid vessels at ranges of 0.6 to 2.5 miles (1 to 4 km). In addition to avoidance behavior, Inupiat hunters have also noticed noise-related changes in whale behavior that make them more difficult to hunt, but do not appear to jeopardize the whales themselves (F. Long Jr., 1998:1 to 8; S. Taalak, 1998:1 to 2). The impacts to bowheads from the level of the proposed activity are expected to be minor.

Evidence suggests that the number of bowhead whales expected to be present within a radius of several miles around Seal Island is very small, but some whales are expected to migrate through the broader offshore corridor within 10 miles (16 km) of the site. Some of these animals may hear underwater noises generated by certain types of construction activities. The expected noise levels and the variability in noises are not known at this time, but can be estimated based on existing noise level data from island-based drilling activities (Johnson et al., 1986:83-86), and empirically-based sound transmission loss data (Greene, 1997:24-42). These data indicate that noise levels within 0.5 miles (0.8 km) are expected to be high enough that disturbances to bowhead whales are possible. Levels at greater ranges are less predictable due to variable noise levels and transmission losses. Construction noise might be above ambient noise levels at ranges of 3 to 4 miles (4.8 to 6.4 km) under some conditions. The short-term behavioral reactions of bowheads to these noises could be avoidance within 3 to 4 miles (4.8 to 6.4 km) of Seal Island. A 5-day acoustical study conducted near Seal Island in 1984 using an array of four hydrophones detected only 42 bowhead calls. A few calls were located and indicated that three whales passed within 1.7 to 3.7 miles (2.8 to 6 km) of the island. These whales were closer than any whales seen during aerial surveys, and the ranges of these whales from the island indicate that not all whales avoided the area within a few miles of the island during drilling and well-logging and after operations had ended. This indicates that such attenuated noise would have a minor impact on this species.

Most sounds produced by construction activities on the island are not expected to propagate very far and are only expected to be detectable above natural background noise levels within ranges of several kilometers from the island. Several island construction activities such as pile driving and hammering, have been shown to generate high sound levels that can be considerably greater than ambient noise (Spencer, 1996; Greene, 1987). The worst case impact of a high noise level activity would happen when a combination of events occurred simultaneously. This includes a high noise level activity such as installation of sheet piles, low ambient noise conditions so that the activity's noise is detectable at greater than normal range, and whales migrating within 6.2 to 9.3 miles (10 to 15 km) of the site. The chances of all three conditions occurring during the project are extremely small. Island construction is scheduled to occur between mid-January through August, with the loudest activities restricted between mid-March and mid-May (Table 4-7). This is during the whales' spring migration when animals rarely come within 40 miles (64.4 km) of the coast (Figure 6.9-3). In the fall when the whales are migrating closer to the coast, low ambient noise conditions (less than 70 dB in any 1/3 octave band below 100 Hz) occur less than 5% of the time (Richardson et al., 1998:3-49 to 3-54). Because island construction activities are scheduled for the spring period when the closest whales are expected to be many tens of miles from the site, no impact is expected during the spring migration period. Most island construction activities would be scheduled for completion before fall migration, and impact to bowhead whales would be minor. However, if construction activities were to extend and coincide with fall migration and subsistence harvest activities, and the harvest success was reduced, the impact could be significant to subsistence. Because no island construction activities are scheduled for the fall period when only a few whales are expected to come within 6.2 to 9.3 miles (10 to 15 km) of the site and very quiet ambient conditions are rare, no impact is expected during the fall migration period.

Construction activities at Seal Island would require helicopter flights from onshore locations. Overall, aircraft overflights can cause a rapid short-term response from bowheads, but evidence does not suggest that this type of disturbance causes bowheads to avoid an area with aircraft activity. However, extensive helicopter activity during installation of modules could contribute to overall avoidance of Seal Island during fall migration due to industrial noise. The biological impact from helicopter and airplane noise is expected to be minor. However, the National Marine Fisheries Service would recommend appropriate measures to avoid and minimize potential effects to bowhead whales during construction.

Beluga Whale:

Ice Road Construction and Operation and Offshore Pipeline Installation: Beluga whales would not be present during ice road construction or operation or during the offshore pipeline installation. Therefore, no impacts to the species as a result of such activities are anticipated.

Island Construction: Beluga whales are expected to be present in the project area from mid-spring through mid-fall. The number of belugas expected near the Seal Island site is very small, as the majority migrate further offshore in the fall. Most of the sounds from the site are expected to be low-frequency and few belugas moving through the area will be able to hear the underwater noises generated from construction activities and vessel noise. Estimates indicate that mid- to high-frequency noise levels within 0.5 miles (0.8 km) are expected to be sufficient for belugas to avoid the immediate area around the construction site (Johnson et al., 1986:83-86; Greene, 1997:3-24 to 3-42). Sound levels at greater distances are expected to be much less due to the effects of frequency dependent transmission loss. Impacts to beluga whales are expected to be negligible.

Animals that come within about 0.3 miles (0.5 km) of Seal Island are expected to hear the mid- to high-frequency underwater noises generated by drilling activities and might avoid the noise area. Impacts to beluga whales from drilling would be minor.

Seals: The zone of potential noise impact for seals is expected to be on the order of 0.6 to 1.2 miles (1 to 2 km), depending on ambient noise conditions and seal responsiveness. Seals would be likely to be affected only during ice road construction and operation activities, they are expected to avoid the area during island reconstruction and related activities.

Ringed Seal: Construction activities, particularly pile installation, would create noise and vibration sufficient to cause disturbance to ringed seals, possibly resulting in abandonment of dens and territories established in the bottomfast ice. Animals are expected to be temporarily displaced from construction areas. Loss of habitat for individual ringed seals due to construction is expected to be small because of the large areal extent of a seal's territory (Section 6.5). A temporary displacement of ringed seals also could occur as a result of the displacement of fish due to underwater noise caused by pile driving. The displacement and any impacts to individual breeding success would be temporary (limited to the late winter/early spring construction period). Impacts to ringed seals would be minor.

Bearded Seal: Due to the low population density of bearded seals in the nearshore Alaskan Beaufort Sea during winter, impact of Seal Island reconstruction on this species is likely to be limited to temporary and localized disturbance of the small number of bearded seals. Some animals might temporarily avoid areas of construction activity. The impact on bearded seals is expected to be negligible.

Spotted Seal: Spotted seals spend most of their time in nearshore ice-free waters and may be disturbed by noise from vessels and construction. Most spotted seal concentrations in the nearshore Alaskan Beaufort Sea lie west of BPXA's proposed project area; the nearest major haulout sites are more than 30 miles (48 km) west of the study area in the Colville River delta. Spotted seals likely would not be affected by construction, with the possible exception of disturbances by increased vessel traffic. Impacts to spotted seals would be negligible.

Polar Bear: No polar bear dens have been reported near the mine site; however, occasional dens have been located in the project area. Disturbance to denning polar bears as a result of noise from gravel mining on the Kuparuk River delta may occur. Disturbance of female bears from maternity dens could result in either abandonment of cubs or premature exposure of cubs (Amstrup, 1993:249). Should denning polar bears be disrupted near the mine site, the impact would be considered minor. However, it is unlikely that the polar bear population would be affected by gravel mining in this area.

Polar bears may avoid the immediate vicinity of the construction area or they may be attracted to it, depending upon the circumstances and the temperament of individual bears. Bears could avoid areas with high levels of in-air noise that is expected from construction equipment. Avoidance of the area is expected to have benefits since it would reduce the number of encounters between bears and humans, thereby reducing the chances of human injury or the need to kill bears. A shift in ringed seal distribution as a result of construction noise also could cause polar bears to avoid the area because of a lack of its primary prey. Avoidance or attraction to the construction site by bears is expected to have a minor impact on bears.

Fish: Gravel hauling, island reconstruction, and pipeline construction activities would be expected to generate noise from construction equipment and transportation sources that may be transmitted through water as described in Section 9.7. Most construction activities would take place during the winter and only affect marine fish (Section 6.4). Island slope protection and facilities installation and associated transportation activities would generate noise during the open water season that could affect marine and anadromous fish. Additional research and analysis is necessary to definitively determine the effects of noise on fish. Although rockfish are not present in the project area, studies on their reaction to noise indicate that impacts from noise on fish are expected to be negligible. However, impacts to fish in the project area may be different due to differences in species.

Birds:

Ice Road Construction, Island Construction, and Pipeline Installation: Construction activities associated with gravel mining and hauling, trenching and burial of the offshore pipelines, and installation of the onshore oil pipelines would take place in the winter. Winter construction activities would create noise and disturbance in the general area from blasting (mining) and use of heavy equipment, but few birds if any would be in the project area during the winter months. Only a few species of terrestrial birds, such as common ravens and ptarmigan, would be present in winter and in very low numbers. The proposed offshore pipeline route would pass between two barrier islands (Egg and Stump Islands) but would not affect the nesting habitats of common eiders and glaucous gulls on these islands since construction activities would be completed prior to the arrival of these birds in late spring/early summer. The overall effect of noise and disturbance on birds from winter construction activities would be temporary to individual ravens or ptarmigan and the impact is considered to be negligible. Spectacled eiders are not expected to be affected by winter construction activities at Seal Island because they are absent from the Alaskan Beaufort Sea during the winter.

Island Slope Protection Installation and Open Water Construction Period Activities: Island slope protection and island infrastructure construction would take place during the open water period when waterfowl and seabirds are present. The major source of noise affecting waterfowl during open water construction activities are helicopters flying to the island. Helicopter flight path and altitude is an important factor for waterfowl during the summer post-breeding season and staging for fall migration.

Information provided by BPXA and ERA Aviation, Deadhorse (Glover - Pers. Comm., 1998:1) indicates that helicopter support for Northstar primarily will be provided from the Deadhorse Airport; however, the Prudhoe Bay airstrip (operated by ARCO Alaska, Inc.) also will be used, if necessary. Helicopter flights between the Kuparuk airstrip and Seal Island are not planned (Glover - Pers. Comm., 1998:1), occasional trips may take place. Overflight restrictions currently are in place for Howe Island to avoid harassment of nesting snow geese. Pilots are requested to avoid harassment of wildlife elsewhere by either altering flight paths or maintaining sufficient altitude. Round trip flights to Seal Island (Chapter 4) are expected to total 1,100 during island construction, range from 1,140 to 1,380 during module installation (depending upon single-season and two-season construction), and total about 30 during drilling. The majority of flights during island construction would take place during April through August; flights associated with module installation would take place from late-August through November; and flights associated with drilling activities would take place throughout the year. Flights during the summer to early-fall would coincide with nesting, brood-rearing, and molting periods and could disturb birds. Flight paths between the airports and Seal Island and typical brant and snow goose nesting colony locations are shown on Figure 9-1. Impacts from fixed-wing aircraft to nesting and brood-rearing birds in the Kuparuk River Delta are not anticipated because the area is not within the approach or landing pattern of the airport and because it is not along flight paths (Perry - Pers. Comm., 1998:1). Nesting sites of spectacled eiders may be distributed throughout the area, but are not as well known as the goose colonies.

Figure 9-1 (Page 1 of 2)

Figure 9-1 (Page 2 of 2)

During spring migration and prior to fall migration, male and female spectacled eiders may be impacted both by construction activities at Seal Island and helicopters flying construction materials/personnel to and from the mainland. Post-breeding male spectacled eiders depart Arctic Coastal Plain wetlands approximately 22 June (+/- 11 days) and stage/migrate offshore a median distance of 4.2 miles (6.7 km) (+/- 6.9 miles [11 km]) (Petersen, in Bright, 1998:15). Post-breeding spectacled eider females depart Arctic Coastal Plain brood-rearing sites about 29 August (+/- 10.5 days) and stage/migrate 10.3 miles (16.6 km) (+/- 10 miles [16.4 km]) offshore. Because post-breeding females are in poor physiological condition, harassment during feeding in these areas may reduce accumulation of fat needed for migration and may have an adverse affect on survival. Therefore, if present, both male and female spectacled eiders would be impacted both by construction activities on Seal Island and helicopter flights to and from the island,

Low-elevation helicopter flights between Deadhorse Airport and Seal Island over tundra nesting areas may flush nesting birds, which may expose eggs to predation and chilling (Gollop et al., 1974:202-232). Multiple flushing events could result in reduced nest success in areas within the helicopter flight paths. The project area supports relatively low densities of eider nests in comparison to other tundra-nesting species (TERA, 1993:9).

Densities of spectacled eider breeding pairs in the Prudhoe Bay area have ranged from 0.21 to 0.49 per square mile (0.08 to 0.19 per square km [km^2]) from aerial surveys (TERA, 1996:3). Based on the mean density of spectacled eider breeding pairs for the Prudhoe Bay area, a 1-mile (1.6 km) wide flight corridor between the Deadhorse Airport and Seal Island would be expected to overfly approximately four to eight breeding pairs. Ground surveys have not been systematically conducted along all proposed pipeline routes and helicopter flight corridors. Low-elevation helicopter flights from Kuparuk Airport would be expected to affect similar numbers of breeding pairs, based on surveys of that area (TERA, 1996:3). Eiders with broods may be tolerant, to some degree, of noisy human activities, as shown by studies of radio-collared eiders with broods in the Prudhoe Bay and Kuparuk oil fields that have not demonstrated avoidance of oil field facilities (TERA, 1995:14; TERA, 1996:9). Nesting, brood rearing, and staging spectacled eiders are expected to be within the area affected by aircraft, and could be directly affected; however, this impact is considered minor and measures to avoid or minimize potential effects would be recommended by the U.S. Fish and Wildlife Service.

Brant have been shown to react negatively to helicopters, and they are likely to be affected by air traffic if colonies are overflown (Derksen et al., 1992:ii). Flight paths to and from Seal Island from the Kuparuk airstrip, the Prudhoe Bay airstrip, and Deadhorse Airport would not fly over brant nesting areas at the mouth of the Kuparuk River. Impacts to brant would depend on the aircraft type, exact flight path, as well as aircraft elevation. However, impacts to the low number of nesting brant (11 to 30 nests) within the flight path are expected to be minor.

The density of foraging birds in offshore waters near the island during the open water period is typically low, approximately 64.8 birds/square mile (25 birds/km^2) (Divoky, 1979:355). Activities on Seal Island during the open water period would likely attract scavenging glaucous gulls and jaegers, increasing the density of birds near Seal Island. Although this is expected to be a minor effect to gulls and jaegers, and noise impacts would be negligible, secondary impacts to other species may occur. This is because an increase in the population of scavengers due to an artificial food source may result in increased predation on nesting waterfowl and shorebirds.

Oldsquaw, common eiders, and surf scoters are also affected by low-level overflights (Gollop et al., 1974:202). Molting seaducks in lagoons tend to seek out sheltered areas during inclement weather, and if they are displaced from these areas, stress levels would increase (Gollop et al., 1974:202-232). Birds may move away from better feeding sites or protected areas because of the disturbance. Repeated low-level flights over molting aggregations of oldsquaws could displace those oldsquaws within the flight corridor. Foraging birds on the water or on land, and seabirds between the barrier islands and Seal Island, are more widespread and likely to suffer only temporary adverse impacts to individuals. Peak densities of molting oldsquaws in nearshore lagoons may reach 1,465 birds/square mile (566 birds/km2), a total of approximately 50,000 birds (Johnson and Herter, 1989:100). It can be assumed that up to 22,000 oldsquaw could be present in the eastern boundary of Simpson Lagoon and Gwydyr Bay based on the maximum density of 1,466 birds/square mile (566 birds/km2)(Johnson and Herter, 1989:100), and could potentially be affected by aircraft overflights of this area. If impacts to the species were to occur during the molting period, which extends from mid-July through mid-September, energy demands could increase and affect the growth of new flight feathers. Furthermore, populations of oldsquaw in Canada and parts of Alaska are declining (Conant et al., 1997:n.p.). Since large portions of these oldsquaw populations migrate through coastal lagoons in the project area, disruption from helicopter traffic through Simpson Lagoon could contribute to their overall declining numbers (Section 6.7.2.2). Overall impacts to oldsquaws and common eiders from aircraft overflights would be significant during construction, and minor during operation. Impacts to most other seabirds and sea ducks would be negligible.

Terrestrial Mammals: Gravel mining and hauling, island reconstruction, and onshore and offshore pipeline construction would take place during winter. Installation of island slope protection and facilities would take place during the open water season. An increase in the ambient noise level is expected during island and pipeline construction activities. The primary noise sources associated with pipeline construction would include vehicles such as trucks, cranes, bulldozers, backhoes, and compactors. Sound levels from these sources are similar to mining equipment.

Approximately 15 vehicle trips would be required daily during the construction period. Trucks would use existing roadways or the ice roads. Sound levels from a truck passing by may be as high as 85 dBA at 50 ft (15.2 m) from the road. An increase in the ambient noise level is expected but pipeline construction is a dynamic process whereby increased noise will be short-term and temporary in any one location.

Caribou: A small number of caribou winter on the Arctic Coastal Plain, most winter in the foothills of the Brooks Range (Child, 1973:4; Gavin, 1978:13). Gravel mining activities would create noise and disturbance in the general gravel pit area from blasting activities and equipment used for loading and transporting gravel. The disturbance may result in some displacement of caribou if any were overwintering in the surrounding area during the mining activities. Caribou move considerable distances to forage on the Arctic Coastal Plain during winter; displacement of wintering caribou would not, therefore, be expected to have an effect on health of these animals and any disturbance would be short-term. Much of the noise and activity associated with mining and gravel hauling would be similar to other industrial activities which periodically occur in the Prudhoe Bay area during the winter months. Impacts to caribou would be minor.

Noise associated with offshore construction is not expected to affect caribou onshore due to the substantial distance from the source, and onshore construction will be limited to winter months. Noise from helicopter inspection overflights during construction of the island and pipelines may cause a mild behavioral effect and, possibly, some movement, as identified in an Air Force study (Armstrong Laboratory, 1993:33-40). Therefore, impacts to caribou are considered minor.

<u>Arctic Fox</u>: Arctic fox are primarily scavengers during the winter and may be attracted to construction activity in order to obtain food scraps. These areas would include gravel mining sites and any areas where human activity would occur. Arctic fox do not typically avoid construction sites and are unlikely to be disturbed by noise. Impacts are considered minor.

Sensitive Receptors: Adverse impacts to sensitive receptors as a result of noise from project construction are expected to be short-term and largely limited to vehicle movement within the Prudhoe Bay industrial complex. Therefore, noise-related impacts to residential, hospital, meeting halls, or similar sensitive receptors are not anticipated.

Subsistence Harvesting: Subsistence resources that are most likely to be affected by construction activities are the bowhead whale and caribou. Although residents harvest several species of marine and terrestrial mammals, fish, and birds, harvesting has not been permitted within the Prudhoe Bay area since the 1970s. Among the Alaskan Beaufort Sea communities, spring harvesting of bowhead whales during their west to east migration is only practiced by Barrow residents, approximately 150 miles (241 km) west of the project area. Construction activities during the spring would not impact bowhead migration patterns or subsistence harvest success. Noise associated with fall construction activities could impact the fall subsistence harvest of Nuiqsut residents who use Cross Island as a base camp. The fall bowhead hunt from Kaktovik, located approximately 100 miles (161 km) east of the project area, would not be impacted by construction noise.

Most construction activities would be completed in the spring and fall. Fall construction would be scheduled for completion prior to the fall (late August - early October) bowhead migration period. However, activities that may continue into the fall and potentially coincide with migration during the first year include grading, installation of filter fabric and slope protection, preparation for and offloading of modules, module installation and hook-up, and drilling rig mobilization at Seal Island. The resupply of drilling consumables by boat would take place during the fall of the second year, and drilling and well completion would be ongoing during three fall seasons.

Although noise generated from such activities would be variable and dependent upon the types of vessels and equipment used, pile-driving and ocean-going tugs are likely to elicit the greatest reaction from migrating bowheads. Tugs can emit high levels of underwater noise at low frequencies. Tugs are one of the loudest types of vessels, so their sounds could travel farther than other vessels. In August 1985, underwater noise was recorded from two tugs that were keeping a barge pressed against a loading ramp at Sandpiper Island. An underwater sound level of 163 dB in the 20 to 1,000 Hz band was recorded at a distance of 0.3 miles (0.5 km) (Miles et al., 1987:106). Peak noise levels (118 dB) in the 20 to 1,000 Hz band were noted at a range of 1 mile (1.6 km) when tugs and barges were present at Seal Island (Davis et al., 1985:61).

Avoidance reactions of bowhead whales to small boats have been observed at distances up to 2.5 miles (4 km), however, most reactions have been observed at ranges of less than 1.2 miles (1.9 km), often when measured levels of underwater noise were less than 90 dB in the 1/3-octave band of maximum noise (Richardson et al., 1985a). The negative response is probably learned by association at these ranges and sound levels, and the animals probably represent the more sensitive segment of the population. The most overt responses are those for whales observed within 0.6 miles (1 km) of an approaching vessel. Whales usually avoid the approaching vessel by trying to outswim it, and response is probably mediated more by the rate of increase in the noise level than by the absolute received level. If overtaken, the whale will turn to swim away from the path of the vessel. These animals probably represent the segment of the population that is less sensitive to vessel noise since they are the animals seen closest to vessels. Whales tend to show little response to vessels that move slowly and are not heading toward them (Richardson et al., 1995a:268-270).

Inupiat hunters have also reported that bowheads are frightened by vessel noise and that bowheads would avoid approaching vessels that are attending a drilling vessel. The direct relationship of avoidance is further demonstrated by observations that whales are not present when vessels are present, but return in the absence of vessel operations. The avoidance response is such that whales have been observed to travel as far as possible from ship activity (A. Brower in USDOI, MMS, 1986:52; J. Ningeok in USDOI, MMS, 1986:16).

Bowheads respond to boats by spending less time at the surface, taking fewer breaths when surfacing, and changing swimming speed and direction. These types of reactions were evident at distances of at least 2.5 miles (4 km) from a vessel (Richardson et al., 1985a:116; Koski and Johnson, 1987:59-61). The underwater noise levels to which the reacting animals were exposed were often not any higher than noise levels experienced during Sea States 1 to 2, and in one case a mother and calf reacted when the nearest approaching vessel was approximately 9.3 miles (15 km) away (Richardson et al., 1985a:116; Koski and Johnson, 1987:59).

If large ships are active near Seal Island during fall bowhead whale migration, deflection behavior could occur at the western border of Nuiqsut's bowhead harvest area. If the whales are deflected at a distance of 25 miles (40 km), and if no whales were harvested within the eastern range of the Cross Island whaling area, impacts to the fall whale harvest could be significant to subsistence. Although unlikely because of the planned schedule of island construction activities, there is a chance that some bowheads that are close enough to hear large vessel noises might move offshore from their normal migration path. If this happened, there is a possibility that some whales near the western boundary of the Cross Island whaling area might deflect offshore, making them unavailable to the hunters. The impact of a major reduction in the subsistence harvest of bowhead whales could be significant to Nuiqsut.

Onshore pipeline construction would be carried out during the winter and is not expected to displace caribou harvested for subsistence. Therefore, impacts to caribou subsistence harvesting is not anticipated.

9.8.2.2 Operation and Maintenance Impacts

Bowhead Whale: Many Inupiat have observed that noise from oil and gas development adversely affects bowheads by deflecting the fall migration or by causing the whales to become more wary. Displacement of bowheads offshore is a major cause of concern to Inupiat whalers who have stated that hunters are forced to travel further to meet harvest quotas and it has been the reason for unsuccessful whaling seasons (Ahmoagak, 1995:4; and F. Long, Jr., 1996:73; USDOI, MMS, 1995:13; USACE, 1996:34). The 1985 harvest failure at Kaktovik has been attributed to exploratory drilling operations (J. Kaleak in MBC, 1996:69). Two offshore drilling activities during open water that year were the Hammerhead Prospect, 34 miles (55 km) east of Cross Island, drilled by ship between August 10, 1985 and September 24, 1985, and the Harvard Prospect, spudded from a gravel island within the Sandpiper unit in September. The location of the drilling vessel may have been considered to cause disturbance within the path of the fall migration pattern, near the Kaktovik subsistence harvest area (Section 7.3).

Impacts to bowhead whales from noise during drilling operations are expected to be similar to noise impacts from drilling during construction, except that during operations, drilling noise would be continuous. Underwater noise from in-air gas flaring is expected to be a negligible impact.

The predicted impacts of drilling operations and maintenance activities are not based upon direct evidence because there is not adequate data documenting bowhead responses to island drilling activities. There is sufficient data indicating that whales are sensitive to offshore industrial activity (e.g., drilling platforms and seismic surveys) and that some whales respond by avoiding the industrial activity and possibly by decreasing vocal activity rate (Richardson et al. 1997; 1998). These results, however, are for cases where the noise level was either very loud (e.g., seismic survey) or the noise source was offshore in moderately deep water. Noises produced at the drilling island site during normal operations and maintenance activities are expected to have substantially lower sound levels than both seismic survey and offshore drilling activities. Furthermore the island site is in shallow water near the coast in an area through which very few bowheads are known to migrate.

Long-term impact on bowhead whales, should it occur at all, as a result of operational drilling activities, would be limited to some displacement of individuals away from Seal Island for three reasons. First, available data from previous studies suggest that noise from drilling machinery on artificial islands is not transmitted effectively through the substrate into the water column (Richardson et al., 1995a:127). The anticipated range at which the drilling noise would be greater than ambient noise is approximately 1.2 miles (1.9 km) up to 6.2 miles (10 km) during periods of unusually low ambient noise conditions. Second, the drilling noise associated with Seal Island operations is expected to be fairly constant, and whales appear to show less response to constant noise sources than variable ones.

Third, evidence suggests that a small number of bowhead whales would occur within a several mile radius of Seal Island (Section 6.9). Measured noise levels during island drilling operations and measured ambient noise levels for Seal Island suggest that, under quiet noise conditions bowheads could hear drilling noises at distances of not more than 6.8 miles (11 km) (Johnson et al., 1986:86; Malme and Mlawski, 1979:1; Richardson et al., 1995a:127-129). The worst case impact would be that the bowhead whales which swim near Seal Island would tend to avoid swimming within 6 miles (10 km) of the site.

Impacts to migrating bowhead whales from routine island operations would generally be limited to noise disturbance emanating from tugs and supply barges. Some Native hunters believe that bowheads change their migration patterns in response to helicopter noise (P. Tukle in USDOI, MMS, 1986:23; E. Brower in USDOI, MMS, 1987:15). Bowheads are known to sometimes react to helicopters by turning or diving abruptly, but these reactions are limited to animals directly below the aircraft (Richardson et al., 1995a:103 and 249). Given that project-related helicopter traffic will mostly take place during freeze-up when ice road and boat access is restricted, noise impacts from routine island helicopter operations would be minor.

Displacement of bowhead whales might occur as a result of Seal Island operations (including drilling). The whaling community firmly believes that displacement of the bowhead migratory path and the whales' avoidance of the Prudhoe Bay area have occurred as a result of industrial activities (J. Tukle in USDOI, MMS 1987:47; P. Tukle in USDOI, MMS, 1986:23), and these experiences lead to the concern that long-term displacement will occur as a result of Seal Island operations. In the past, displacement of the migration resulted in the need to hunt in areas as far as 40 miles (64 km) from traditional hunting areas (Section 7.3.2.2) and led to meat spoilage due to extended haul distances and times (D. Rexford in USACE, 1996:41). This increased distance also greatly increased the risk to the whalers and requires greater fuel expenditures. However, significant long-term displacement is not expected to occur as a result of Seal Island operations. Operations will occur on an island and, as a result, the range at which noise generated by the operations will be above ambient level is expected to be much less than the range for seismic or drillship operations. Therefore, any displacement is expected to be on the order of a few miles and involve only a few animals. This displacement might occasionally have a some effect on subsistence harvesting, but would have minor impacts on the whales.

Oil spill response activities could result in the need for icebreaking barges pushed by tugs to maintain a corridor between West Dock and Seal Island as part of a shore-based response system during the broken/thin ice period of spring breakup and fall freezeup. During freezeup there would potentially be a period of time from mid-October through early November (between 10 to 20 days, depending on the ice growth), when the ice would be thin enough (less than 18 inches [46 centimeters]) to allow icebreaking barges pushing a tug to maintain the corridor. Scenarios for Northstar have suggested that it would be necessary to travel between West Dock and Seal Island every 48 hours in order to maintain a partially-consolidated channel. The duration of the trips would be approximately 1 to 2 hours each way, depending on the ice cover. Assuming that such activities were possible over a 10- to 20-day period, with round trips occurring every 48 hours, only 5 to 10 round trips would occur between West Dock and Seal Island during this time frame in the fall.

Since tugs are one of the loudest types of vessels and their sounds travel farther than other vessels and with the additional sound created by the ice-breaking during a time of low ambient noise, it is possible that during the fall migration of bowheads that the whales passing Seal Island could hear the noise created by the ice-breaking barge activities. A tug pushing a barge in thin ice conditions means that there is no full-astern situation, which is noisier than a bow-forward situation. True icebreaking (assumed in relatively thin ice) has an estimated source level in the 165 to 177 dB relative to 1 μPa-m range, or 172 dB at the 50 Hz spectrum level (Richardson et al., 1995:117-121). The tug and barge are expected to have a peak spectrum level of around 162 dB in the 100 to 1,000 Hz band, compared to icebreaking with peak spectrum level of around 170 dB (Richardson et al., 1995: 112 and Figure 6.5). However, icebreaking activity showed greatest peak spectrum level (180 dB) in the 10 to 40 Hz band, not the 100 to 1,000 Hz band, where these high levels represent tones due to shaft and blade rates. Therefore, the mechanism of using a tug pushing a barge to break thin ice is not expected to produce greater noise levels than a tug operating alone. This tug and barge combination is expected to create on the order of 10 to 15 dB less noise than an icebreaker operating under comparable conditions. Because an estimated 5 to 10 round trips could potentially occur between West Dock and Seal Island, with a duration of 1 to 2 hours each way, it is unlikely that a large number of whales passing by Seal Island would be affected. If icebreaking barge noise did result in bowheads deviating from their normal fall migratory route, the impact on the whales is considered minor. If the noise caused a migration or behavior deviation that reduced the success of subsistence bowhead harvesting, the effect could be considered a significant impact to subsistence. However, the proposed icebreaking barge operations are not expected to commence prior to October 15. Although bowhead whales have been observed in the project area between August 31 to October 22, very few bowhead whales are expected to be in the project vicinity or to its east after October 15; such icebreaking barge operations should not effect the fall subsistence harvesting of bowheads. Spring icebreaking barge activities do not coincide with the spring bowhead migration past the project area. The National Marine Fisheries Service would recommend appropriate measures to avoid and minimize potential effects to bowhead whales associated with operation and maintenance activities.

Beluga Whale: Beluga whales migrate north of the project area and generally would not be affected by project noise. Those that come within about 0.3 miles (0.5 km) of the operational site are expected to hear the mid- to high-frequency underwater noises generated by operation activities. There is good reason, however, to conclude that belugas would not hear noises from the operation at distances beyond 0.3 to 0.6 miles (0.5 to 1 km) because the sound energy would be restricted to low frequencies and belugas have poor hearing in the low frequency range (Awbrey et al., 1988:2274). The short-term behavioral reactions of belugas to the expected low-frequency noises probably would be a modest avoidance effect within approximately 0.5 miles (0.8 km) of the site if underwater mid- to high-frequency noises are produced. Impacts to beluga whales would be minor.

Transportation of personnel and supplies during routine island operations would generate noise from the use of trucks on ice roads during winter (November to April), helicopters during broken ice seasons (May/June and October/November), and barges during open water (May/June to September/October). These activities likely would cause some temporary disturbance of marine mammals and possibly temporary displacement from the immediate vicinity of Seal Island and along the ice road corridor; the noise impacts to beluga whales from transportation activities during routine island operations would be negligible.

Oil spill response activities could result in the need for icebreaking barges pushed by tugs to maintain a corridor between West Dock and Seal Island as part of a shore based response system in the broken ice period during spring breakup and fall freezeup. Although the use of the icebreaking barges propelled by a tug may not generate the same noises as a true icebreaking vessel, impacts to belugas can be inferred from observations of icebreaking vessels. Beluga whales have been observed responding strongly to icebreaker vessel noises at ranges of up to 31 miles (50 km) (Cosens and Dueck, 1988:52). However, since most belugas tend to concentrate further offshore (Section 6.5) it is unlikely that they would hear such noises. If oil spill response activities required the use of icebreaking barges with tugs, and displacement of belugas occurred as a result of these activities, it would still be considered a minor impact to these whales.

Seals: Impacts from noise during operation drilling would be similar to those during construction, except that noise would exist over a longer period. The zone of potential noise impact for seals during operation drilling would be the same as for construction, on the order of 0.6 to 1.2 miles (1 to 2 km), depending on ambient noise conditions and seal responsiveness. Noise from operations would be more constant and not as variable as noise from construction, so fewer animals are expected to respond to operation noises than to noises from construction activities. Long-term effects are not known, but based on observations of short-term responses of these seals to manmade noise, seals would either avoid a limited area around the site or habituate to the additional noise; therefore, impacts to ringed and bearded seals would be minor.

Oil spill response activities could result in the need for icebreaking barges pushed by tugs to maintain a corridor between West Dock and Seal Island as part of a shore-based response system during the broken ice period of spring breakup and fall freezeup. Although the use of the icebreaking barges propelled by a tug may not generate that same noises as a true icebreaking vessel, impacts to ringed and bearded seals can be inferred from observations of icebreaking vessels. There have been some observations of short-term ringed seal reactions to ships and icebreakers (Brueggerman et al., 1992 as cited from Richardson et al., 1995a:225) showing that animals hauled out on the ice tended not to respond at ranges of several kilometers, but they did respond by diving into the water at closer ranges. There are some observations of bearded seals on pack ice diving into the water when an icebreaker was working at ranges of less than 0.6 miles (1 km); however, these animals seemed to be less responsive to the icebreaker when it was in transit in open water (Richardson et al., 1995a:275). Therefore, it is likely that these activities could cause disturbance to bearded seals and result in displacement when the icebreaking barge propelled by the tug passed through the corridor. Although this activity may occur as only 5 to 10 round trips, it would be considered a minor impact on bearded and ringed seals if displacement away from the corridor occurred. The opening of a corridor between West Dock and Seal Island may also attract seals to the open water corridor when icebreaking barges are not present. If this attraction resulted in seals congregating in the open water corridor, this would be considered a minor impact.

Polar Bears: Polar bears appear to be relatively tolerant of industrial disturbance in general and may approach the project site out of curiosity (Amstrup, 1993:249). Bears could avoid areas with increased in-air noise levels that is expected from such things as drilling generators and compressors. Polar bears could avoid or be attracted to Seal Island, depending on the age/sex/reproductive status, physiological condition, and temperament of the individual bear. No bears have been killed during the last 25 years of oil field development, and only one bear has been killed in more than 20 years of exploration (S. Amstrup - Pers. Comm., 1998:1). Avoidance of the site by bears would not have any adverse impact on bears. Impacts would be negligible.

Oil spill response activities could result in the need for icebreaking barges pushed by tugs to maintain a corridor between West Dock and Seal Island as part of a shore-based response system during the broken ice period of spring breakup and fall freezeup. The open water lead created by the icebreaking barge may attract seals and, as a consequence, polar bears may be attracted to the corridor as well. Should attraction of polar bears to the area occur as a consequence of maintaining the corridor, it would be considered a minor impact. It is also likely that icebreaking barges propelled by tugs could disturb and displace polar bears as the vessels pass through the corridor. Although this activity may occur as only 5 to 10 round trips of about 1 to 2 hours each way, any displacement due to disturbance from noise would be considered a minor impact to polar bears.

Fish: Fish are not expected to be present within the area between the shoreline and the barrier islands during the winter; therefore, there would be no impacts from noise. However, if the area between the shoreline and the barrier islands did not entirely freeze and fish were present and exposed to noise, impacts to fish would be negligible. Noise from boat and barge traffic during open water periods would cause some displacement of fish; however, impacts would be minor.

Birds: Noise from operation would be limited to offshore activity with the exception of aircraft and vessels necessary to ferry personnel and supplies. Noise from compressors, drilling equipment, the gas flare, grinding and injection equipment, and generators on Seal Island would create sounds that some birds may avoid. Other species may be attracted by noise they have learned is associated with the presence of human garbage. Birds that would frequent garbage sites are likely to include gulls and ravens. The attraction to a new food resource would result in an increased number of gulls and ravens in the project area. As a result of increased survival rates due to an additional food source, the distribution and densities of these birds could increase, which would result in minor impact to population numbers. Pipeline operation does not generate noise and, therefore, any impacts.

Impacts to birds from drilling activities during the operation phase would depend on the season. During winter, impacts would be limited to a few individuals. Birds attracted to the island during the summer open water period to feed or for shelter would include oldsquaw, common eider, king eider, and glaucous gull. However, habituation to drilling activities would lessen impacts to these species, thus, impacts from noise would be considered negligible.

Impacts from routine operation of the production facilities at Seal Island on birds would depend on the season and would involve noise and disturbance from activity on the island and transportation of personnel and material to the island. During the winter months (October to April) very few birds are present in the Alaskan Beaufort Sea; therefore, noise impacts to birds from facilities operating at Seal Island in the winter are not anticipated.

Some birds (oldsquaw, phalaropes, eiders, gulls) are expected to gather in the lee of the island during broken ice and openwater; however, due to the low density of birds 6 miles (9.7 km) offshore, large numbers are not expected. It is expected that birds would become accustomed to operation noises and, except for particularly loud events, would not be disturbed by on-going activities. Disturbance or displacement of these birds by operational noise during broken ice or open water would have negligible impacts. Helicopter and barge traffic ferrying personnel and supplies to the island during the broken ice and open water periods has the potential to disturb birds onshore and in nearshore waters. These noise effects would be similar to those from island slope protection and summer construction activities. Overall impacts to spectacled eiders, oldsquaws, common eider, and surf scoters from aircraft overflights in nearshore waters would be minor. Impacts to most other seabirds and sea ducks would be negligible. Impacts to brant and spectacled eiders from onshore helicopter overflights are expected to be minor.

No studies on the effects of noise on spectacled eiders have been conducted. It can only be inferred from studies of distribution of radio-collared eiders with broods in the Prudhoe Bay and Kuparuk oil fields that spectacled eiders have not demonstrated avoidance of oil field facilities or high noise areas (TERA,, 1995:14; TERA, 1996:9). TERA (1995:10-11) noted that at "the present stage of understanding it is difficult to formulate defensible hypotheses as to what would be expected regarding what spectacled eiders would do in the absence of facilities, largely because of the uncertainty as to what constitutes brood rearing habitat." TERA (1995:11) also noted that "qualitatively, the movements documented for our marked broods (6 broods) do not suggest avoidance of facilities or obstacles to movements." However, it is of importance to note that noise and activity may result in avoidance of facilities, whether or not they pose obstacles to brood movement (TERA, 1995:11-12).

Spectacled eiders appear to tolerate some degree of noise from industrial sources throughout the Prudhoe Bay region. Most broods observed in the Prudhoe Bay area spent part of their time within 656 ft (200 m) of high-noise production facilities, and some broods were located near Deadhorse airport (TERA, 1996:IV). Ground surveys of spectacled eiders within 1,640 ft (500 m) of the Kuparuk and Milne Point oil fields showed eiders to be present at an average distance of 722 to 732 ft (220 to 233 m) from oil field facilities, with one pair as close as 32.8 ft (10 m) (Anderson and Cooper, 1994:24). Anderson and Cooper (1994:58) noted that spectacled eiders were widely distributed in the Kuparuk and Milne Point oil fields but were not abundant at any single location. During the brood-rearing period, eiders with broods were also found to move extensively through the region and did not appear to avoid high noise areas (TERA, 1995:7-9). Anderson (1992) reported potential avoidance by spectacled eiders of the GHX-1 facility at Prudhoe Bay (as cited in TERA, 1995:12). However, the Prudhoe Bay area supports low densities of eider nests and broods, ranging from 0.34 to 0.51 nests/square mile (0.13 to 0.22/km^2) (TERA, 1995:5), based on aerial and ground surveys conducted from the Kuparuk River to the Sagavanirktok River, an area of approximately 463.3 square miles (1,200 km^2) (TERA, 1995:1-2). Effects of noise from project operations would be considered a minor impact.

Given the similarities in ecology between Steller’s and spectacled eiders, it is expected that industrial noise would result in a minor impact to both species.

Oil spill response activities could result in the need for icebreaking barges pushed by tugs to maintain a corridor between West Dock and Seal Island during the broken ice period, until the ice becomes greater than 18 inches (46 centimeters) thick and movement between the two sites is not feasible. As a result, during the spring bird migration oldsquaws, king eiders, common eiders, and spectacled eiders may become attracted to these created open leads and congregate there (however, the fall migration is not expected to coincide with these operations because icebreaking activities should not occur prior to October 15). The open water leads created by such an activity would enable these birds to feed more easily off the epontic community beneath the ice. Icebreaking barges moving periodically through the leads would flush these birds from these feeding areas. However, assuming that fall freezeup allows for only 5 to 10 roundtrips, with a duration of only about 1 to 2 hours each way, it is unlikely that a noticeable disturbance would occur to birds that congregated in the created open leads. However, if such activity resulted in decreased productivity or survival of these birds, it would be considered a minor impact.

Terrestrial Mammals: Noise from operation will be limited to offshore activity, with the exception of aircraft necessary to ferry personnel and supplies and vehicular traffic. Pipeline operation would not generate noise. No impacts would occur to terrestrial mammals from noise emitted on the island due to the substantial distance from the source.

The effects of noise from helicopter inspection overflights to caribou, Arctic fox, and grizzly bear would be similar to those described for construction activity. Helicopter inspection overflights may elicit a mild behavioral effect, but this would be temporary. Impacts would be minor.

Sensitive Receptors: Adverse impacts to sensitive receptors as a result of noise from project operation is not expected because processing, gas compression, and related activities would be at the Seal Island facility. Furthermore, noise impacts from transportation activities would be limited to the Prudhoe Bay industrial complex and not in proximity to residential, hospital, meeting halls, or similar sensitive receptors.

Subsistence Harvesting: Impacts to the bowhead whale subsistence harvest as a result of operations and maintenance are likely to be less than those of construction and the same, regardless of alternative. However, the sensitivity of bowhead whales to low frequency sound indicates that operational noise would be heard at distances of 5 to 10 miles (8 to 16 km) under quiet ambient conditions.

The reaction of bowhead whales to vessel noise is documented through observations from Inupiat hunters and from marine mammal surveys. Although the avoidance reaction due to noise from a small boat has been noted at distances as small as 1.2 to 2.5 miles (1.9 to 4.0 km) (Richardson et al., 1995a:268), observations related to outboard motor operations noted avoidance reactions at approximately 3 miles (4.8 km) (T. Brower, Sr. in NSB, 1980:107), and reactions to moderate-sized vessels have ranged from 6 miles (9.7 km) (Ljungblad et al., 1985:45) to 9.3 miles (15 km) (Richardson et al., 1985a:116; Koski and Johnson, 1987:59-61). Observations of bowhead avoidance due to large noise sources (i.e., drilling vessels) have been noted at 13 to 15 miles (21 to 24 km) (LGL and Greenridge, 1987:41) and have been found to affect subsistence harvesting (T. Napageak in USDOI, MMS, 1995:13; B. Adams in USDOI, MMS, 1995:26; H. Brower, Jr. in USDOI, MMS, 1995:84; B. Rexford in MBC, 1996:80; J. Kaleak in

MBC, 1996:69; B. Oyagak in USDOI, MMS, 1986:11). Although most noise-related activities that would cause displacement at distances sufficient to impact subsistence harvesting are likely to be related to logistics resupply and island grading and slope protection maintenance (each requiring annual usage of three barges), if such activities coincided with the fall migration, impacts resulting in a reduction in bowhead subsistence harvest could be significant.

Oil spill response activities could result in the need for icebreaking barges pushed by tugs to maintain a corridor between West Dock and Seal Island as part of a shore-based response system during the broken ice period of spring breakup and fall freezeup. Should such activities result in the displacement of bowhead whales, beluga whales, ringed and bearded seals, polar bears, and birds, subsistence users of these resources would be impacted. Although such displacements may last for only a short period of time (i.e, the period of time of the activity), if these activities resulted in the reduction of subsistence bowhead whale harvest for the local residents, it could be considered a significant impact to subsistence. However, these proposed icebreaking barge operations are not expected to commence prior to October 15. Because very few bowhead whales are expected to be either in or east of the project vicinity after October 15, such icebreaking barge operations should not effect the fall subsistence harvesting of bowheads. Spring icebreaking barge activities do not coincide with the spring bowhead migration past the project area.

Impacts to caribou herds within the project area could affect subsistence harvesting if productivity were to be reduced or migration patterns to traditionally used subsistence harvest areas were disrupted. Although helicopter overflights for periodic inspection of the onshore pipeline through open tundra could have a greater impact on caribou than those that parallel existing pipelines, flight elevations would be sufficient to avoid disruption of migration patterns. Lease stipulations for Northstar require that aircraft operations within 30 miles (48 km) of the coast between the Colville And Kuparuk Rivers avoid caribou by an altitude of at least 1,500 ft (457 m) or a lateral distance of 1 mile (1.6 km). Although a greater potential exists for migration pattern disruption along Alternative 2 and the link between Point Storkersen and Point McIntyre (Alternative 3) than those of Alternatives 4 and 5, no impacts to caribou subsistence harvesting are anticipated, regardless of the alternative selected.

9.8.2.3 Abandonment Impacts

Noise impacts related to abandonment are likely to be similar to those of construction. If the facility were decommissioned, vessel and barge traffic would be required for removal and transport to onshore locations or to other ports. Removal of the island protection would result in greater noise-related impacts than those of abandonment in place.

9.9 SUMMARY OF ENVIRONMENTAL CONSEQUENCES

The project would generate noise from construction, operation, maintenance, and abandonment activities. Major noise sources would include ships, boats, helicopters, drilling equipment, trucks and busses for ferrying supplies and personnel. Construction of the island and pipeline will require diesel generators, bulldozers, backhoes, compressors, and pile drivers. Noise-related impacts would only occur during some circumstances, such as those related to maintenance or oil spill cleanup. In such cases, displacement of subsistence species could have a significant impact on subsistence harvesting.

- The bowhead whale may experience some degree of behavioral reactions and avoidance of Seal Island during migration due to noise, but the impact is considered minor. However, if such behavioral reactions were to result in long-term changes in bowhead migration patterns (over the life of the project and beyond), impacts to subsistence harvesting activities would be considered significant.

- Impacts on other marine mammals (ringed and bearded seals, beluga whale, and polar bear) due to noise from offshore sources are considered minor and limited to behavioral reactions and avoidance of Seal Island. Minor impacts would be expected from onshore noise sources.

- Impacts due to noise from offshore sources on fish are considered negligible. No impacts to fish would be expected from onshore noise sources.

- Impacts on birds due to noise from onshore and offshore sources is considered negligible, with four exceptions: 1) noise from helicopter overflights during construction could affect molting common eiders and oldsquaw, which may result in a significant impact; 2) noise from helicopters that may overfly nesting areas may affect nesting brant and result in a minor impact; 3) noise from helicopter overflights may have a minor impact to nesting eiders, waterfowl, and shorebirds in tundra areas, and molting sea ducks in nearshore waters; 4) barge traffic to the island during broken ice and open water periods may disturb foraging birds, and result in a minor impact; and 5) repair of the concrete mat armor protection system could displace some foraging birds from activities on the island slopes, which may result in a minor impact.

- Impacts from noise from offshore sources would have no effect on terrestrial mammals due to distance to the source. Noise from onshore construction sources would not impact denning grizzly bears and impacts from operation would be negligible. Impacts to Arctic fox from construction and operation activities would be negligible. Noise from aircraft overflights during construction and operation may result in a disturbance to some caribou, resulting in minor impacts during calving, migration, and insect-relief periods.

- If industrial noise were to occur as a result of an oil spill cleanup or offshore maintenance and repair activities during a period that coincided with the fall bowhead migration, the migration pattern could be deflected. A pattern deflection that would result in decreased harvest success or failure of the fall bowhead harvest would result in a significant impact to local whaling communities, such as Nuiqsut and Kaktovik.

- Impacts from noise during abandonment would be similar to those of construction. If the island slope protection were removed as part of abandonment, noise related impacts would be greater than if the slope protection were to remain in place.

Recognizing that the potential impacts described above would be felt by North Slope Inupiat, a minority population as addressed in Executive Order 12898, questions regarding Environmental Justice are raised.

For a discussion of Environmental Justice considerations, see Section 7.10.

9.10 REFERENCES

Ahmaogak, George N., Sr. "Comments Regarding the Development of a Policy Pertaining to Research in the U.S. Arctic." Inuit Studies 9.2 (1985): 27-31.

---. Concerns of Eskimo People Regarding Oil and Gas Exploration and Development in the United States Arctic. Unpublished paper presented at the Workshop on Technologies and Experience of Arctic Oil and Gas Operations, 10-12 April 1995, Girdwood, Alaska. N.p.: n.p., 1995.

---. "Protecting the Habitat of the Bowhead Whale." Proceedings of the Sixth Conference of the Comite Arctique International. Eds. L. Rey and V. Alexander. New York: E.J. Brill, 1989. 593-597.

Amstrup, Steve, U.S. Geological Survey, Biological Resource Division. Meeting with B. Kovol, Dames & Moore re: Polar bear kills by oil industry. 13 Nov. 1998.

Amstrup, Steven C. "Human Disturbances of Denning Polar Bears in Alaska." Arctic 46.3 (1993): 246-250.

---. "Movements, Distribution, and Population Dynamics of Polar Bears in the Beaufort Sea." Diss. Univ. of Alaska, Fairbanks. Fairbanks: n.p., 1995.

Anderson, Betty A. The Effects of Point McIntyre/ GHX-2 Gravel Hauling on Brant. Prepared for ARCO Alaska, Inc by Alaska Biological Research, Inc. Anchorage: ABR, 1992.

Anderson, Betty A., and Brian A. Cooper. Distribution and Abundance of Spectacled Eiders in the Kuparuk and Milne Point Oilfields, Alaska, 1993 Final Report. Prepared for ARCO Alaska, Inc by Alaska Biological Research, Inc. Anchorage: ABR, 1994.

Anderson, Betty A., Alice A. Stickney, and Robert J. Ritchie. Avian Studies in the Kuparuk Oilfield, Alaska, 1995. Final Report. Prepared for ARCO Alaska, Inc. and the Kuparuk River Unit by ABR, Inc. Fairbanks: ABR, 1996.

---. Avian Studies in the Kuparuk Oilfield, Alaska, 1996. Final report. Prepared for ARCO Alaska, Inc. and the Kuparuk River Unit by ABR, Inc. Fairbanks: ABR, 1997.

Armstrong Laboratory. Behavioral Responses of Caribou to Low-Altitude Jet Aircraft. AL/OE-TR-1994-0117. December. N.p.: AL, 1993.

Awbrey, F. T., J. A. Thomas, and R. A. Kastelein. "Low-Frequency Underwater Hearing Sensitivity in Belugas, *Delphinapterus leucas*." J. Acoust. Soc. Am. 84.6 (1988): 2273-2275.

Bel'kovich, V. M. "Some Biological Observations on the White Whale from the Aircraft." Zool. Zh. 39.9

(1960): 1414-1422.

Belanger, Luc, and Jean Bedard. "Responses of Staging Greater Snow Geese to Human Disturbance." J. of Wildlife Management 53.3 (1989): 713-719.

Bergerud, Arthur T. "The Role of the Environment in the Aggregation, Movement and Disturbance Behavior of Caribou." The Behavior of Ungulates and Its Relation to Management. The Papers of an International Symposium Held at the University of Calgary, Alberta, Canada, 2-5 Nov. 1971. Paper No. 29.Vol. 2. Morges, Switz.: International Union for Conservation of Nature and Natural Resources, 1974. 552-584.

Blix, A.S., and J. W. Lentfer. "Noise and Vibration Levels in Artificial Polar Bear Dens as Related to Selected Petroleum Exploration and Developmental Activities." Arctic 45.1 (1992): 20-24.

Bright, Larry K., U.S. Fish and Wildlife Service. Letter to Colonel S. Jahn, U.S. Army Corps of Engineers, Alaska District re: Comments on Northstar PDEIS. 18 Mar. 1998.

Brueggeman, J. J., G. A. Green, R. A. Grotefendt, M. A. Smultea, D. P. Volsen, R. A. Rowlett, C. C. Swanson, C. I. Malme, R. Mlawski, and J. J. Burns. 1991 Marine Mammal Monitoring Program (Seals and Whales) Crackerjack and Diamond Prospects Chukchi Sea. Prepared for Shell Western E & P Inc. and Chevron USA Inc. by EBASCO Environmental. Bellevue: EBASCO, 1992.

Budelsky, R. A. "Sex and the Single Male: Bearded Seal Mating Strategies Off Pt. Barrow, Alaska." Abstract 10th Bienn. Conference Biol. Marine Mammals, Nov. 1993, Galveston, Texas. Galveston: n.p., 1993. 33.

Burns, John J., and Kathryn J. Frost. The Natural History and Ecology of the Bearded Seal, *Erignathus barbatus*, Final Report. Fairbanks: ADF&G, 1979.

Burns, John J., and Samual J. Harbo, Jr. "An Aerial Census of Ringed Seals, Northern Coast of Alaska." Arctic 25.4 (1972): 279-280.

Burns, John J., and Glenn A. Seaman. "Part II: Biology and Ecology." Investigations of Belukha Whales in Coastal Waters of Western and Northern Alaska. Contract NA 81 RAC 00049.Prepared for Alaska Department of Fish and Game. Fairbanks: ADF&G, 1985.

Burns, John J., Brendan P. Kelly, Larry D. Aumiller, Kathryn J. Frost, and Sue Hills. Studies of Ringed Seals in the Alaskan Beaufort Sea During Winter: Impacts of Seismic Exploration, Annual Report. Annual Report, Contract NO. NA 81 RAC 00045, NOAA Project No. RU #232, Reporting Period 1 January to 31 December 1982. Fairbanks: USF&G, 1982.

Calef, George W., Elmer A. DeBock, and Grant M. Lortie. "The Reaction of Barren-Ground Caribou to Aircraft." Arctic 29.4 (1976): 201-212.

Calvert, W., and I. Stirling. "Winter Distribution of Ringed Seals (*Phoca hispida*) in the Barrow Strait Area, Northwest Territories, Determined by Underwater Vocalizations." Can. J. Fish. Aquat. Sci. 42.7 (1985): 1238-1243.

Canadian Wildlife Service, United States. Department of the Interior. Fish and Wildlife Service, and United States. Department of the Interior. Geological Survey (CWS et al.). Conservation Issues for North American Sea Ducks: A Concept Paper for a Sea Duck Joint Venture Under the North American Waterfowl Management Plan. N.p.: n.p., 1997.

Child, K. N. The Reactions of Barren-Ground Caribou (*Rangifer tarandus* Granti) to Simulated Pipeline and Pipeline Crossing Structures at Prudhoe Bay, Alaska. Alaska Cooperative Wildlife Research Unit, University of Alaska, Fairbanks, Alaska. Fairbanks: UAF, 1973.

Clark, C. W. "Acoustic Behavior of Mysticete Whales." Sensory Abilities of Cetaceans. Eds. J. Thomas and R. Kastelein. N.p.: Plenum Press, 1991. 571-83.

Clark, C. W., and J. H. Johnson. "The Sounds of the Bowhead Whale, *Balaena mysticetus*, During the Spring Migrations of 1979 and 1980." Can. J. of Zool. 62 (1984): 1436-1441.

Clark, C. W., W. T. Elison, and K. Beeman. A Preliminary Account of the Acoustic Study Conducted During the 1985 Spring Bowhead Whale, *Balaena mysticetus*, Migration Off Point Barrow, Alaska. Rep. Interior Whal. Comm. Vol. 36. N.p.: n.p., 1986.

Cleator, H. J., I. Stirling, and T. G. Smith. "Underwater Vocalization of the Bearded Seal (*Erignathus barbatus*)." Can. J. Zool. 67.8 (1989): 1900-1910.

Contant, Bruce, Deborah J. Groves, Carl Ferguson, and Rodney J. King. "Oldsquaw Ducks - Towards Listing?" Seventh Alaska Bird Conference, 1-5 December, 1997, Anchorage, Alaska. Abstract. Sponsored by the U.S. Fish and Wildlife Service Migratory Bird Management. N.p.: n.p., 1997.

Cosens, Susan E., and Larry P. Dueck. "Responses of Migrating Narwhal and Beluga to Icebreaker Traffic at the Admiralty Inlet Ice-Edge, N.W.T. in 1986 ." Port and Ocean Engineering Under Arctic Conditions . Symposium on Noise and Marine Mammals. 17-21 August, 1987, University of Alaska Fairbanks. Eds. W.M. Sackinger and M.O. Jeffries. Fairbanks: UAF, 1988. 27-38.

Cummings, W. C., D. V. Holliday, and B. J. Graham. "Measurements and Localization of Underwater Sounds From the Prudhoe Region, Alaska, March 1981." Environmental Assessment of the Alaskan Continental Shelf , Final Reports of Principal Investigators. December 15, 1981.Vol. 19. Prepared for OCSEAP, Arctic Project Office, and the Alaska Eskimo Whaling Commission by Oceanographic Consultants and Tracor, Inc. N.p.: USDOC, 1983. 393-443.

Davis, Rolph A., Charles R. Greene, and Peter L. McLaren. Studies of the Potential for Drilling Activities on Seal Island to Influence Fall Migration of Bowhead Whales Through Alaskan Nearshore Waters. Prepared for Shell Western E&P Inc. Pacific Frontier Division by LGL, Ltd. and

Greeneridge Sciences Inc. King City, Can.: LGL, Ltd., 1985.

Derksen, Dirk V., Karen S. Bollinger, Dan Esler, Kent C. Jensen, Eric J. Taylor, Mark W. Miller, and Milton W. Weller. Effects of Aircraft on Behavior and Ecology of Molting Black Brant Near Teshekpuk Lake, Alaska, Final Report 1987-1991. Anchorage: USDOI, MMS, 1992.

Divoky, George J. "The Distribution, Abundance and Feeding Ecology of Birds Associated With Pack Ice ." Environmental Assessment of the Alaskan Continental Shelf, Annual Reports of Principal Investigators for the Year Ending March 1979. Volume I. Receptors - Mammals, Birds. Prepared for the U.S. Department of Commerce, National Oceanic and Atmospheric Administration and U.S. Department of Interior, Bureau of Land Management. N.p.: n.p., 1979. 355-372.

Eberhardt, Lester E., Wayne C. Hanson, John L. Bengtson, Robert A. Garrott, and Eric E. Hanson. "Arctic Fox Home Range Characteristics in an Oil-Development Area." J. Wildlife Management 46.1 (1982): 183-190.

Ellison, William T., Christopher W. Clark, and Garner C. Bishop. "Potential Use of Surface Reverberation by Bowhead Whales, *Balaena mysticetus*, in Under-Ice Navigation: Preliminary Considerations." Thirty-Seventh Report of the International Whaling Commission. N.p.: Cambridge, 1987. 329-332.

Finley, K. J. "The Estuarine Habit of the Beluga or White Whale *Delphinapterus leucas*." Cetus 4.2 (1982): 4-5.

Ford, J. White Whale-Offshore Exploration Acoustic Study. Prepared for Imperial Oil Ltd. by F. F. Slaney & Co. Ltd. Vancouver, Can.: FFS, 1977.

Fraker, M. A. The 1976 White Whale Monitoring Program, Mackenzie Estuary, N.W.T. Prepared for Imperial Oil Ltd. by F. F. Slaney & Co. Ltd. Vancouver, Can.: FFS, 1977.

Fraker, M. A., and P. N. Fraker. The 1979 Whale Monitoring Program/Mackenzie Estuary. Prepared for Esso Resources Canada Ltd. by LGL, Ltd. Sidney, Can.: LGL, 1979.

Frost, Kathryn J., and Lloyd F. Lowry. "Effects of Industrial Activities on Ringed Seals in Alaska, As Indicated by Aerial Surveys." Port and Ocean Engineering Under Arctic Conditions. Symposium on Noise and Marine Mammals. 17-21 August, 1987, University of Alaska, Fairbanks. Eds. W.M. Sackinger and M.O. Jeffries. Fairbanks: UAF, 1988. 15-26.

Frost, K. J., L. F. Lowry, and R. R. Nelson. "Belukha Whale Studies in Bristol Bay, Alaska." Proceedings of the Workshop on Biological Interactions Among Marine Mammals and Commercial Fisheries in the Southeastern Bering Sea, Oct. 1983. Eds. B. R. Melteff and D. H. Rosenberg. University of Alaska Sea Grant Rep. 84-1. Fairbanks: UAF, 1984.

Frost, Kathryn J., Lloyd F. Lowry, James R. Gilbert, and John J. Burns. Ringed Seal Monitoring:

Relationships of Distribution and Abundance to Habitat Attributes and Industrial Activities. Final Report Contract No. 84-ABC-00210, NOAA Project No. RU #667. Prepared by Department of Fish & Game for the MMS, DOI as part of the Alaska Outer Continental Shelf Environmental Assessment Program. N.p.: ADF&G, 1988. 101.

Gallagher, M. L., K. D. Brewer, and J. D. Hall. Site Specific Monitoring Plan Cabot Prospect, Final Report. Prepared for ARCO Alaska, Inc. by Coastal & Offshore Pacific Corp. Walnut Creek: COPAC, 1992.

Gavin, Angus. Caribou Migrations and Patterns, Prudhoe Bay Region, Alaska's North Slope 1969-1977. Prepared for Atlantic Richfield Company. Winnipeg, Ca.: n.p., 1978.

George, Craig, Harry Brower, Jr., Geoff Carroll, and Robert Suydam. Some Thoughts on the Effects of Hunting and Industrial Noise on Bowhead Whale Distribution and Behavior, Draft. Draft paper dated April 22, 1996.Prepared by North Slope Borough Department Wildlife Management and Alaska Department Fish & Game. Barrow: DWM, 1996.

George, John C., Christopher Clark, Geoff M. Carroll, and William T. Ellison. "Observations on the Ice-Breaking and Ice Navigation Behavior of Migrating Bowhead Whales (*Balaena mysticetus*) Near Point Barrow, Alaska, Spring 1985." Arctic 42.1 (1989): 24-30.

Glover, Bob, ERA Aviation. Telephone conversation with G. High, Dames and Moore. 2 Apr. 1998.

Gollop, M. A., J. R. Goldsberry, and Rolph A. Davis. "Effects of Gas Compressor Noise Simulator Disturbance to Terrestrial Breeding Birds, Babbage River, Yukon Territory, June, 1972." Disturbance to Birds by Gas Compressor Noise Simulators, Aircraft, and Human Activity in the Mackenzie Valley and North Slope, 1972. Arctic Gas Biological Report Series Vol. 14. Prepared for Alaskan Arctic Gas Study Company by LGL, Ltd. N.p.: LGL, Ltd., 1974. 49-96.

Green, D. M., H. A. DeFerrari, D. McFadden, J. S. Pearse, A. N. Popper, W. J. Richardson, S. H. Ridgway, and P. L. Tyack. Low-Frequency Sound and Marine Mammals: Current Knowledge and Research Needs. N.p.: National Research Council, 1994.

Green, Jeffrey E., and Stephen R. Johnson. "The Distribution and Abundance of Ringed Seals in Relation to Gravel Island Construction in the Alaskan Beaufort Sea." Biological Studies and Monitoring at Seal Island, Beaufort Sea, Alaska 1982 . AWR-820005/RCS. Ed. B.J. Gallaway. Prepared for Shell Oil Company by LGL Alaska Research Associates. Anchorage: LGL Alaska, 1983. 1-28.

Greene, Charles R., Jr. "Characteristics of Marine Seismic Survey Sounds in the Beaufort Sea." J. Acoust. Soc. Am. 83.6 (1988): 2246-2254.

---. "Characteristics of Underwater Noise During Construction of Seal Island, Alaska, 1982." Biological Studies and Monitoring at Seal Island, Beaufort Sea, Alaska 1982. AWR-820005/RCS. Ed. B.J. Gallaway, Ph.D. Prepared for Shell Oil Company by LGL Alaska Research Associates Inc.

Anchorage: LGL Alaska, 1983. 117-49.

---. "Physical Acoustics Measurements." Northstar Marine Mammal Monitoring Program, 1996: Marine Mammal and Acoustical Monitoring of a Seismic Program in the Alaskan Beaufort Sea, Draft Report. Ed. W. J. Richardson. LGL Report TA2121-2.Prepared for BP Exploration (Alaska) Inc. and National Marine Fisheries Service by LGL, Ltd. and Greenridge Sciences Inc. N.p.: LGL, Ltd., 1997. 3-1-3-64.

Green, Charles R. Jr., and W. John Richardson. "Characteristics of Marine Seismic Survey Sounds in the Beaufort Sea." J. Acoust. Soc. Am. 836.6 (1988):2246-2254.

Greene, Charles R. Jr., John S. Hanna, and Robert W. Blaylock. "Physical Acoustics Measurements." Northstar Marine Mammal Monitoring Program, 1996: Marine Mammal and Acoustical Monitoring of a Seismic Program in the Alaskan Beaufort Sea. Ed. W. John Richardson. LGL Report TA2121-2.Prepared for BP Exploration (Alaska) Inc. and National Marine Fisheries Service by LGL Ltd. and Greeneridge Sciences Inc. Anchorage: LGL, 1997. 3-1-3-63.

Greene, Charles R., Robert Norman, John S. Hanna, and Robert W. Blaylock. "Physical Acoustics Measurements." Marine Mammal and Acoustical Monitoring of BPXA's Seismic Program in the Alaskan Beaufort Sea, 1997. LGL Report TA2150-3. Draft. Prepared by LGL Ltd. and Greeneridge Sciences Inc. for BP Exploration (Alaska) Inc. and National Marine Fisheries Service. King City, Can.: LGL Ltd., 1998. 3-1 to 3-64.

Hall, J. D., M. L. Gallagher, K. D. Brewer, and D. K. Ljungblad. Passive Acoustic Monitoring Program at the ARCO, Alaska, Inc. "Fireweed" Prospect Sep-Oct, 1990. Prepared for ARCO by Coastal & Offshore Pacific Corporation and Ljungblad Associates. N.p.: COPAC, 1991.

Hall, J. D., M. L. Gallagher, K. D. Brewer, P. R. Regos, and P. E. Isert. 1993 Kuvlum Exploration Prospect, Site Specific Monitoring Program Final Report. Prepared for ARCO Alaska, Inc. by Coastal & Offshore Pacific Corporation. Walnut Creek: Coastal & Offshore Pacific Corporation, 1994.

---. Kuvlum #1 Exploration Prospect, Site Specific Monitoring Program, Final Report. Prepared for ARCO Alaska, Inc. by Coastal & Offshore Pacific Corporation, Walnut Creek, California. Walnut Creek: COPAC, 1993.

Hanley, Peter T., James E. Hemming, John W. Morsell, Thomas A. Morehouse, Linda E. Leask, and Gordon S. Harrison. Natural Resource Protection and Petroleum Development in Alaska. FWS/OBS-80/22.Prepared for the U.S. Department of the Interior Fish and Wildlife Service, Office of Biological Services by Dames & Moore, Institute of Social and Economic Research, and Gordon S. Harrison and Associates. Washington, D.C.: USFWS, 1981.

Harrington, Fred H., and Alasdair M. Veitch. "Calving Success of Woodland Caribou Exposed to Low-Level Jet Fighter Overflights." Arctic 45.3 (1992): 213-218.

---. "Short-Term Impacts of Low-Level Jet Fighter Training on Caribou in Labrador." Arctic 44.4 (1991): 318-327.

Harris, Ross E., Gary W. Miller, Robert E. Elliott, and W. John Richardson. "Seals." Northstar Marine Mammal Monitoring Program, 1996: Marine Mammal and Acoustical Monitoring of a Seismic Program in the Alaskan Beaufort Sea. Ed. W. John Richardson. LGL Report TA2121-2. Prepared for BP Exploration (Alaska) Inc. and National Marine Fisheries Service by LGL Limited and Greeneridge Sciences Inc. Anchorage: LGL, 1997. 4-1-4-42.

Jensen, Finn B. "Sound Propagation in Shallow Water: A Detailed Description of the Acoustic Field Close to Surface and Bottom." J. Acoust. Soc. Am. 70.5 (1981): 1397-1406.

Johnson, S. R., C. R. Greene, R. A. Davis, and W. J. Richardson. Bowhead Whales and Underwater Noise Near the Sandpiper Island Drillsite, Alaskan Beaufort Sea, Autumn 1985. June 30, 1986. Prepared for Shell Western E&P Inc., Alaska Division by LGL, Ltd. and Greeneridge Sciences Inc., Santa Barbara, California. Anchorage: Shell, 1986.

Johnson, S. R., J. J. Burns, C. I. Malme, and R. A. Davis. Synthesis of Information on the Effects of Noise and Disturbance on Major Haulout Concentrations of Bering Sea Pinnipeds. OCS Study MMS 88-0092. Prepared for U.S. Department of the Interior, Minerals Management Service, Alaska OCS Region by LGL, Ltd. Anchorage: USDOI, 1989.

Johnson, Stephen R., and Dale R. Herter. The Birds of the Beaufort Sea. Anchorage: BPXA, 1989.

Kelly, Brendan P. "Ringed Seal, *Phoca hispida*." Selected Marine Mammals of Alaska: Species Accounts With Research and Management Recommendations. Ed. Jack W. Lentfer Washington, D.C.: MMC, 1988. 57-66.

Kelly, Brendan P., Lori T. Quakenbush, and John R. Rose. Ringed Seal Winter Ecology and Effects of Noise Disturbance, Final Report. Contract No. NA81RAC00045. Fairbanks: Institute of Marine Science, 1986.

Ketten, D. R. "The Cetacean Ear: Form, Frequency, and Evolution." Marine Mammal Sensory Systems. Eds. J. A. Thomas, R. A. Kastelein, and A. Ya. Supin. New York: Plenum, 1992. 773.

Ketten, D.R., J. Lien, and S. Todd. "Blast Injury in Humpback Whale Ears: Evidence and Implications." J. Acoust. Soc. Am. 94.3, Pt. 2 (1993): 1849-1850.

Klimley, Peter A., and Sallie C. Beavers. Playback of AROC-Type Signal to Bony Fishes to Evaluate Phonotaxis. MMRP/ATOC Bi-Monthly Report #9. Bodega Marine Laboratory. Davis: UC, 1997.

Koski, W. R, and S. R. Johnson. "Behavioral Studies and Aerial Photogrammetry." Responses of Bowhead Whales to an Offshore Drilling Operation in the Alaskan Beaufort Sea, Autumn 1986. Prepared for Shell Western E & P Inc. by LGL, Ltd. and Greeneridge Sciences Inc. N.p.: n.p., 1987.

LGL, Ltd., and Greeneridge Sciences Inc.(LGL and Greeneridge). Responses of Bowhead Whales to an Offshore Drilling Operation in the Alaskan Beaufort Sea, Autumn 1986. Prepared for Shell Western E & P Inc. by LGL, Ltd. and Greeneridge Sciences, Inc. N.p.: n.p., 1987. 371.

---. Marine Mammal and Acoustical Monitoring of BPXA's Seismic Program in the Alaskan Beaufort Sea, 1997; 90 Day Report. LGL Report TA2150-1. Prepared for BP Exploration (Alaska) Inc. and National Marine Fisheries Service. King City, Can.: LGL Ltd., 1997.

Ljungblad, Donald, Bernd Wursig, Steven L. Swartz, and James M. Keene. 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. Prepared for the U.S. Department of the Interior Minerals Management Service, Alaska OCS Region by SEACO, Inc. San Diego: SEACO, Inc., 1985.

Long, Frank, Jr. "History of Subsistence Whaling by Nuiqsut." Proceedings of the 1995 Arctic Synthesis Meeting. 23-25 October, 1995, Sheraton Anchorage Hotel. OCS Study MMS 95-0065. Costa Mesa: MBC, 1996. 73-76.

Malme, Charles I., and Ralph Mlawski. Measurements of Underwater Acoustic Noise in the Prudhoe Bay Area. BBN 152876, Tech. Mem. No. 513.Prepared for Exxon Production Research Company by Bolt Beranek and Newman, Inc. Houston: Exxon, 1979.

Mohl, B. "Hearing in Seals." The Behavior and Physiology of Pinnipeds. Eds. R. J. Harrison, R. C. Hubbard, R. S. Peterson, C. E. Rice, and R. J. Schusterman. New York: Appleton-Century-Crofts, 1986.

Miles, P. R., C. I. Malme, and W. J. Richardson. Prediction of Drilling Site-Specific Interaction of Industrial Acoustic Stimuli and Endangered Whales in the Alaskan Beaufort Sea. OCS Study MMS 87-0084.Prepared for U.S. Department of the Interior, Minerals Management Service, Alaska OCS Region by BBN Laboratories, Cambridge, MA and LGL, Ltd. Anchorage: USDOI, 1987.

Miller, Frank L., and Anne Gunn. "Play by Peary Calves Before, During, and After Helicopter Harassment." Can. J. of Zool. 59.5 (1981): 823-827.

Miller, Gary W., Robert E. Elliott, and W. John Richardson. "Marine Mammal Distribution, Numbers and Movements. "Northstar Marine Mammal Monitoring Program, 1995: Baseline Surveys and Retrospective Analyses of Marine Mammal and Ambient Noise Data From the Central Alaskan Beaufort Seas. Final Report. LGL Report TA 2101-2.Prepared for BP Exploration (Alaska) Inc. by LGL, Ltd. and Greeneridge Sciences Inc. King City, Can.: LGL, Ltd., 1996. 3-72.

Miller, Gary W., Robert E. Elliott, and W. John Richardson. "Whales." Marine Mammal and Acoustical

Monitoring of BPXA's Seismic Program in the Alaskan Beaufort Sea, 1997. LGL Report TA2150-3. Draft. Prepared by LGL Ltd. and Greeneridge Sciences Inc. for BP Exploration (Alaska) Inc. and National Marine Fisheries Service. King City, Can.: LGL Ltd., 1998. 5-1 to 5-123.

Miller, Gary W., Robert E. Elliott, William R. Koski, and W. John Richardson. "Whales." Northstar Marine Mammal Monitoring Program, 1996: Marine Mammal and Acoustical Monitoring of a Seismic Program in the Alaskan Beaufort Sea. Ed. W. John Richardson. Final report. LGL Report TA2121-2. Prepared for BP Exploration (Alaska) Inc. and National Marine Fisheries Service by LGL Limited and Greeneridge Sciences Inc. Anchorage: LGL, 1997. 5-1-5-115.

Moore, Sue E., and Donald K. Ljungblad. "Gray Whales in the Beaufort, Chukchi, and Bering Seas: Distribution and Sound Production." The Gray Whale *Eschrichtius Robustus*. Eds. Mary Lou Jones, Steven L. Swartz, and Stephen Leatherwood Ontario, Ca: Academic Press, Inc., 1984. 543-52.

Pearson, A.M. The Northern Interior Grizzly Bear, *Ursus arctos* L. Canadian Wildlife Service Report Series Number 34. Ottawa, Can.: Canadian Wildlife Service, 1975.

Perry, G., ARCO/Kuparuk Field. Telephone interview conducted by G. High, Dames & Moore. 3 Apr. 1998.

Ray, G. C., W. A. Watkins, and J. J. Burns. "The Underwater Song of *Erignathus* (Bearded Seal)." Zoologica (N.Y.) 54.2 (1969): 79-83.

Richardson, W. John, ed. Marine Mammal and Acoustical Monitoring of BPXA's Seismic Program in the Alaskan Beaufort Sea, 1997. LGL Report TA2150-3. Draft. Prepared by LGL Ltd. and Greeneridge Sciences Inc. for BP Exploration (Alaska) Inc. and National Marine Fisheries Service. King City, Can.: LGL Ltd., 1998.

---. Northstar Marine Mammal Monitoring Program, 1996: Marine Mammal and Acoustical Monitoring of a Seismic Program in the Alaskan Beaufort Sea. Final report. LGL Report TA2121-2. Prepared for BP Exploration (Alaska) Inc. and National Marine Fisheries Service by LGL, Ltd. and Greeneridge Sciences Inc. Anchorage: LGL, Ltd., 1997.

Richardson, W.J., C.R. Greene Jr., M.A. Smultea, B. Wÿrsig, J.S. Hanna, W.R. Kiski, G.W. Miller, N.J. Patenaude, R. Blaylock, and R. Elliott. Acoustic Effects of Oil Production Activities on Bowhead and White Whales Visible During Spring Migration Near Pt. Barrow, Alaska--1991 and 1994 Phases: Sound Propagation and Whale Responses to Playbacks of Icebreaker Noise. OCS Study MMS 95-0051, LGL Report TA954, Contract 14-12-0001-30412. Prepared for U.S. Department of the Interior Minerals Management Service, Procurement Operations by LGL, Ltd. and Greeneridge Sciences Inc. N.p.: n.p., 1995b.

Richardson, W. John, and Charles I. Malme. "Man-made Noise and Behavioral Responses." The Bowhead

Whale. Eds. J.J. Burns, J.J. Montague, C.J. Cowles. The Society for Marine Mammalogy. Special Publication Number 2. Lawrence: Allen Press, Inc., 1993. 764.

Richardson, W. John, Charles R. Greene, Jr., Charles I. Malme, Denis H. Thomson, Sue E. Moore, and Bernd Würsig. Marine Mammals and Noise. San Diego: API, 1995a.

Richardson, W. John, C.R. Greene, and B. Wÿrsig. Behavior, Disturbance Responses and Distribution of Bowhead Whales *Balaena Mysticetus* in the Eastern Beaufort Sea, 1980-84: OCS Study, MMS 85-0034. Prepared for the U.S. Department of the Interior Minerals Management Service by LGL, Ltd., Greeneridge Sciences Inc., and Moss Landing Marine Laboratories. Bryan:LGL, Ltd., 1985a.

Richardson, W. John, M. A. Fraker, B. Wÿrsig, and R. S. Wells. "Behavior of Bowhead Whales *Balaena mysticetus* Summering in the Beaufort Sea: Reactions to Industrial Activities." Biol. Conserv. 32.3 (1985b): 195-230.

Schevill, W. E., and B. Lawrence. "Underwater Listening to the White Porpoise (*Delphinapterus leucas*)." Science 109.2824 (1949): 143-144.

Schevill, W. E., W. A. Watkins, and C. Ray. "Underwater Sounds of Pinnipeds." Science 141.3575 (1963): 50-53.

Shideler, Dick. "Attraction to Human Activity." Guidelines for Oil and Gas Operations in Polar Bear Habitats. OCS Study, MMS 93-0008; Contract # 14-35-0001-30572. Ed. Joe C. Truett. Prepared by LGL Ecological Research Associates, Inc. Funded by U.S. Department of the Interior, Minerals Management Service. Washington, D.C.: USDOI, 1993

Shideler, Richard, and John Hechtel. “Grizzly Bear Use of the North Slope Oil Fields.” Proceedings of North Slope Environmental Studies Conference, 9-10 March, 1995, Anchorage, Alaska. Anchorage: BPXA, 1995. 32.

Sjare, B. L., and T. G. Smith. "The Vocal Repertoire of White Whales, *Delphinapterus leucas*, Summering in Cunningham Inlet, Northwest Territories." Can. J. Zool. 64.2 (1986): 407-415.

Spencer, Paul. BP Northstar, Report on Noise Generation at the Production Structure. Job 113672. N.p.: Sandwell, 1996.

Stickney, Alica A., Robert J. Ritchie, Betty A. Anderson, Debora A. Flint, Paul W. Banyas, and James G. King. Tundra Swan and Brant Surveys on the Arctic Coastal Plain, Colville River to Staines River, Alaska, 1992, Final Report. Prepared for ARCO Alaska, Inc., Kuparuk River Unit, BP Exploration (Alaska) Inc., and Endicott Unit Owners by Alaska Biological Research, Inc. Anchorage: ABR, 1993.

Stirling, I. "Vocalization in the Ringed Seal (*Phoca hispida*)." J. Fish. Res. Board Can. 30.10 (1973):

1592-1594.

Stirling, Ian. "Attraction of Polar Bears *Ursus maritimus* to Off-shore Drilling Sites in the Eastern Beaufort Sea." Polar Record 24.148 (1988): 1-8.

Terhune, J. M., and K. Ronald. "The Harp Seal, *Pagophilus groenlandicus* (Erxleben, 1777). III. The Underwater Audiogram." Can. J. Zool. 50.5 (1972): 565-569.

---. "Masked Hearing Thresholds of Ringed Seals." J. Acoust. Soc. Am 58.2 (1975): 515-516.

Terhune, J., and S. Turnbull. "Variation in the Psychometric Functions and Hearing Thresholds of a Harbour Seal." Sensory Systems of Aquatic Mammals. Eds. R. A. Kastelein, J. A. Thomas, and P. E. Nachtigall. Woerden, Neth: De Spil Publ., 1995.

Troy Ecological Research Associates (TERA). Distribution and Abundance of Spectacled Eiders in the Vicinity of Prudhoe Bay, Alaska: 1991-1993. Prepared for BP Exploration (Alaska) Inc. Anchorage: BPXA, 1995.

---. "Distribution and Abundance of Spectacled Eiders in the Vicinity of Prudhoe Bay, Alaska: 1994 Status Report." Northern Alaska Research Studies. Prepared for BP Exploration (Alaska) Inc. N.p.: TERA, 1996.

---. Population Dynamics of Birds in the Pt. McIntyre Reference Area 1981-1992. Prepared for BP Exploration (Alaska) Inc. by Troy Ecological Research Associates Anchorage: BPXA, 1993.

Truett, Joe C., Ray Schweinsburg, Dick Shideler, John Hechtel, Richard Tremaine, Denis Thomson, and William Koski. Guidelines for Oil and Gas Operations in Polar Bear Habitats. OCS Study, MMS 93-0008; Contract # 14-35-0001-30572. Ed. Joe C. Truett. Prepared by LGL Ecological Research Associates, Inc. Funded by U.S. Department of the Interior, Minerals Management Service. Washington, D.C.: USDOI, 1993.

Turl, C. W. "Low-Frequency Sound Detection by a Bottlenose Dolphin." J. Acoust. Soc. Am. 94.5 (1993): 3006-3008.

United States. Department of the Interior. Fish and Wildlife Service. Alaska Region (USDOI, FWS). Habitat Conservation Strategy for Polar Bears in Alaska. Anchorage: USFWS, 1995.

Walker, L. W. "Nursery of the Gray Whale." Nat. History 58.6 (1949): 248-256.

Ward, David H., and Robert A. Stehn. Response of Brant and Other Geese to Aircraft Disturbance at Izembek Lagoon, Alaska, Final Report. Intra-agency Agreement 14-12-0001-30332. Anchorage: USFWS, 1989. 193.

Wenz, Gordon M. "Acoustic Ambient Noise in the Ocean: Spectra and Sources." J. of the Acoust. Soc.

Am. 34.12 (1962): 1936-1956.

Worl, Rosita. "The North Slope Inupiat Whaling Complex." Senri Ethnological Studies 4. Alaska Native Culture and History: Papers Presented at the Second International Symposium, National Museum of Ethnology, Osaka, August 1978. N.p.: n.p., 1980. 305-20.

Wright, John M., and Steve G. Fancy. The Response of Birds and Caribou to the 1980 Drilling Operation at the Point Thomson #4 Well. Contract No. WD-A100. Prepared for Exxon Company, U.S.A. by LGL Ecological Research Associates. N.p.: LGL, 1980.

Würsig, Bernd, and Christopher Clark. "Behavior." The Bowhead Whale. Eds. J.J. Burns, J.J. Montague, C.J. Cowles. The Society for Marine Mammalogy. Special Publication Number 2 Lawrence: Allen Press, Inc., 1993. 157-99.

TRADITIONAL KNOWLEDGE

Adams, Billy. Testimony *in:* United States. Department of the Interior. Minerals Management Service. Official Transcript, Proceedings of Public Hearing, Draft Environmental Impact Statement for the Proposed Oil and Gas Lease Sale 144 in the Beaufort Sea. Assembly Chambers, Barrow, Alaska, November 8, 1995. Anchorage: Executary Court Reporting, 1995.

Ahkivgak, Ralph. Testimony *in:* North Slope Borough, Commission on History and Culture. Qiniqtuagaksrat Utuqqanaat Inuuniagninisiqun (The Traditional Land Use Inventory for the Mid-Beaufort Sea). Barrow: North Slope Borough, 1980.

Ahmaogak, George N., Sr. Testimony *in:* Ahmaogak, George N., Sr. Concerns of Eskimo People Regarding Oil and Gas Exploration and Development in the United States Arctic. Unpublished paper presented at the Workshop on Technologies and Experience of Arctic Oil and Gas Operations, 10-12 April 1995, Girdwood, Alaska. N.p.: n.p., 1995.

Ahmaogak, George N., Sr. Testimony *in:* Ahmaogak, George N., Sr. "Protecting the Habitat of the Bowhead Whale." Proceedings of the Sixth Conference of the Comite Arctique International. Eds. L. Rey and V. Alexander. New York: E.J. Brill, 1989.

Ahsogeak, Horace. Testimony *in:* North Slope Borough, Commission on History and Culture. Qiniqtuagaksrat Utuqqanaat Inuuniagninisiqun (The Traditional Land Use Inventory for the Mid-Beaufort Sea). Barrow: NSB, 1980.

Ailers, Loren. Testimony *in:* United States. Department of the Interior. Minerals Management Service. Alaska OCS Region. Official Transcript, Proceedings of Public Hearing, Draft Environmental Impact Statement for the Proposed Oil and Gas Lease Sale in the Diapir Field (Proposed Sale 71), Kaktovik, Alaska, February 4, 1982. N.p.: Akulaw Court Reporting, 1982.

Aishanna, Herman. Testimony *in:* United States. Department of the Interior. Minerals Management

Service. Official Transcript, Proceedings of Public Hearing, Draft Environmental Impact Statement for the Proposed Oil and Gas Leasing in the Diapir Field Lease Offering. Assembly Chambers, North Slope Borough Building, Barrow, Alaska, October 24, 1983. N.p.: Akulaw Court Reporting, 1983.

Albert, Thomas. Testimony *in:* United States. Army Corps of Engineers. Transcript of Proceedings, Environmental Impact Statement for Beaufort Sea Oil and Gas Development, Northstar Environmental Impact Statement Project. Public Scoping Meeting, Monday, March 25, 1996, Barrow, Alaska. Prepared for the United States. Army Corps of Engineers by Alaska Stenotype Reporters. Anchorage: ASR, 1996.

Albert, Thomas. Testimony *in:* United States. Department of the Interior. Minerals Management Service. Official Transcript, Proceedings of Public Hearing, Draft Environmental Impact Statement for the Proposed Oil and Gas Lease Sale 144 in the Beaufort Sea. Assembly Chambers, Barrow, Alaska, November 8, 1995. Anchorage: Executary Court Reporting, 1995.

Brower, Arnold. Testimony *in:* United States. Department of the Interior. Minerals Management Service. Transcript of Proceedings, Draft Environmental Impact Statement for the Proposed Oil and Gas Lease Sale 97 in the Beaufort Sea. Barrow, Alaska, December 08, 1986. Anchorage: Accu-Type Depositions, Inc., 1986.

Brower, Eugene. Testimony *in:* United States. Department of the Interior. Minerals Management Service. Official Transcript, Proceedings of Public Hearing, Draft Environmental Impact Statement for the Proposed Oil and Gas Lease Sale 144 in the Beaufort Sea. Assembly Chambers, Barrow, Alaska, November 8, 1995. Anchorage: Executary Court Reporting, 1995.

Brower, Eugene. Testimony *in:* United States. Department of the Interior. Minerals Management Service. Official Transcript, Proceedings of Public Hearing, Draft Environmental Impact Statement Chukchi Sea, Proposed Oil and Gas Lease Sale 109. Barrow, Alaska, April 10, 1987. Anchorage: Accu-Type Depositions, Inc., 1987.

Brower, Harry Jr. Testimony *in:* United States. Department of the Interior. Minerals Management Service. Official Transcript, Proceedings of Public Hearing, Draft Environmental Impact Statement for the Proposed Oil and Gas Lease Sale 144 in the Beaufort Sea. Assembly Chambers, Barrow, Alaska, November 8, 1995. Anchorage: Executary Court Reporting, 1995.

Brower, Harry. Testimony *in:* United States. Department of the Interior. Minerals Management Service. Official Transcript, Proceedings of Public Hearing, Draft Environmental Impact Statement for the Proposed Oil and Gas Lease Sale 124 in the Beaufort Sea Planning Area, Alaska Outer Continental Shelf. North Slope Borough Conference Chambers, Barrow, Alaska, April 17, 1990. Anchorage: Executary Court Reporting, 1990.

Brower, Thomas Sr. Testimony *in:* North Slope Borough, Commission on History and Culture.

Qiniqtuagaksrat Utuqqanaat Inuuniagninisiqun (The Traditional Land Use Inventory for the Mid-Beaufort Sea). Barrow: North Slope Borough, 1980.

George, John Craighead. Testimony *in:* United States. Army Corps of Engineers. Transcript of Proceedings, Environmental Impact Statement for Beaufort Sea Oil and Gas Development, Northstar Environmental Impact Statement Project. Public Scoping Meeting, Monday, March 25, 1996, Barrow, Alaska. Prepared for the United States. Army Corps of Engineers by Alaska Stenotype Reporters. Anchorage: ASR, 1996.

George, John Craighead. Testimony *in:* United States. Department of the Interior. Minerals Management Service. Official Transcript, Proceedings of Public Hearing, Draft Environmental Impact Statement for the Proposed Oil and Gas Leasing in the Diapir Field Lease Offering. Assembly Chambers, North Slope Borough Building, Barrow, Alaska, October 24, 1983. N.p.: Akulaw Court Reporting, 1983.

Kaleak, Joseph. Testimony *in:* MBC Applied Environmental Sciences. Alaska OCS Region Proceedings of the 1995 Arctic Synthesis Meeting. 23-25, October, 1995, Sheraton Anchorage Hotel. OCS Study MMS 95-0065. Costa Mesa: MBC, 1996.

Lampe, Leonard. Testimony *in:* United States. Army Corps of Engineers. Transcript of Proceedings, Environmental Impact Statement for Beaufort Sea Oil and Gas Development, Northstar Environmental Impact Statement Project. Public Scoping Meeting, Tuesday, May 7, 1996, Nuiqsut, Alaska. Prepared by Alaska Stenotype Reporters. Anchorage: ASR, 1996.

Long, Frank, Jr. Testimony *attached to:* Maggie Ahmaogak, Alaska Eskimo Whaling Commission. Letter to T. Carpenter, U.S. Army Corps of Engineers, Alaska District re: Submittal of comments and statement of the Draft Environmental Impact Statement for the proposed Northstar Project. 25 Aug. 1998.

Long, Frank, Jr. Testimony *in:* Long, Frank Jr. Alaska OCS Region Proceedings of the 1995 Arctic Synthesis Meeting. 23-25, October, 1995, Sheraton Anchorage Hotel. OCS Study MMS 95-0065. Costa Mesa: MBC, 1996.

Long, Frank, Jr. Testimony *in:* United States. Army Corps of Engineers. Transcript of Proceedings, Environmental Impact Statement for Beaufort Sea Oil and Gas Development, Northstar Environmental Impact Statement Project. Public Scoping Meeting, Tuesday, May 7, 1996, Nuiqsut, Alaska. Prepared by Alaska Stenotype Reporters. Anchorage: ASR, 1996.

Long, Frank, Jr. Testimony *in:* United States. Department of the Interior. Minerals Management Service. Official Transcript, Proceedings of Public Hearing, Draft Environmental Impact Statement for the Proposed Oil and Gas Lease Sale 144 in the Beaufort Sea. City Hall, Nuiqsut, Alaska, November 6, 1995. Anchorage: Executary Court Reporting, 1995.

MBC Applied Environmental Sciences. Arctic Seismic Synthesis and Mitigating Measures Workshop, Draft Proceedings. 5 - 6 March 1997, Barrow, Alaska. OCS Study MMS 97-0014.Sponsored by U.S. Department of Interior, Minerals Management Service. Proceedings prepared for U.S. Department of Interior, Minerals Management Service by MBC Applied Environmental Sciences. Costa Mesa: MBC, 1997. Attachment C.

- Fred Kanayurak
- Van Edwardsen
- Marchie Nageak
- Oliver Leavitt
- Jim Allen Killbear
- Eddie Rexford
- Thomas Napageak
- George Taalak
- Roxy Oyagak Jr.
- Burton Rexford
- Harry Brower Jr.
- Ben Itta
- Joseph Kaleak
- James Lampe
- Charlie Brower
- Archie Ahkivianna
- Eli Nukapigak

Napageak, Thomas. Testimony *in:* United States. Department of the Interior. Minerals Management Service. Official Transcript, Proceedings of Public Hearing, Draft Environmental Impact Statement for the Proposed Oil and Gas Lease Sale 144 in the Beaufort Sea. City Hall, Nuiqsut, Alaska, November 6, 1995. Anchorage: Executary Court Reporting, 1995.

Ningeok, Jonas. Testimony *in:* United States. Department of the Interior. Minerals Management Service. Alaska OCS Region. Official Transcript, Proceedings of Public Hearing on Draft Environmental Impact Statement for the Proposed Oil and Gas Lease Sale 97 in the Beaufort Sea. Kaktovik, Alaska, December 10, 1986. Anchorage: Accu-Type Depositions, Inc, 1986.

Nuiqsut Whaling Captains Meeting. Interviews with Jon Isaacs and Karen Shemet. Dames & Moore and Stephen R. Braund & Associates. Nuiqsut. 13 Aug. 1996.

- Thomas Napageak

Oyagak, Billy. Testimony *in:* United States. Department of the Interior. Minerals Management Service. Transcript of Proceedings, Draft Environmental Impact Statement for the Proposed Oil and Gas Lease Sale 97 in the Beaufort Sea. Nuiqsut, Alaska, December 12, 1986. Anchorage: Accu-Type Depositions, Inc., 1986.

Pederson, Michael. Testimony *in:* United States. Army Corps of Engineers. Transcript of Proceedings, Environmental Impact Statement for Beaufort Sea Oil and Gas Development, Northstar Environmental Impact Statement Project. Public Scoping Meeting, Monday, March 25, 1996, Barrow, Alaska. Prepared for the United States. Army Corps of Engineers by Alaska Stenotype Reporters. Anchorage: ASR, 1996.

Rexford, Burton. Testimony *in:* MBC Applied Environmental Sciences. Alaska OCS Region Proceedings of the 1995 Arctic Synthesis Meeting. 23-25 October, 1995, Sheraton Anchorage Hotel. OCS

Study MMS 95-0065. Costa Mesa: MBC, 1996.

Rexford, Burton. Testimony *in:* United States. Army Corps of Engineers. Transcript of Proceedings, Environmental Impact Statement for Beaufort Sea Oil and Gas Development, Northstar Environmental Impact Statement Project. Public Scoping Meeting, Monday, March 25, 1996, Barrow, Alaska. Prepared for the United States. Army Corps of Engineers by Alaska Stenotype Reporters. Anchorage: ASR, 1996.

Rexford, Delbert. Testimony *in:* United States. Army Corps of Engineers. Transcript of Proceedings, Environmental Impact Statement for Beaufort Sea Oil and Gas Development, Northstar Environmental Impact Statement Project, Public Scoping Meeting, Monday, March 25, 1996, Barrow, Alaska. Prepared for the United States. Army Corps of Engineers by Alaska Stenotype Reporters. Anchorage: ASR, 1996.

Rexford, Herman. Testimony *in:* United States. Department of the Interior. Minerals Management Service. Official Transcript, Proceedings of Public Hearing, Draft Environmental Impact Statement for the Proposed Oil and Gas Lease Sale BF in the Beaufort Sea. Kaktovik, Alaska, May 15, 1979. N.p.: n.p., 1979.

Taalak, S. Testimony *attached to*: Maggie Ahmaogak, Alaska Eskimo Whaling Commission. Letter to T. Carpenter, U.S. Army Corps of Engineers, Alaska District re: Submittal of comments and statement of the Draft Environmental Impact Statement for the proposed Northstar Project. 25 Aug. 1998.

Tukle, Joash. Testimony *in:* United States. Department of the Interior. Minerals Management Service. Official Transcript, Proceedings of Public Hearing, Draft Environmental Impact Statement Chukchi Sea, Proposed Oil and Gas Lease Sale 109. Barrow, Alaska, April 10, 1987. Anchorage: Accu-Type Depositions, Inc., 1987.

Tukle, Patsy. Testimony *in:* United States. Department of the Interior. Minerals Management Service. Transcript of Proceedings, Draft Environmental Impact Statement for the Proposed Oil and Gas Lease Sale 97 in the Beaufort Sea. Nuiqsut, Alaska, December 12, 1986. Anchorage: Accu-Type Depositions, Inc., 1986.