



MARINE MAMMAL COMMISSION

9 December 2011

Mr. P. Michael Payne, Chief
Permits, Conservation, and Education Division
Office of Protected Resources
National Marine Fisheries Service
1315 East-West Highway
Silver Spring, Maryland 20910-3226

Dear Mr. Payne:

The Marine Mammal Commission, in consultation with its Committee of Scientific Advisors on Marine Mammals, has reviewed the application from Shell Offshore, Inc., seeking an incidental take authorization under section 101(a)(5)(D) of the Marine Mammal Protection Act. The applicant is seeking authorization to take small numbers of marine mammals by harassment incidental to offshore exploratory drilling at the Torpedo and Sivulliq prospects in Camden Bay, Beaufort Sea, Alaska, during the 2012 Arctic open-water season. The Commission also has reviewed the National Marine Fisheries Service's 7 November 2011 *Federal Register* notice (76 Fed. Reg. 68974) announcing receipt of the application and proposing to issue the authorization, subject to certain conditions.

RECOMMENDATIONS

The Marine Mammal Commission recommends that the National Marine Fisheries Service—

- issue the requested incidental harassment authorization contingent upon the successful negotiation of a conflict avoidance agreement between Shell and the Alaska Eskimo Whaling Commission and the bowhead whale hunters it represents;
- facilitate development of more comprehensive conflict avoidance agreements that involve other species and potentially affected communities and co-management organizations and take into account all potential adverse effects on all marine mammal species taken for subsistence purposes;
- require Shell to evaluate the source levels of the available drilling rigs at the proposed drilling locations, recalculate the 120-dB re 1 μ Pa harassment zones and estimated takes as appropriate, and use the rig best suited for the proposed drilling locations based, in part, on consideration of the size of the harassment zones and the requirements of the Marine Mammal Protection Act to reduce impacts of the proposed activity to the least practicable level; Shell also should make the data associated with the monitoring program publicly available for evaluation by independent researchers;
- require Shell to develop and employ a more effective means to monitor the entire corrected 120-dB re 1 μ Pa harassment zone associated with the drilling rig and support vessels for the presence and movements of bowhead whales and other marine mammals and for estimating the actual number of takes that occur;
- track and enforce Shell's implementation of mitigation and monitoring measures to ensure that they are executed as expected;

- require Shell to cease drilling operations in mid- to late-September to reduce the possibility of having to respond to a large oil spill in ice conditions; and
- require Shell to develop and implement a detailed, comprehensive and coordinated Wildlife Protection Plan that includes strategies and sufficient resources for minimizing contamination of sensitive marine mammal habitats and that provides a realistic description of the actions that Shell can take, if any, to respond to oiled or otherwise affected marine mammals; the plan should be developed in consultation with Alaska Native communities (including marine mammal co-management organizations), state and federal resource agencies, and experienced non-governmental organizations.

RATIONALE

Shell has proposed to drill one exploratory well at each of two locations near Camden Bay, Beaufort Sea, Alaska, during the 2012 Arctic open-water season (early July through late October). One of the two wells would be drilled at Shell's Torpedo prospect (either Torpedo "H" in Flaxman Island Lease Block 6610 or Torpedo "J" at Lease Block 6559). The other well would be drilled at Shell's Sivulliq prospect (either Sivulliq "N" or "G" – both in Flaxman Island Lease Block 6658). Shell would use one of two drilling rigs, the *Kulluk* or the *Discoverer*, with estimated broadband sound source levels of 185.5 dB re 1 μ Pa at 1 m and 177–185 dB re 1 μ Pa at 1 m, respectively. Shell also would deploy other vessels and aircraft for support purposes, including management of ice in the drilling areas. Drilling would occur 26.1 to 37.2 km from shore, in waters 32.6 to 37.8 m in depth. Shell would conduct geophysical surveys at the end of each drill hole using a zero-offset vertical seismic profile airgun array. A typical eight-airgun array consists of four 150-in³ airguns and four 40-in³ airguns, with source levels of 238 and 241 dB re 1 μ Pa at 1 m, depending on source depth.

Drilling and associated activities could affect marine mammals in several ways. Sound emitted from drilling, ice management, and seismic profile surveys could cause marine mammals to change their behavior, modify habitat use patterns, or mask their calls. If received at sufficiently high levels, such sound also could affect marine mammals physically, including temporary or permanent hearing impairment. In addition, oil spills—albeit unlikely—have the potential to affect marine mammals through exposure to toxic contaminants either externally through contact with the oil or internally through ingestion of the oil or inhalation of oil fumes.

The Service preliminarily has determined that the proposed activities could result in a temporary modification in the behavior of small numbers of up to eight species of marine mammals, but that the total taking would have a negligible impact on the affected species or stocks. The Service does not anticipate any take of marine mammals by death or serious injury. The Service believes that the likelihood of an oil spill is extremely remote and therefore does not propose to authorize take from an oil spill. The Service also believes that the potential for temporary or permanent hearing impairment from drilling and other acoustic impacts would be at the least practicable level because of Shell's proposed mitigation and monitoring measures, as well as additional monitoring and mitigation measures proposed by the Service. Together, these include—

- (1) using Service-approved vessel-based observers to monitor for marine mammals on the drillship and all support vessels, including the ice management vessels, throughout the exploration drilling period;
- (2) using two observers to monitor the 190- and 180-dB re 1 μ Pa exclusion zones (for pinnipeds and cetaceans, respectively) and beyond during active drilling or airgun operations and before and during start-ups of airguns day or night;
- (3) using ramp-up and shut-down procedures;
- (4) prohibiting initiation of airgun operations during nighttime or low visibility conditions after an extended shutdown;
- (5) reducing vessel speeds to 9 knots or less when transiting the Beaufort Sea;
- (6) reducing vessel speed to 9 knots or less and avoiding multiple changes in vessel direction and speed within 274 m of whales;
- (7) avoid injury to whales by reducing vessel speed and changing direction as necessary, especially when weather conditions diminish visibility;
- (8) limiting aircraft overflights to an altitude of 457 m or higher and a horizontal distance of 305 m or greater when marine mammals are present (except during takeoff, landing, or an emergency situation);
- (9) conducting aerial surveys before, during, and after operations at the exploration well sites;
- (10) conducting in-situ measurements of sound propagation from the drilling vessel, support vessels, and the airgun array;
- (11) deploying acoustic recorders along the bowhead whale migration path to record vocalizations of bowhead whales as they pass through the drilling area;
- (12) reporting injured and dead marine mammals to the Service and local stranding network using the Service's phased approach and suspending activities, if appropriate; and
- (13) submitting field and technical reports and a final comprehensive report to the Service.

Availability of marine mammals for subsistence

Shell has met, and plans to continue meeting, with various stakeholders to develop and implement a plan of cooperation. The plan specifies measures to minimize impacts to Alaska Natives who use marine mammals for subsistence purposes. As part of the plan, Shell would traverse north through the Bering Strait and Chukchi Sea offshore of the polynya zone and notify communication and call centers in local communities if it is necessary to move into the polynya zone. Shell also would implement a proposed communication plan with local subsistence users and village whaling associations before initiating exploratory drilling operations and maintain communication throughout the open-water season. Shell would suspend all drilling activities on 25 August to avoid disruption of the Kaktovik and Nuiqsut (Cross Island) fall bowhead whale hunts. Shell would employ local subsistence hunters from the Beaufort and Chukchi Sea villages to advise the company regarding the whale migration and subsistence hunt. Finally, Shell would collect (and cool as necessary) all drilling mud, cuttings with adhered mud, ballast water, and other waste water and other discharge for transport and disposal outside the Arctic, recycling all drilling mud to the extent practicable. Based on the timing and location of the proposed activities and these additional mitigation measures, the Service preliminarily has determined that the expected taking would not

have an unmitigable adverse impact on the availability of marine mammals for subsistence use by Alaska Natives. Shell should be acknowledged for its efforts to avoid such impacts.

However, it is not yet clear that those steps are sufficient. A determination of “no unmitigable adverse impact” on the availability of marine mammals for subsistence uses should be based, in part, on concurrence of those people who are the experts regarding the availability of marine mammals for subsistence hunts—the Alaska Native hunters themselves. Shell signed a conflict avoidance agreement in 2011 with the Alaska Eskimo Whaling Commission and intends to enter into negotiations again in 2012. Negotiating and completing a conflict avoidance agreement related to bowhead whales is useful but also prompts the question as to why such agreements are not being developed with subsistence hunters taking other species that might be affected by oil and gas operations. With that in mind, the Marine Mammal Commission recommends that the National Marine Fisheries Service issue the requested incidental harassment authorization contingent upon the successful negotiation of a conflict avoidance agreement between Shell and the Alaska Eskimo Whaling Commission and the bowhead whale hunters it represents. Such an agreement should help promote cooperation and communication among the parties involved and minimize potential conflicts between industry activity and bowhead whale subsistence hunts. Similarly, the Marine Mammal Commission recommends that the National Marine Fisheries Service facilitate development of more comprehensive conflict avoidance agreements that involve other species and potentially affected communities and co-management organizations and take into account all potential adverse effects on all marine mammal species taken for subsistence purposes.

Minimizing and monitoring responses to drilling activities

Studies indicate that bowhead whales are sensitive to low-frequency sounds produced by drilling activities, with observed behavioral responses to sounds as low as 115 dB re 1 μ Pa at 1 m (Richardson et al. 1990, Wartzok et al. 1989). Richardson et al. (1987) hypothesized that a decrease in the number of bowhead whales in the Canadian Beaufort Sea during a five-year period might have been partly caused by increasing industrial activities associated with offshore oil and gas development (i.e., seismic, drilling, and construction activities) during the same timeframe. Although marine mammal behavioral responses to drilling, icebreaking, and seismic activities are expected to be temporary in nature, little is known about the potential for longer-term effects. To ensure the least practicable adverse impact, Shell should strive to reduce the number of animals potentially affected by drilling-related sounds.

Shell stated in its application that it would use either the *Kulluk* or the *Discoverer* to drill the two exploratory wells in the Beaufort Sea. Source levels from the *Kulluk* were measured in the Beaufort Sea in 1986 at 185.5 dB re 1 μ Pa at 1 m, which included sound from a nearby support vessel. No sound measurements are available for the *Discoverer* in the Arctic; however, sound measurements of the *Discoverer* in the South China Sea were used to model the sound propagation of the *Discoverer* (including a nearby support vessel) at planned drilling locations in the Beaufort Sea. Broadband source levels varied by activity and direction from the ship but were generally between 177 and 185 dB re 1 μ Pa at 1 m.

Shell used a 120-dB re 1 μ Pa threshold to estimate the area in which whales and other marine mammals may be taken by Level B harassment. The company used the 120-dB re 1 μ Pa threshold because drilling is considered a continuous sound source. Based on a 120-dB re 1 μ Pa threshold, the estimated harassment zones modeled for the two drilling rigs differ considerably, with a “corrected” harassment zone (the Level B harassment zone multiplied by 1.5) of 19.91 km for the *Kulluk* and 4.98 km for the *Discoverer* (Table 4 in the *Federal Register* notice). Based on the average density of bowhead whales migrating past the proposed drilling site in the fall, Shell estimated that approximately 5,575 whales would be taken by harassment if the *Kulluk* were used, compared to approximately 1,387 whales if the *Discoverer* were used. Those estimates are in addition to takes from proposed icebreaking and seismic survey activities.

Those estimates of source levels, harassment zones, and takes raise several important questions:

- What are the actual source levels of the two drilling rigs in the areas identified for exploratory drilling? Do the source levels estimated for the *Discoverer*, derived from measurements taken in the South China Sea, provide a reliable basis for estimating their levels in the Camden Bay area? Do measurements taken for the *Kulluk* in the Beaufort Sea in 1986 provide a reliable basis for estimating current source levels, considering structural or mechanical changes that may have been made to the *Kulluk* since those measurements were taken?
- Are the differences in the corrected harassment zones for the two drilling rigs real? The corrected 120-dB re 1 μ Pa harassment zone for the *Kulluk* is 19.91 km, which is based on a point estimate of 185.5 dB re 1 μ Pa at 1 m. The corrected 120-dB re 1 μ Pa harassment zone for the *Discoverer* is 4.98 km, which is based on a range of 177–185 dB re 1 μ Pa at 1 m. Summing across band levels gives a broadband source level for the *Discoverer* of 185.5 dB re 1 μ Pa at 1 m (D. Hannay, JASCO, pers. comm.). If the broadband source levels for the two drilling rigs are the same, why is there a four-fold difference in the size of the corrected harassment zone for the two drilling rigs?
- If the differences in corrected harassment zones are real, why is the quieter rig not being used in this case, when noise reduction is such an important issue?
- How will Shell monitor the resulting large harassment zones to estimate actual numbers of takes? The corrected radius of the 120-dB re 1 μ Pa harassment zone for the *Kulluk* could be as large as 20 km, which is too large to be monitored effectively using visual methods, especially in poor weather or low visibility conditions. Although Shell also would be required to monitor bowhead whale movements using acoustic recorders, recorders can detect only vocalizing whales. Actual numbers of whales in the area may be difficult to estimate based on acoustic recordings, as whales exposed to drilling sounds may vocalize at a lower rate than undisturbed whales (Richardson et al. 1985, Blackwell et al. 2011). In addition, acoustic recorders would not be able to monitor for the presence and movements of marine

mammals that do not vocalize (i.e., pinnipeds). The use of aerial surveys around the drill rig will help to alleviate this problem but only to the extent that the surveys can be flown given weather conditions in the Beaufort Sea. Sufficient aerial survey data combined with acoustic data will provide a more suitable means of monitoring impacts from drilling and associated operations.

- What is the basis for determining that the taking of an estimated 5,608 bowhead whales is consistent with the “small numbers” and “negligible impact” requirements of the Marine Mammal Protection Act, considering that the total population of bowhead whales numbers between 10,000 and 11,000 whales (Allen and Angliss 2011)? The proposed drilling activities near Camden Bay would occur during the peak of the westward migration of bowhead whales (Quakenbush 2010), in areas and at times that whales are feeding (Lowry et al. 2004, Huntington and Quakenbush 2009). Sounds from drilling and seismic activities may cause shifts in distribution that could affect feeding, socializing, resting, travel times, and migration routes. Although the Service discusses these impacts, the basis for assuming that the impacts would be negligible is not clear, especially considering uncertainties regarding how impacts of noise on individual animals may affect population reproduction or survival rates (Hutchinson and Ferrero 2011). In addition, if Shell uses the *Kulluk* instead of a quieter drilling rig and it results in a larger number of takes, how can the Service conclude that the company will have the least practicable impact?

For all these reasons, the Marine Mammal Commission recommends that the National Marine Fisheries Service require Shell to evaluate the source levels of the available drilling rigs at the proposed drilling locations, recalculate the 120-dB re 1 μ Pa harassment zones and estimated takes as appropriate, and use the rig best suited for the proposed drilling locations based, in part, on consideration of the size of the harassment zones and the requirements of the Marine Mammal Protection Act to reduce impacts of the proposed activity to the least practicable level. Shell also should make the data associated with the monitoring program publicly available for evaluation by independent researchers. The Marine Mammal Commission also recommends that the Service require Shell to develop and employ a more effective means to monitor the entire corrected 120-dB re 1 μ Pa harassment zone for the presence and movements of bowhead whales and other marine mammals and for estimating the actual number of takes that occur. Monitoring only a portion of the harassment zone and then extrapolating to estimate the total number of takes is reasonable only if the company and Service have a basis for making assumptions about the composition and distribution of marine mammals throughout the areas potentially affected.

Finally, requiring certain mitigation and monitoring measures will mean little if the parties involved fail to implement them. In this case, Shell would be working under a tight schedule to drill its proposed wells, and its ability to meet that schedule would be determined in part by seasonal changes in weather and, particularly, ice conditions. Although Shell may recognize that the specified mitigation and monitoring measures are important, it may not deem these measures to be its highest priority if they conflict with operations considered essential to drilling progress. Under such conditions, mitigation and monitoring measures may not be implemented fully and their value

compromised. To avoid such situations, the Marine Mammal Commission recommends that the National Marine Fisheries Service track and enforce Shell's implementation of mitigation and monitoring measures to ensure that they are executed as expected.

Mitigation measures for potential oil spills

The *Federal Register* notice and Shell's application provided a summary of potential risks to marine mammals from oil spills, including contact with oil, ingestion of oil or contaminated prey, and inhalation of oil. Shell also notes that oil spill cleanup activities may have more of an impact than the oil itself. The Commission believes that Shell's summary of potential impacts under-represents the risks to marine mammals, and that information regarding the long-term effects of exposure to oil and oil spill cleanup activities is inadequate (Marine Mammal Commission 2011). Shell also concludes that there is a "very low likelihood of a large oil spill event," and that "even if a large spill were to occur, the impacts identified in the [Minerals Management Service] 2003 Multi-Sale Environmental Impact Statement [for the Beaufort Sea Planning Area, Oil and Gas Lease Sales 186, 195, and 202] would not necessarily follow because Shell's spill response capabilities would minimize the amount of oil reaching the environment." Here, too, the Commission believes that this statement both downplays the risks of an oil spill to marine mammals and overstates Shell's ability to respond to a large spill. The Commission also believes that the Service is being too dismissive of the potential for a large oil spill based on the conclusion that such a spill is not likely.

However, the risk of a spill is not simply a function of its probability of occurrence—it also must take into account the consequences if such a spill occurs. Those consequences are, in part, a function of the spill's characteristics and the ability of the industry and government to mount an effective response. In all areas, but particularly in the Arctic, the longstanding but still unresolved question is whether the responsible parties can mount an effective response. Having just witnessed the requirements for and difficulties of responding to a major spill in the much less harsh environment of the Gulf of Mexico, the Commission sees no basis for concluding that the necessary response capability exists in Arctic ice conditions. The assertion that Shell would be able to respond adequately to any kind of major spill is simply unsupported by all the available evidence. The Commission does not mean to dismiss Shell's efforts to develop response capabilities, but the reality is that the harsh conditions and lack of infrastructure, trained personnel, supplies, etc., could make it virtually impossible to respond effectively to a significant Arctic spill.

With regard to marine mammals that might be affected, impacts from a spill would be determined by the time of year, the species in or migrating through the area down-current from the facility (i.e., in the spill's path), and the amount of disruption to their natural behavior (e.g., reproduction, feeding). Given that marine mammals move through this area in large pulses, it may or may not be the case that few animals would be affected; actual effects would depend on the timing and circumstances, such as the size of the spill. It also is important to consider that some of the animals may already be in a compromised state as a result of climate disruption, stochastic variation in food resources, or variation in physiological state due to normal life history events (e.g., molting or reproduction in pinnipeds).

Shell's Oil Discharge Prevention and Contingency Plan outlines several measures for preventing and responding to a spill, as summarized in the incidental harassment authorization application. Although Shell revised the contingency plan in May 2011 in response to new Bureau of Ocean Energy Management safety and environmental requirements, the contingency plan is still inadequate for addressing a large oil spill in the Arctic. For example, the plan includes worst-case discharge scenarios, but they are based on an August spill rather than a late October spill, which would be a more appropriate worst-case. The plan does include a "response strategy" for a spill occurring on October 1, noting that as the response continues into its second week "the hours of daylight and average air temperatures continue to drop, making oil surveillance and tracking more difficult, along with the location, containment, and recovery of oil" and that "the formation of grease ice and nilas (e.g., a thin elastic crust of ice up to 10 centimeters thick that bends easily under pressure) make it increasingly difficult to work with booms as they begin to fill with ice, preventing the effective collection of oil." The plan goes on to state that "as freeze-up continues and blowing snow begins to accumulate on young ice, it becomes impossible to operate the physical containment and recovery systems safely and effectively." These statements all indicate that Shell has little chance of recovering oil that spills after October 1, when new ice is forming.

Even if a spill were to occur during summer, Shell's ability to contain the well and recover spilled oil is limited by the lack of adequate infrastructure. The contingency plan states that the preference is to use the original drilling rig to drill a relief well. However, if there is damage to the rig as a result of a blowout or other accident, Shell would need to move a second rig onsite, which may take several weeks considering that the second rig would likely be fully engaged in drilling activities in the Chukchi Sea. The plan proposes to use skimming and in-situ burning for recovery of oil—technologies that were effective in recovering only 8 percent of the oil spilled from the Gulf of Mexico Macondo well (NOAA 2010) and which have not been proven to be effective in Arctic conditions.

In the event of a spill, Shell has included provisions for wildlife protection in its contingency plan. However, the provisions of the "Wildlife Protection Plans" are limited to monitoring and deterrents at the spill site, placement of containment booms to prevent contamination of sensitive shoreline, and the designation of a facility to treat oiled animals. Based on experience gained from the Exxon Valdez, the Deepwater Horizon, and other small and large oil spills, a more detailed, comprehensive, and coordinated strategy would be needed to respond to, recover, and rehabilitate oiled wildlife. The Commission must question whether such response activities are realistic, given that the expertise and infrastructure needed to carry out these activities are simply not available in the Arctic, and Arctic conditions could restrict severely such activities because of human safety concerns.

For these and other reasons, the Commission must question whether Shell can respond effectively to a large spill under harsh Arctic conditions. At the same time, the impact of a spill on Arctic marine mammals could be significant and long-lasting. Therefore, the Marine Mammal Commission recommends that the National Marine Fisheries Service require Shell to cease drilling operations in mid- to late-September to reduce the possibility of having to respond to a large oil spill in ice conditions. The Marine Mammal Commission also recommends that the National Marine

Mr. P. Michael Payne
9 December 2011
Page 9

Fisheries Service require Shell to develop and implement a detailed, comprehensive and coordinated Wildlife Protection Plan that includes strategies and sufficient resources for minimizing contamination of sensitive marine mammal habitats and that provides a realistic description of the actions that Shell can take, if any, to respond to oiled or otherwise affected marine mammals; the plan should be developed in consultation with Alaska Native communities (including marine mammal co-management organizations), state and federal resource agencies, and experienced non-governmental organizations.

Please contact me if you have questions regarding these recommendations.

Sincerely,



Timothy J. Ragen, Ph.D.
Executive Director

Cc: Kaja Brix, National Marine Fisheries Service Alaska Regional Office
Jim Kendall, Bureau of Ocean Energy Management Alaska Region

References

- Allen, B.M., and R.P. Angliss. 2011. Alaska marine mammal stock assessments, 2010. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-AFSC-223, 292 pages.
- Blackwell, S.B., T.L. MacDonald, C.S. Nations, A.M. Thode, K.H. Kim, C.R. Greene, Jr., M. Guerra, D. Mathias, and A.M. Macrander. 2011. Effects of seismic exploration activities on the calling behavior of bowhead whales, *Balaena mysticetus*, in the Alaskan Beaufort Sea. 19th Biennial Conference on the Biology of Marine Mammals, Tampa, Florida.
- Huntington, H.P., and L.T. Quakenbush. 2009. Traditional knowledge of bowhead whale migratory patterns near Kaktovik and Barrow, Alaska. Report to the Barrow and Kaktovik Whaling Captains Associations, 13 pages.
- Hutchinson, D.R., and R.C. Ferrero. 2011. Marine mammals and anthropogenic noise, *in* Holland-Bartels, L., and B. Pierce (eds.), "An evaluation of the science needs to inform decisions on Outer Continental Shelf energy development in the Chukchi and Beaufort Seas, Alaska." U.S. Geological Survey Circular 1370, 278 pages.
- Lowry, L.F., G. Sheffield, and J.C. George. 2004. Bowhead whale feeding in the Alaskan Beaufort Sea, based on stomach content analyses. *Journal of Cetacean Research Management* 6(3):215-223.

- Marine Mammal Commission. 2011. Assessing the long-term effects of the BP Deepwater Horizon oil spill on marine mammals in the Gulf of Mexico: a statement of research needs. 38 pages.
- National Oceanic and Atmospheric Administration (NOAA). 2010. BP Deepwater Horizon Oil Budget: What Happened To the Oil? (4 August 2010).
- Quakenbush, L.T., J.J. Citta, J.C. George, R.J. Small, and M.P. Heide-Jørgensen. 2010. Fall and winter movements of bowhead whales (*Balaena mysticetus*) in the Chukchi Sea and within a potential petroleum development area. *Arctic* 63(3):289-307.
- Richardson, W.J., M.A. Fraker, B. Würsig, and R.S. Wells. 1985 Behaviour of bowhead whales *Balaena mysticetus* summering in the Beaufort Sea: reactions to industrial activities. *Biological Conservation* 32:195-230.
- Richardson, W.J., R.A. Davis, C.R. Evans, D.K. Ljungblad, and P. Norton. 1987. Summer distribution of bowhead whales, *Balaena mysticetus*, relative to oil industry activities in the Canadian Beaufort Sea, 1980-84. *Arctic* 40(2):93-104.
- Richardson, W.J., B. Würsig, and C.R. Greene, Jr. 1990. Reactions of bowhead whales, *Balaena mysticetus*, to drilling and dredging noise in the Canadian Beaufort Sea. *Marine Environmental Research* 29:135-160.
- Wartzok, D., W.A. Watkins, B. Würsig, and C.I. Malme. 1989. Movements and behaviors of bowhead whales in response to repeated exposures to noises associated with industrial activities in the Beaufort Sea. Unpublished manuscript from Purdue University to Amoco Production Company, Box 800, Denver, Colorado 80201, 228 pages.