**ENDANGERED SPECIES ACT – SECTION 7 CONSULTATION**

**BIOLOGICAL OPINION**

**AGENCY:** National Marine Fisheries Service, Conservation and Education Division

**ACTIVITY:** Authorization of Small Takes Under the Marine Mammal Protection Act for certain Oil and Gas Exploration Activities in the U.S. Beaufort and Chukchi Seas, Alaska for 2010.

**CONSULTATION CONDUCTED BY:** National Marine Fisheries Service, Alaska Region

**APPROVED BY:** ______________________

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## Biological Opinion

NOAA Fisheries, Office of Protected Resources, Conservation and Education Division (Permits Division), has formally consulted National Marine Fisheries Service, Alaska Region, on the potential effects of authorization of "small take" permits under section 101(a)(5) of the Marine Mammal Protection Act, as amended, for certain oil and gas exploration activities in the U. S. Beaufort Sea and Chukchi Seas for 2010. This opinion considers the effects of these actions on threatened and endangered species under the jurisdiction of NOAA Fisheries. In formulating this Biological Opinion, NOAA Fisheries used information presented by the Permits, Conservation and Education Division (Permits Division); NMFS' 2008 Biological Opinion for Oil and Gas Leasing and Exploration Activities in the U.S. Beaufort and Chukchi seas, Alaska and Authorization of Small Takes Under the Marine Mammal Protection Act; Mineral Management Service's 2008 Supplement to the 2006 Biological Evaluation of the Potential Effects of Oil and Gas Leasing and Exploration in the Alaska OCS Beaufort Sea and Chukchi Sea Planning Areas on Endangered Bowhead Whales *(Balaena mysticetus)*, Fin Whales (*Balaenoptera physalus)*, and Humpback Whales (*Megaptera novaeangliae)*; NMFS's 2006 Draft Recovery Plan for Fin Whales, NMFS's 1991 Recovery Plan for Humpback Whales; NMFS's Marine Mammal Stock Assessment Reports; reports from the International Whaling Commission along with other research relating to bowhead whales and information provided by NOAA's National Marine Mammal Laboratory, the North Slope Borough, and the Alaska Eskimo Whaling Commission; and the traditional knowledge of the Alaskan Eskimo community.

## Consultation History

On July 17, 2008, pursuant to section 7(a)(2) of the Endangered Species Act and at the request of the Bureau of Ocean Energy Management, Regulation, and Enforcement (formerly the Minerals Management Service), the National Marine Fisheries Service, Alaska Region prepared a biological opinion for federal oil and gas leasing and exploration activities authorized by the Bureau of Ocean Energy Management within the Alaskan Beaufort and Chukchi seas.

On April 8, 2010, NOAA Fisheries, Office of Protected Resources sent a letter requesting consultation for the proposed issuance of Incidental Harassment Authorizations (IHAs) to take marine mammals by harassment during oil and gas industry activities in the U.S. Arctic Ocean during 2010. Shortly thereafter, on June 9, 2010, NOAA Fisheries, Office of Protected Resources, informed NMFS, Alaska Region that some of the proposed activities, namely the proposed exploration drilling, had been postponed by President Obama's moratorium on offshore drilling and therefore would not occur during 2010. Accordingly, on June 18, 2010, NOAA Fisheries, Office of Protected Resources requested that the original consultation be terminated and a new one be commenced regarding the proposed issuance of IHA permits for remaining activities, *i.e.*, the 2010 open-water seismic survey activities.

Pursuant to 50 CFR § 402.14(k), NMFS prepared this biological opinion for the 2010 open-water seismic activities as an incremental step consultation to the one completed when NMFS, Alaska Region issued the 2008 biological opinion. This biological opinion is tiered to the 2008 biological opinion and incorporates the analysis in the 2008 biological opinion of the potential effects of subsequent steps of OCS exploration, development and production.

## I. DESCRIPTION OF THE PROPOSED ACTION

This opinion will address the potential effects of authorization of "small take" permits under section 101(a)(5) of the Marine Mammal Protection Act, as amended, for certain oil and gas exploration activities in the U. S. Beaufort Sea and Chukchi seas for 2010. Its purpose is to provide an assessment of those actions on the continued existence of the bowhead, humpback, and fin whale, as well as to provide measures to conserve the species and mitigate impact. This Biological Opinion incorporates much of the information provided by the Permits Division, as well as pertinent research on the bowhead, fin, and humpback whales and matters related to oil exploration. Traditional knowledge and the observations of Inupiat hunters are presented, along with information gained through scientific research. This combined knowledge contributes, along with western science, to a more complete understanding of these issues. A reasonable assessment of potential effects can only be made by considering both these systems of knowledge.

Section 101(a)(5) of the Marine Mammal Protection Act (MMPA) directs the Secretary of Commerce to allow, upon request by U.S. citizens engaged in a specified activity (other than commercial fishing) in a specified geographical region, the incidental but not intentional taking of small numbers of marine mammals if certain findings are made. Such authorization may be accomplished through regulations and issuance of letters of authorization under those regulations, or through issuance of an incidental harassment authorization (IHA). These authorizations may be granted only if an activity would have no more than a negligible impact on the species (or stock) in question, would not have an unmitigable adverse impact on the availability of the marine mammal for subsistence uses, and that the permissible method of taking and requirements pertaining to the monitoring and reporting of such taking are set forth to ensure the activity will have the least practicable adverse effect on the species or stock and its habitat. These authorizations are often requested for oil and gas activities which produce underwater noise capable of harassing marine mammals. Harassment is a form of taking otherwise prohibited by the MMPA and ESA.

The specific activities subject to this consultation are described below.

- High energy, deep two-dimensional (2-D) and three-dimensional (3-D) seismic surveys in the Chukchi Sea between July 15 and November 30, 2010, by StatOil USA E&P Inc. (Statoil).
    - Subcomponents of this action include marine mammal monitoring involving the presence (and related effects) of two additional ships.

- Site-specific on-lease activities by Shell Offshore Inc. (SHELL) including:
    - Site clearance and shallow hazards surveys, ice gouging and strudel scour surveys in the Beaufort Sea between July and October 2010. Specifically, the following activities are proposed:
        - Marine high resolution geophysical surveys to evaluate shallow hazards in the Harrison Bay area of the Beaufort Sea, including proposed site clearance and shallow hazards surveys, ice gouging and strudel scour surveys. These surveys will occur in an area approximately 216 square miles north of Thetis Island and between roughly 3 and 20 miles offshore.
        - Ice gouge surveys will occur in both State of Alaska and Federal waters of the Outer Continental Shelf (OCS) in the Beaufort Sea near Point Thomson ranging from near shore to approximately 37 miles offshore. Strudel scour survey will occur in State of Alaska waters near Point Thomson ranging from near shore to 3 miles offshore.
    - Ice gouge surveys in the Chukchi Sea near Point Lay between July and October 2010.

**StatOil 2-D and 3-D Seismic Surveys**

Statoil proposes to conduct 2-D and 3-D seismic surveys in the Chukchi Sea between July 15, 2010 and November 30, 2010. They intend that the M/V *Geo Celtic*, or similar vessel, will arrive in Dutch Harbor ~mid July 2010. Departure date from Dutch Harbor will depend on ice conditions. However, it is expected to occur around mid/end July with an expected transit time of ~5 days (weather depending). Thus, for the purposes of our analyses, we assume that the seismic operations will not occur sooner than July 20, 2010. If the seismic vessel and its accompanying vessels were to transit through the spring lead system, the potential effects would be greater than anticipated here, and thus, not considered in this opinion.

StatOil anticipates that seismic surveying will occur during approximately 60 days of this period but has requested a longer time period to accommodate downtime. StatOil expects the startup date of seismic data acquisition to be early/mid August (dependent on ice conditions at the site). These surveys would occur on approximately ~915 $mi^2$ (2,370 $km^2$) in the MMS OCS Lease Sale 193 area in the northern Chukchi Sea. If completed as intended, the entire 3D program will consist of ~3,100 mi (4,990 km) of production line, not including line turns. Hence, the overall spatial footprint due to vessel transit is larger than the surveyed area.

Water depth within the study area is ~100–165 ft (30–50 m).

Potential acoustic and disturbance effects that could occur from this action are related to not only the seismic source but also to the vessels themselves. Three vessels will be involved in this action: a seismic vessel and two chase vessels.

One seismic source vessel will be employed to tow the two 3,000 $in^3$ airgun arrays and hydrophone streamer for the 3D (and 2D) seismic data acquisition and to serve as a platform for marine mammal monitoring. This seismic vessel is the M/V *Geo Celtic* or similar equipped vessel. According to the Bergen Group website (http://bergengroup.no/publish_files/Bergen_Group_Proforma_3Q.pdf), this vessel is the world's largest seismic vessel. It is an ice-class vessel (ICE-C). It is 100.80 m long, with maximum breadth of 28 m, and it cruises at 16 knots. Marine mammal monitoring will occur from this vessel.

**Figure 1.** The seismic vessel M/V *Geo Celtic*.

There are two "chase/monitoring" vessels, the M/V *Gulf Provider (*or similarly equipped vessel) and the M/V *Thor Alpha (*or similar equipped vessel). The M/V *Gulf Provider*, which will be utilized in marine mammal monitoring, crew transfers, and support and supply duties has the following dimensions: 57.8 m (190 ft) length, 3.8 m (12.5 ft) draft.



**Figure 2.** The M/V *Gulf Provider* and the M/V *Thor Alpha*.

The M/V *Thor Alpha* will be used to conduct marine mammal monitoring, support and supply duties. This ship is 55.10 m long and its "breath moulded" is 12.50 m.

StatOil will conduct sound source verification measurements from one of the chase/monitoring vessels. These sound source verifications will occur directly upon arrival in the 3D survey area, depending on ice conditions.

The actual 3D surveys will begin following the sound source verification. Based on an estimated duration of 60 days from first to last shotpoint, and depending on the start date, the survey is expected to be completed by the first half of October. StatOil proposes to conduct acquisition 24 hours/day.

The M/V *Geo Celtic* will tow two identical airgun arrays at ~20 ft (6 m) depth and at a distance of ~902 ft (275 m) behind the vessel. StatOil's IHA application specified that each array is composed of three strings consisting of 26 active G-guns (4×60 $in^3$, 8×70 $in^3$, 6×100 $in^3$, 4×150 $in^3$, and 4×250 $in^3$) with a total discharge volume of 3,000 $in^3$. Each array also consists of 5 clusters of 10 inactive airguns (spares). StatOil specified that a 60 $in^3$ gun will be used as the mitigation gun.

A second priority action is to acquire 2D seismic survey data. There are four proposed 2D lines having a total length of ~ 420 mi (675 km).

StatOil's IHA application specifies that: "The M/V *Geo Celtic* will serve as the platform from which vessel-based marine mammal observers will watch for marine mammals during the transit to the survey area, airgun operations, and transit to the demobilization port. Two chase/monitoring vessels will be used to protect the streamer from damage, for supply and support and for monitoring activities as required. All chase/monitoring vessels will have marine mammal observers MMOs [marine mammal observers] onboard and will assist with the implementation of mitigation measures . . ."

**Mitigations Associated with the StatOil Seismic Survey**

The StatOil IHA applications lists steps they have built into the survey to reduce its effect on the environment:

- They have kept the total discharge volume (of the airguns) to be used as low as possible without compromising data quality. The total volume for the proposed survey is 3,000 $in^3$.
- They have included spare airguns into the array to facilitate a more effective operation with the expectation that this will reduce overall field time.
- They have designed their survey to reduce the total number of lines and shotpoints needed to acquire the 3D seismic data in the survey area, again, with the expectation of reducing survey duration.

**SHELL Open Water Marine Survey Program in the Beaufort and Chukchi Seas**

The Permits Division is proposing to authorize the take of marine mammal by harassment by SHELL incidental to their proposed marine surveys designed to gather site clearance, shallow hazards, ice gouge, and strudel scour data in several areas of the Beaufort Sea and ice gouge data in the Chukchi Sea, Alaska. The activities include:

- Beaufort Sea Site Clearance and Shallow Hazards Surveys
- Beaufort Sea Marine Surveys
    - Ice Gouge Survey
    - Strudel Scour Survey
- Chukchi Sea Marine Survey
    - Ice Gouge Survey

SHELL intends to conduct these marine surveys during the 2010 Arctic open water season (July through October).

The best available information about the vessels to be used, and the time of the surveys is provided in SHELL's IHA application for this action and reproduced below:

| Chukchi Sea Marine Survey | | | |
|---|---|---|---|
| **Vessel Task** | **Notional Operating Timeframe** | | **Proposed Vessel** |
| Ice Gouge | July through October | | *Mt. Michell*, or similar vessel |
| **Beaufort Sea Marine Surveys** | | | |
| **Vessel Task** | **Notional Operating Timeframe** | | **Proposed Vessel** |
| Site Clearance | July through October | | *Mt. Michell*, or similar vessel |
| Ice Gouge | July through October | | *Mt. Michell*, or similar vessel |
| Strudel Scour | July to Mid-August | | *Annika Marie*,or similar vessel |

Table 1 of NMFS's May 18, 2010, notice of its proposal to issue an IHA to SHELL (75 FR 27708), which is reproduced below, lists active acoustic sources proposed to be used for SHELL's 2010 open water marine survey in the Chukchi and Beaufort seas:

| Survey types | Active acoustic sources | Frequency | Modeled source level | Radii (m) at modeled received levels (dB re 1 µPa) | | | |
|---|---|---|---|---|---|---|---|
| | | | | 190 | 180 | 160 | 120 |
| Site Clearance & Shallow Hazards. | 40 cu-in airgun ................ | ........................................ | 217 | 35 | 125 | 1,220 | 14,900 |
| | Dual frequency side scan | 190 & 240 kHz ............... | 225 | Not modeled/measured because frequency outputs beyond marine mammal hearing range. | | | |
| | Single beam echo sound | high: 100–340 kHz, low: 24–50 kHz. | 180–200 | Not modeled/measured because frequency outputs beyond marine mammal hearing range. | | | |
| | Shallow sub-bottom profiler. | 3.5 kHz (Alpha Helix) ...... | 193.8 | 1 | 3 | 14 | 310 |
| | | 3.5 kHz (*Henry C.*) .......... | 167.2 | NA | NA | 3 | 980 |
| | | 400 Hz ............................ | 176.8 | NA | NA | 9 | 1,340 |
| Ice Gouging Surveys ....... | Dual freq sub-bottom profiler. | (2–7 kHz & 8–23 kHz ..... | 184.6 | NA | 2 | 7 | 456 |
| | Multibeam Echo Sounder | 240 kHz .......................... | Not modeled/measured because frequency outputs beyond marine mammal hearing range. | | | | |
| Strudel Scour Survey ...... | Multibeam Echo Sounder | 240 kHz .......................... | Not modeled/measured because frequency outputs beyond marine mammal hearing range. | | | | |
| | Single Beam Bathymetric Sonar. | >200 kHz ........................ | 215 | Not modeled/measured because frequency outputs beyond marine mammal hearing range. | | | |

**Beaufort Sea Site Clearance and Shallow Hazards Surveys**

Based on information provided in the IHA applications, this activity will occur on SHELL's leases in Harrison Bay in the central Beaufort Sea (see Fig. 3, reproduced from SHELL's IHA application). The specific locations where site clearance and shallow hazards surveys within Harrison Bay had not been definitively set when the IHA application was submitted, and was not known at the time of consultation. According to the IHA application:

> The site clearance and shallow hazards surveys will be conducted within an area of approximately 216 $mi^2$ (558 $km^2$) north of Thetis Island more than 3 mi (4.8 km) to approximately 20 mi (33 km) offshore. Approximately 63 mi (162.7km) of the data acquisition is planned within this general area. The survey track line is approximately 351.5 $mi^2$ (565 $km^2$). The average depth of the survey area ranges from 35 to 85 ft (10.7 to 26 m).

The IHA application specified that the vessel to be used in the survey had not yet been determined, but will be similar to the R/V *Mt. Mitchell*, which is the vessel that was used by SHELL for surveys in the Chukchi Sea in 2009. The application specified that the R/V *Mt. Mitchell* is a diesel powered hydrographic research vessel that is 70 m (231 ft) long, 12.7 m (42 ft) wide, and has a draft of 4.5 m (15 ft) (http://www.globalseas.com/mt-mitchell/history).

SHELL is proposing to conduct this work within the timeframe of July through October 2010, ice and weather permitting. The survey is expected to take 30 days. Exact dates are not given in the application. Thus, it is unclear when SHELL proposes to transit through the Chukchi Sea in order to be on site for these surveys.

It is proposed that the following acoustic instrumentation, or something similar, be used:

- Dual-frequency side scan sonar, (100–400 kHz or 300–600 kHz), or similar.
- Single beam Echo Sounder, (high: 100–340 kHz, low: 24–50 kHz), or similar;
- Multibeam Echo Sounder, (240 kHz), or similar.
- Deep Penetration Profiler, (40 cu-in airgun source with 48-channel streamer), or similar.
- Medium Penetration Profiler, (40 cu-in airgun source with 24-channel streamer), or similar.
- Shallow Sub-Bottom Profiler, (2–12 kHz), or similar.

**Beaufort Sea Marine Surveys**

Two marine survey activities are proposed for the Beaufort Sea–an ice gouge survey, and a strudel scour survey. These surveys can be accomplished by one vessel for each survey.

Ice gouge survey.—As part of the feasibility study for SHELL's Alaskan prospects a survey is required to identify and evaluate seabed conditions. Ice gouging is created by ice keels, which project from the bottom of moving ice and gouge into seafloor sediment. Ice gouge features are mapped, and by surveying each year, new gouges can be identified. The ice gouge information is used to aid in predicting the prospect of, orientation, depth, and frequency of future ice gouges. Ice gouge information is required for the design of potential pipelines and for the design of pipeline trenching and installation equipment.

The 2010 ice gouge survey will be conducted using the conventional survey method where the acoustic instrumentation will be towed behind the survey vessel, or possibly with the use of an Autonomous Underwater Vehicle (AUV). The same acoustic instrumentation will be used during both AUV and the conventional survey methods. The AUV is a self-propelled autonomous vehicle that will be equipped with acoustic instrumentation and programmed for remote operation over the seafloor where the ice gouge survey is to be conducted, and the vehicle is launched and retrieved from a marine vessel. It is proposed that the following acoustic instrumentation, or something similar, be used for the survey: a dual-frequency subbottom profiler (2 to 7 kHz or 8 to 23 kHz), a multibeam echo sounder (240 kHz), and a side-scan sonar system (190 to 210 kHz).

The IHA application specified that the vessel to be used in the survey had not yet been determined, but will be similar to the R/V *Mt. Mitchell*, which is described above. Ice and weather permitting, SHELL proposes to conduct this work within the timeframe of July through October 2010. Actual locations of the ice gouge survey were not identified in the IHA application, although the general area within which the survey will be conducted is

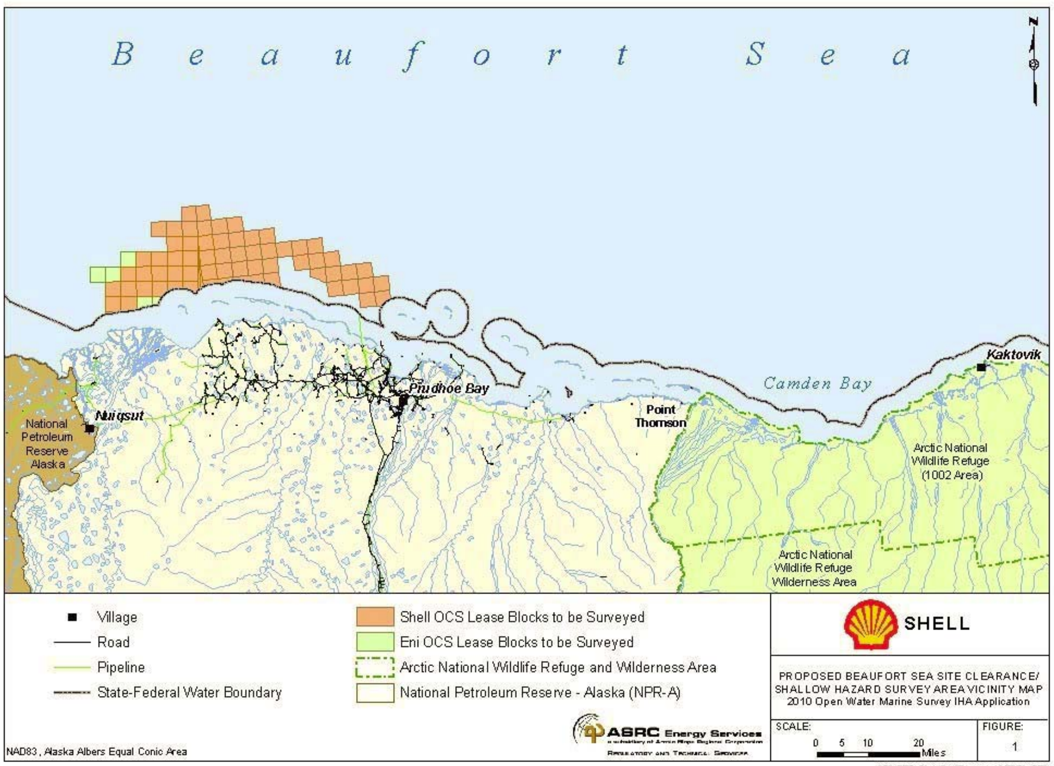


**Figure 3.** SHELL's Beaufort Sea proposed shallow hazard survey area vicinity map. This figure is reproduced from Figure 1 of SHELL's IHA application.

illustrated in a map in the application as within federal waters of the OCS in the Beaufort Sea east of the Badami Unit (see SHELL's IHA Application, Fig. 2).

<u>Strudel scour survey</u>.—During the early melt on the North Slope, the rivers begin to flow and discharge water over the coastal sea ice near the river deltas. That water flows down holes in the ice ("strudels") and scours the sea floor. These areas are called "strudel scours." Information on these features is required for prospective pipeline planning.

Two proposed activities are required to collect this information: helicopter survey via aerial overflights during the melt to locate the strudels; and strudel scour marine surveys to gather bathymetric data. The helicopter flights will occur during late May through early June and are expected to take no more than two days, weather permitting. There are no planned landings during the overflights other than at the Deadhorse or Kaktovik airports. Areas that have strudel scour identified during the aerial surveys will be verified and surveyed with a marine vessel after the breakup of nearshore ice. This proposed activity is not expected to take more than five days to conduct, and will occur in the shallow water areas near the coast in the vicinity of Point Thompson.

It is proposed that the following acoustic instrumentation be used for the survey: multibeam echo sounder (240 kHz) and side-scan sonar system (190 to 210 kHz); and single beam bathymetric sonar (source levels for these types of units are typically somewhat lower than multibeam or sidescan sonars; a units used during a previous survey had a source level at high power of 215 dB re 1 µPa (0-peak) and a standard operating frequency of 200 kHz). The IHA application specified that the vessel to be used in the survey had not yet been determined, but will be similar to the R/V *Mt. Mitchell*, which is described above.

**Chukchi Sea Marine Survey – Ice Gouge Survey**
SHELL intends to conduct ice gouge surveys annually over a few years to enhance baseline and statistical understanding of the formation, longevity, and temporal distribution of sea floor features and baseline environmental and biologic conditions. Actual locations of the ice gouge surveys were not specified in SHELL's IHA application, but the general survey area is illustrated in a map in the application as within federal waters of the OCS in the Chukchi Sea (see SHELL's IHA Application, Fig. 4). The equipment and method to conduct the survey will be the same as for the Beaufort Sea ice gouge survey.

## Action Area

Federal regulations implementing the ESA (50 C.F.R. §402.02) define the action areas as follows:

> Action area means all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action.

In order to define the actions areas for the proposed action, we must have some basic understanding of the zone over which direct and indirect effects of this action might occur. Based on literature on effects from drillships and effects from seismic surveys on migrating bowhead whales, bowheads may react to noise as low as 120 dB. Based on this metric, we can define an action area as including at least 100 km from all areas of seismic operation by StatOil and within at least 2 km for SHELL's proposed seismic work.

Therefore, the action area for purposes of this Biological Opinion is defined as waters within 100 kilometers of the described activities in the Chukchi Sea, and within 2 km of the activities in the Beaufort Sea. The direct and indirect effects of this action on the endangered fin, humpback, and bowhead whale are expected to be confined to the action area.

### Term of this Opinion

This opinion will be valid upon issuance and remain in force for the duration of the IHAs, during 2010 and 2011. Consultation will be re-initiated if there are significant changes in the type of exploratory activities occurring, if new information indicates these actions are impacting the listed species, or other listed species/critical habitats to a degree or in a manner not previously considered, or if new species or critical habitats become listed under the Act.

## II. STATUS OF THE SPECIES (RANGEWIDE)

NMFS has determined that the described actions may affect the following marine mammal species currently listed under the Endangered Species Act of 1973 (16 U.S.C. 1531 *et seq*.; ESA):

- Bowhead whale (*Balaena mysticetus*) Endangered
- Fin whale (*Balaenoptera physalus)* Endangered
- Humpback whale (*Megaptera novaeangliae)* Endangered

This opinion will consider the potential effects of these actions on these species. However, we believe the bowhead whale is most likely to be effected by oil and gas exploration, and that this species is likely more sensitive to noise and disturbance than humpback and fin whales. Additionally, there now exists a considerable database on the Western Arctic bowhead stock (also referred to as the Bering/Chukchi/Beaufort stock or BCB) and the potential and measured impacts to these whales due to oil exploration in the Arctic. Much of this information will be generally applicable to other large balenopterid whales, notably fin and humpback whales. Therefore, the bowhead whale often receives the most attention under this opinion.

### Bowhead Whale

Information in this section provides updates and, in some cases, summarizes information from previous consultation documents (e.g., NMFS 2006, 2008, MMS, 2006, 2008) and supplements this information with more recent information on the Bering-Chukchi-Beaufort (BCB) or Western Arctic stock of the bowhead whale. Since the time of the writing of the previous section 7 documents (e.g., MMS, 2006, 2008; NMFS 2006, 2008), there has been considerable research focused on the bowhead whale in MMS's Chukchi Sea and Beaufort Sea OCS Planning areas. Key studies include: 1) the bowhead feeding study (BOWFEST), a multi-year, multi-disciplinary study including oceanographic studies (e.g., Okkonen et al., 2009), use of photography to assess feeding prevalence (Mocklin, 2009; aerial surveys (Goetz et al., 2009), acoustics (Berchok et al., 2009), local ice-based surveys (George, 2009), and stomach examination (George and Sheffield, 2009); 2) the bowhead tagging study (Quakenbush et al., 2009); 3) the bowhead whale aerial survey project (BWASP) (e.g., Monnett and Treacy, 2005; Clarke et al., 2010); 4) aerial surveys in the Chukchi Sea (COMIDA) (Clarke et. al., 2009); 5) coordinated studies undertaken to resolve stock structure (see main text and summary in George et al., 2007); and 6) boat-based monitoring, aerial surveys, and acoustic studies funded by industry (e.g. LGL, Greeneridge and Jasco, 2010).

Documents that also summarize a large volume of information about bowhead whales are available. For example, NMFS published the Notice of Determination - Endangered and Threatened Species; Final Determination on a Petition to Designate Critical Habitat for the Bering Sea Stock of Bowhead Whales August 30, 2002 (67 FR 55767), and NMFS issued its Biological Opinion on Issuance of Annual Quotas Authorizing the Harvest Of Bowhead Whales to the Alaska Eskimo Whaling Commission for the Period 2008 Through 2012 (NMFS, 2008a). The MMS published Aerial Surveys of Endangered Whales in the Beaufort Sea, Fall 2002-2004 (Monnett and Treacy, 2005) and the National Marine Mammal Laboratory (NMML) published the results of these surveys in 2006-2008 (Clarke et al., 2010) and the results of the COMIDA surveys in the Chukchi Sea (Clarke and Ferguson, 2010). The most recent marine mammal stock assessment for the Western Arctic stock of the bowhead whale was revised November 14, 2008 (Allen and Angliss, 2010).

The Scientific Committee (SC) of the International Whaling Commission (IWC) has reviewed and critically evaluated new information available on the bowhead whale at all recent meetings (e.g., IWC, 2003a, 2005a,b; see http://www.iwcoffice.org/_documents/sci_com/SCRepFiles2009/Annex%20F%20-%20Final-sq.pdf for 2009 summaries). The IWC SC conducted an in-depth status assessment of this population in 2004 (IWC, 2004a, b). In recent years, a considerable amount of research has been conducted on bowhead stock structure as requested by the IWC SC during its 2004 meeting. Results from this research were summarized in George et al. (2009) who wrote that:

> Collectively, these studies have resulted in over 80 research papers and contributed new information on BCB stock structure, but particularly the genetic structure of the BCB bowhead whale population. It should be recognized that these studies add to the baseline of over 30 years of research (resulting in >300 IWC SC submitted papers), including an intensive program in the 1970-80s when a similar suite of studies (e.g., aerial and ship based surveys, analysis of commercial whaling records, abundance estimation, harvest documentation, local knowledge, etc.)…was undertaken.

Details on bowheads that are outside the scope of the material provided here may be provided in one or more of the aforementioned documents. We have reviewed and considered information in these documents and other available information in our evaluation of potential environmental impacts.

We explicitly consider traditional knowledge (also called traditional ecological knowledge or TEK) in this opinion. "Observations that form traditional knowledge and scientific observations are independent sources of information that when combined, can increase our depth of knowledge" (Quakenbush and Huntington, 2010, citing Huntington et al., 2004). The value of the knowledge that Alaska Native bowhead hunters have about bowhead population status, behavior, habitat use, and response to anthropogenic activities is well documented. Thus, we believe it is an essential component of our achieving a full understanding of the status of the bowhead whale in this area and understanding ways in which bowheads may be affected by the proposed action.

**ESA Listing History and Status**

The bowhead whale was listed as an endangered species under the Endangered Species Conservation Act, the predecessor to the ESA, on June 2, 1970 (35 FR 8495). The species was then listed as endangered under the ESA in 1973. On February 22, 2000, NMFS received a petition requesting that portions of the U.S. Beaufort and Chukchi seas be designated as critical habitat for the Western Arctic stock (Bering Sea stock) of bowhead whales. On August 30, 2002, the NMFS made a determination not to designate critical habitat for this population of bowheads (67 FR 55767) because: (1) the population decline was due to overexploitation by commercial whaling, and habitat issues were not a factor in the decline; (2) the population is abundant and increasing; (3) there is no indication that habitat degradation is having any negative impact on the increasing population; and (4) existing laws and practices adequately protect the species and its habitat.

Shelden et al. (2001) proposed that the bowhead whale species should be listed under the ESA as five distinct population segments, based on the distinct population segment definition developed by the NMFS and FWS in 1996. The five separate stocks of bowhead whales are the Bering Sea stock (referred to in IWC documents as the BCB Seas bowhead and as the Western Arctic stock in the NMFS's Alaska Marine Mammal stock assessments), the Spitsbergen stock, the Davis Strait stock, the Hudson Bay stock (but see Heide-Jørgensen et al., 2006 and Heide-Jørgensen and Laidre, 2007), and the Okhotsk stock. Shelden et al. (2001) evaluated each proposed distinct population segment to determine whether one or more should be reclassified. The authors presented two models to evaluate the status of bowhead whale stocks, one that they developed based on World Conservation Union criterion D1 and E (World Conservation Union, 1996, as referenced in Shelden et al., 2001), and a model developed by Gerber and DeMaster (1999) for ESA classification of North Pacific humpback whales. Under each of these classification systems, the authors determined that the Bering Sea population of bowhead whales should be delisted, whereas the other four populations of bowheads should continue to be listed as endangered (see also criticism of this determination by Taylor, [2003], the response of Shelden et al. [2003] and discussion by the IWC SC [IWC, 2003a]).

While five stocks are recognized, the Western Arctic population of the bowhead whale is the only one known to occur in the action area. All further references to the bowhead whale in this document concern only the Western Arctic population.

**Population and Stock Structure**

The bowhead whale was historically found in all arctic waters of the northern hemisphere. Five populations are currently recognized by the International Whaling Commission (IWC) (1992) (but see Heide-Jørgensen et al. [2006] and Heide-Jørgensen and Laidre [2007], and references cited therein, who argued that bowheads that summer in eastern Canada and winter in West Greenland, considered the Hudson Bay and Davis Strait Stocks, consist of a single population). Three of these populations are found in the North Atlantic and two in the North Pacific, some or all of which may be reproductively isolated (Shelden and Rugh, 1995). The Spitsbergen population is found in the North Atlantic east of Greenland in the Greenland, Kara, and Barents Seas. Thought to have been the most numerous of bowhead populations, Woodby and Botkin (1993) estimate the unexploited population at 24,000 animals. The Spitsbergen bowhead is now severely depleted, possibly in the tens of animals (Shelden and Rugh, 1995).

The Davis Strait population is found in Davis Strait, Baffin Bay, and along the Canadian Arctic Archipelago. This population is separated from the Bering Sea population by the heavy ice found along the Northwest Passage (Moore and Reeves, 1993). The population was estimated to have originally numbered over 11,700 (Woodby and Botkin, 1993) but was significantly reduced by commercial whaling between 1719 and 1915. The population is today estimated at 350 animals (Zeh et al., 1993) and recovery is described as “at best, exceedingly slow” (Davis and Koski, 1980).

The Hudson Bay population, also found in Foxe Basin, is differentiated from the Davis Strait population by their summer distribution, rather than genetic or morphological differences (Reeves et al., 1983). No reliable estimate exists for this population; however, Mitchell (1977) places a conservative estimate at 100 or less. More recently, estimates of 256-284 whales have been presented for the number of whales within Foxe Basin (Cosens et al., 1997). There has been no appreciable recovery of this population.

The Okhotsk Sea population occurs in the North Pacific off the western coast of Siberia near the Kamchatka Peninsula. The pre-exploitation size of this population may have been 3,000 to 6,500 animals (Shelden and Rugh, 1995), and may now number somewhere in the 300-400 range, although reliable population estimates are not currently available. It is possible this population has mixed with the Bering Sea population, although the available evidence indicates the two populations are essentially separate (Moore and Reeves, 1993).

The BCB Seas bowhead is the largest of all surviving bowhead populations and the only stock to inhabit U.S. waters. Many of the other stocks are likely small (e.g., the Hudson Bay/Davis Strait which may be over a thousand) or very small (but see Department of Fisheries and Oceans [DFO] 2009 regarding estimates of the eastern arctic bowhead and related discussions regarding population size). Ivashchenko and Clapham (2010) noted that the estimated current size (in the low hundreds) of the Okhotsk stock is not based on quantitative analysis, but that the population is very likely to be relatively small. Thus, available data indicate that the viability of bowheads in the BCB Seas stock is highly important to the long-term future of the biological species as a whole.

While all questions regarding genetic distinctions have not been resolved, the best available information indicates that bowheads that may occur in the Bering, Chukchi and Beaufort seas, including in the action area, are probably part of a single population, called the Bering-Chukchi-Beaufort (BCB) by the IWC and the Western Arctic stock by NMFS. Hence, it is likely that a single population is affected by the proposed action**.**

**Past and Current Population Abundance**
Woodby and Botkin (1993) estimated that the historic population abundance of bowheads in the Western Arctic stock was between 10,400 and 23,000 whales in 1848 before commercial whaling, which severely depleted bowhead whales. They estimated that between 1,000 and 3,000 animals remained in 1914 near the end of the commercial-whaling period.

Based on both survey data and the incorporation of acoustic data, the abundance of the Western Arctic stock of bowhead whales was estimated between 7,200 and 9,400 individuals in 1993 (Zeh, Raftery, and Schaffner, 1995), with 8,200 as the best population estimate. This estimate was recently revised by Zeh and Punt (2004) to 8,167 (CV= 0.017) and is the estimate used by the NMFS in their draft 2005 stock assessment (Angliss and Outlaw, 2005). An alternative method produced an estimate of 7,800 individuals, with a 95% confidence interval of 6,800-8,900 individuals. Data indicate that the Western Arctic stock increased at an estimated rate of about 3.1% (Raftery, Zeh, and Givens, 1995) to 3.2% (Zeh, Raftery, and Schaffner, 1995) per year from 1978-1993. The estimated increase in the estimated population size most likely is due to a combination of improved data and better census techniques, along with an actual increase in the population.

George et al. (2004) estimated abundance in 2001 to be 10,470 (SE = 1,351) with a 95% confidence interval of 8,100-13,500. This estimate indicates a substantial increase in population abundance since 1993 and suggests that population abundance may have reached the lower limits of the historical population estimate. Zeh and Punt (2004, cited in Angliss and Outlaw, 2005) provided a slightly revised population estimate of 10,545 CV(N) =0,128 to the IWC in 2004 and this is similar to the estimate of 2001 abundance provided by the IWC for this stock (10,500; 95% confidence interval: 8,500–13,500) (http://www.iwcoffice.org/conservation/estimate.htm on May 1, 2010). George et al. (2004) estimated that the annual rate of increase (ROI) of the population from 1978-2001 was 3.4% (95% CI 1.7%-5%) and Brandon and Wade (2004) estimate an ROI of 3.5% (95% CI 2.2-4.9%). The number of calves (121) counted in 2001 was the highest ever recorded for this population and this fact, when coupled with the estimated rate of increase, suggests a steady recovery of this population (George et al., 2004). This steady recovery is likely due to low anthropogenic mortality, a relatively pristine habitat, and a well-managed subsistence hunt (George et al., 2004). Based on capture-recapture statistical analysis of the "captures" of 4,894 putative individuals obtained from 10 years of photographic surveys conducted during the period of the spring migration past Barrow, Schweder et al.(2009) recently derived an estimate of abundance in 2001 of 8,250 and a point estimate of yearly growth of 3.2%. This estimated rate of increase is similar to the previous estimates.

Koski (2009) (Paper SC/61/FI12 submitted to the IWC SC) estimated the abundance of BCB bowheads based on photo-identification data collected in 2003-05 for use in capture-recapture analyses, with accounting in the analyses for unmarked whales. This work was reviewed by the IWC SC' Subcommittee on Bowhead, Right, and Gray whales in 2009. This subcommittee agreed that Koski's 2009 abundance estimate for BCB stock of bowheads in 2004 of 11,800 (CV = 0.255; 95% confidence interval: 7,200–19,300) is an acceptable estimate of the abundance of the BCB stock of bowhead whales and was suitable for use in the Bowhead Whale Strike Level Algorithm used in setting acceptable harvest levels (IWC, 2009).

As discussed above, all available information (e.g., Shelden et al., 2001; IWC, 2004a,b, 2005a,b; NMFS, 2003a,b; George et al., 2004; Allen and Angliss, 2010; Koski, 2009) indicates that the BCB Seas population of bowheads has been increasing in recent years and may have reached the lower limit of the estimate of the population size that existed prior to intensive commercial whaling.

**Reproduction, Survival and Non-Human Sources of Mortality**

Information gained from the various approaches at aging the Western Arctic stock of bowhead whales and estimating survival rates all suggest that bowheads are slow-growing, late-maturing, long-lived animals with survival rates that are currently high (Zeh et al., 1993; see below). Female bowheads probably become sexually mature at an age exceeding 15 years, from their late teens to mid-20's (Koski et al., 1993) (Schell and Saupe, 1993: about 20 years). Their size at sexual maturity is about 12.5-14.0 meters (m) long, probably at an age exceeding 15 years (17-29 years: Lubetkin et al., 2004 cited in IWC, 2004b). Most males probably become sexually mature at about 17-27 years (Lubetkin et al., 2004 cited in IWC, 2004b). Schell and Saupe (1993) looked at baleen plates as a means to determine the age of bowhead whales and concluded that bowheads are slow-growing, taking about 20 years to reach breeding size. Based on population structure and dynamics, Zeh et al. (1993) also concluded that the bowhead is a late-maturing, long-lived animal (George et al., 1999) with fairly low mortality. Photographic recaptures by Koski et al. (1993) also suggested advanced age at sexual maturity of late teens to mid-twenties.

Mating may start as early as January and February, when most of the population is in the Bering Sea but has also been reported as late as September and early October (Koski et al., 1993). Mating probably peaks in March-April (IWC, 2004b). Gestation has been estimated to range between 13 and 14 months (Nerini et al., 1984; Reese et al., 2001) and between 12 and 16 months by Koski et al. (1993) (see also information and discussion in IWC, 2004b). Reese et al. (2001) developed a nonlinear model for fetal growth in bowhead whales to estimate the length of gestation, with the model indicating an average length of gestation of 13.9 months. Data indicate most calving occurs during the spring migration when whales are in the Chukchi Sea. Some calving also likely occurs in the Beaufort spring lead system. Koski et al. (1993) reported that calving occurs from March to early

August, with the peak probably occurring between early April and the end of May (Koski et al., 1993). The model by Reese et al. (2001) also indicated that conception likely occurs in early March to early April, suggesting that breeding occurs in the Bering Sea. The conception date and length of gestation suggests that calving is likely to occur in mid-May to mid-June, when whales are between the Bering Strait and Point Barrow (in the Chukchi Sea). Reese et al. (2001) said this is consistent with other observations in the region, including: (a) relatively few neonate-cow pairs reported by whalers at St. Lawrence Island; (b) many neonates seen during the whale census in late May; (c) relatively few term females taken at Barrow; (d) taken females with term pregnancies appeared close to parturition; and (e) most of the herd believed to have migrated past Barrow by late May. Females give birth to a single calf probably every 3-4 years.

There is little information regarding causes of natural mortality for Western Arctic bowhead whales. Bowhead whales have no known predators except, perhaps, killer whales and subsistence whalers. The frequency of attacks by killer whales probably is low (George et al., 1994). A relatively small number of whales likely die as a result of entrapment in ice (Philo et al., 1993). Little is known about the effects of microbial or viral agents on natural mortality.

The discovery of traditional whaling tools recovered from five bowheads landed since 1981 (George et al., 1995) and estimates of age using aspartic-acid racemization techniques (George et al., 1999; Rosa et al., 2004) both suggest bowheads can live a very long time, in some instances more than 100 years. The oldest harvested females whose ages were estimated using corpora albicans accumulation to estimate female age were more than 100 years old (George et al., 2004, cited in IWC, 2004b). Rosa et al. (2004) reported that the ages of 5 of 84 landed bowheads estimated using aspartic acid racemization exceeded 100 years old. The oldest of these whales was estimated to be 178 years old (Rosa et al., 2004). Discussion in the IWC (2004b) indicated that neither lifespan nor age at sexual maturity is certain. Lifespan may be greater than the largest estimates.

Using aerial photographs of naturally marked bowheads collected between 1981 and 1998, Zeh et al. (2002:832) estimated "the posterior mean for bowhead survival rate…is 0.984, and 95% of the posterior probability lies between 0.948 and 1." They noted that a high estimated survival rate is consistent with other bowhead life-history data.

### Migration, Distribution, and Habitat Use

The Western Arctic stock of bowheads generally occurs north of 60° N. and south of 75° N. latitude (Angliss and Outlaw, 2005) in the Bering, Chukchi, and Beaufort seas. They have an affinity for ice and are associated with relatively heavy ice cover and shallow continental shelf waters for much of the year.

<u>Winter and other use of the Bering Sea</u>.—Bowhead whales of the Western Arctic stock overwinter in the central and western Bering Sea. Most mating probably occurs in the Bering Sea. The amount of feeding in the Bering Sea in the winter is unknown as is the amount of feeding in the Bering Strait in the fall (Richardson and Thomson, 2002). Previously, Moore and Reeves (1993) concluded that, in the Bering Sea, bowheads

frequent the marginal ice zone, regardless of where the zone is, and polynyas. Important winter areas in the Bering Sea include polynyas along the northern Gulf of Anadyr, south of St. Matthew Island, and near St. Lawrence Island. Bowheads congregate in these polynyas before migrating (Moore and Reeves, 1993). However, recent tagging data (L. Quakenbush, ADF&G, unpublished data) also show whales in ice covered habitats, in locations away from the major polynyas.

Observations by Mel'nikov, Zelensky, and Ainana (1997) from shore-based observations of waters adjacent to the Chukotka Peninsula in 1994-1995 indicate that bowheads winter in the Bering Sea along leads and polynyas adjacent to the Asian coastline. Mel'nikov, Zelensky, and Ainana (1997) summarized that in years when there is little winter ice, bowheads inhabit the Bering Strait and potentially inhabit southern portions of the Chukchi Sea.

During their southward migration in the autumn, bowheads pass through the Bering Strait in late October through early November, or later (e.g. tagging data indicate some may linger into January; L. Quakenbush, ADF&G, unpublished data) on their way to overwintering areas in the Bering Sea. Large numbers of bowheads were taken in June and July during commercial whaling over large portions of the northwestern and northcentral Bering Sea (Dahlheim et al., 1980, from Townsend, 1935).

Spring migration.—Some, or nearly all (see stock discussion above) of the bowheads that winter in the Bering Sea migrate northward through the Bering Strait to the Chukchi Sea and through the Alaskan Beaufort Sea to summer feeding grounds in the Canadian Beaufort Sea. The bowhead northward spring migration appears to coincide with ice breakup and probably begins most years in April (possibly late March depending on ice conditions) and early May. It is thought to occur after the peak of breeding, which is believed to occur in March-April (C. George, cited in IWC, 2004b). Based on shore-based surveys in 1999-2001, Mel'nikov et al. (2004) observed that the start of spring migration from the Gulf of Anadyr varies between cold and mild years by up to 30 days, but in both instances, continues at least until June 20. Mel'nikov et al. (2004) also reported that weather influenced migration, with migration seeming to stop when there were storms or high winds in the western Bering Strait or at the exit from the Gulf of Anadyr. Bowheads migrate up both the eastern and western sides of the Bering Strait in the spring (Mel'nikov, Zelensky, and Ainana, 1997; Mel'nikov et al., 2004). They pass through the Bering Strait and eastern Chukchi Sea from late March to mid-June through newly opened leads in the shear zone between the shorefast ice and the offshore pack ice. During spring aerial surveys in the late 1980's, bowheads were documented to be migrating in shorefast leads and polynyas up the coast of northwestern Alaska (see Figs. 4 and 5 in Mel'nikov, Zelensky, and Ainana, 1997).

Alaska Native whaling captains from Wainwright reported that "In the past, bowhead whales first arrived at Wainwright in late April, but . . . now they appear in the area in early April and at times even in March. Most whales have passed by early June." (Quakenbush and Huntington, 2010:8). In the spring of 2010, the first bowhead of the spring season was seen near Barrow on March 24, 2010 and a few continued to be seen the first week of April

(C. George, NSB, pers. commun., email March 24, 2010 and April 5, 2010). Hunters reported that ice conditions determined local distribution and that when leads near Wainwright are closed, whales travel farther offshore. They reported that the whales often follow the shorefast ice edge but that they may also stay farther offshore, traveling directly between the Icy Cape and Point Belcher areas. Figure 2 of Quakenbush and Huntington (2010:15) depicts areas between Icy Cape and Point Franklin identified by whaling captains as areas where feeding, calving and mating have been observed.

Whaling captains from Wainwright also reported that bowhead whales have occasionally been observed in June and July after shorefast ice near Wainwright has broken up. In 2007, a large whale was seen near Pt. Franklin in June and many large whales were seen in July. Observations about 35 years ago of 3 very large bowheads in July near the mouth of the Kuk River suggests that such occurrence is not a brand new phenomenon but may be part of the normal range of variability in habitat use in this area.

Several studies of acoustical and visual comparisons of the bowhead's spring migration off Barrow indicate that bowheads also may migrate under ice within several kilometers of the leads. Data from several observers indicate that bowheads migrate underneath ice and can break through ice 14-18 cm (5.5-7 inches [in]) thick to breathe (George et al., 1989; Clark, Ellison, and Beeman, 1986). Bowheads may use cues from ambient light and echoes from their calls to navigate under ice and to distinguish thin ice from multiyear floes (thick ice). After passing through Barrow from April through mid-June, they move easterly through or near offshore leads. East of Point Barrow, the lead systems divide into many branches that vary in location and extent from year to year. The spring-migration route is offshore of the barrier islands in the central Alaskan Beaufort Sea.

The migration past Barrow takes place in pulses in some years (e.g., in 2004) but not in others (e.g., 2003) (Koski et al., 2004, cited in IWC, 2004b), with temporal segregation by size class (Zeh et al., 1993; Angliss et al., 1995; Koski et al., 2006; Wainwright whaling captains as reported in Quakenbush and Huntington 2010). At Barrow, the first migratory pulse is typically dominated by subadults. This pattern gradually reverses and by the end of the migration, adults constitute a large proportion of the bowheads passing Barrow. The last whales to pass Barrow tend to be females that are accompanied by calves (Angliss et al., 1995; Koski et al., 2006; Koski and Miller, 2009; C. George, NSB unpublished data).

Wainwright whaling captains reported that the young and mid-sized whales require open leads or ponds and that, if leads close up, whales may delay migration. They reported that they may congregate in pools as they wait for better conditions. These captains reported that the third wave, which consists of the largest whales and most of the female and calf pairs, occurs in the last half of May and early June. They reported that these whales are capable of pushing through young ice (to approximately 45 cm) and are able to migrate when leads are closed. Wainwright whaling captains reported (Quakenbush and Huntington 2010:8) that "[w]hales in the third wave may also be found in cracks and openings far out in the pack ice."

Traditional ecological knowledge and tagging data both indicate that the nearshore lead area is a very important migration area (Quakenbush and Huntington, 2010), and that some nearshore are used for feeding and calving (Quakenbush and Huntington, 2010). Tagging data (L. Quakenbush and John Citta, ADF&G, unpublished data; Quakenbush et al., 2009), also show that part of the spring lead system used by bowhead whales extends into the Chukchi sea 193 lease sale area and into areas where there are active leases.

Summer.—Tagging studies (e.g., Quakenbush 2009b; ADF&G unpublished data), data from small boat surveys (George and Sheffield, 2009) near Barrow, and other new data suggest that the paradigm that underlay some of the previous management, that being that all of the bowheads round the corner at Barrow, swim east across the leads to Canadian waters and stay there until "a fall migration begins" from the Canadian Beaufort (sometime around September 1), oversimplifies a more complex and varied pattern. For example, tagging data demonstrate that bowheads may be in the ice in leads northeast of Barrow in mid June to mid July, transit to the Camden Bay area and to the Canadian Border from both the east and the west in late July, move from the mid Beaufort halfway across the Chukchi in mid-August, etc. Data from the Barrow-based boat surveys in 2009 (George and Sheffield, 2009) showed that bowheads were observed almost continuously in the waters near Barrow, including feeding groups in the Chukchi Sea at the beginning of July. Many whales (including a cow/calf pair), some feeding, were observed northeast of Barrow in early August and there were large numbers of feeding whales east of Point Barrow, later in August into September. These new data add to previous observations of bowhead whales that were near Barrow, in the central Beaufort Sea, or in the Chukchi Sea in the summer.

Harry Brower, Jr. observed whales in the Barrow area in the middle of the summer, when hunters were hunting bearded seals on the ice edge (Brower, as cited in USDOI, MMS, 1995). The monitoring program conducted while towing the single steel drilling caisson to the McCovey location in 2002 recorded five bowhead whales off Point Barrow on July 21.

Some biologists conclude that almost the entire Bering Sea bowhead population migrates to the Beaufort Sea each spring and that few whales, if any, summer in the Chukchi Sea. Incidental sightings suggest that bowhead whales may occupy the Chukchi Sea in the summer more regularly than commonly believed. Moore (1992) summarized observations of bowheads in the northeastern Chukchi in late summer. Other scientists maintain that a few bowheads swim northwest along the Chukotka coast in late spring and summer in the Chukchi Sea. Natives living along the coast of Russia and other observers have long reported observations of bowheads during the summer along the Chukotka Peninsula (Bogoslovskaya, 2003; Zelensky et al., 1995). Current data are not available to estimate abundance, typify spatial and temporal patterns of use, or determine if individual bowheads show strong site fidelity to this area.

While sample sizes from the tagging study are insufficient to draw broad conclusions about relative distribution, it is clear from all sources of data that bowheads may be in the U.S. Beaufort and the Chukchi Sea in the spring, the summer and the fall. They may occupy the northeastern Chukchi Sea in late summer more regularly than commonly believed (Moore, 1992; USDOC, NOAA, and NSB, 2005).

Fall habitat use and migration.—Those bowheads that have been summer feeding in the Canadian Beaufort Sea begin moving westward into Alaskan waters in August and September. While few bowheads generally are seen in Alaskan waters until the major portion of the migration takes place (typically mid-September to mid-October), in some years bowheads are present in substantial numbers in early September (Greene and McLennan, 2001; Treacy, 1998). In 1997, Treacy (1998) reported sighting 170 bowheads, including 6 calves, between Cross Island and Kaktovik on September 3 during the first flight of the survey that year. In 1997, Treacy (1998) observed large numbers of bowheads between Barrow and Cape Halkett in mid-September. Large numbers were still present between Dease Inlet and Barrow in early October (although they may not have been the same individuals).

There is some indication that the fall migration, just as the spring migration, takes place in pulses or aggregations of whales (Moore and Reeves, 1993). Eskimo whalers report that smaller whales precede large adults and cow-calf pairs on the fall migration (Braham et al., 1984, as reported in Moore and Reeves, 1993).

Inupiat whalers estimate that bowheads take about 2 days to travel from Kaktovik to Cross Island, reaching the Prudhoe Bay area in the central Beaufort Sea by late September, and 5 days to travel from Cross Island to Point Barrow (T. Napageak, 1996, as cited in NMFS, 1999).

Bowheads are capable of traveling rapidly. Based on tagging data, Heide-Jørgensen et al. (2006) showed that, at least in the Atlantic, bowhead whales travel long distances (>1,000 km) in relatively short periods of time (7-10 days). Mate, Krutzikowsky, and Winsor (2000) tagged 12 juvenile bowhead whales with satellite-monitored radio tags in the Canadian Beaufort Sea. The whale with the longest record traveled about 3,886 km from Canada across the Alaskan Beaufort Sea to the Chukchi Sea off Russia and averaged 5.0 km/h. This whale's speed was faster, though not significantly faster, in heavy ice than in open water.

Oceanographic conditions can vary during the fall migration from open water to more than nine-tenths ice coverage. The extent of ice cover may influence the timing or duration of the fall migration. Miller, Elliot, and Richardson (1996) observed that whales within the Northstar region (147°-150° W. longitude) migrate closer to shore in light and moderate ice years and farther offshore in heavy ice years, with median distances offshore of 30-40 km (19-25 miles [mi]) in both light and moderate ice years and 60-70 km (37-43 mi) in heavy ice years. Moore (2000) looked at bowhead distribution and habitat selection in heavy, moderate, and light ice conditions in data collected during the autumn from 1982-1991. This study concluded that bowhead whales select shallow inner-shelf waters during moderate and light ice conditions and deeper slope habitat in heavy ice conditions. During the summer, bowheads selected continental slope waters and moderate ice conditions (Moore, DeMaster, and Dayton, 2000). Interseasonal depth and ice-cover habitats were significantly different for bowhead whales. Ljungblad et al. (1987) observed during the years from 1979-1986 that the fall migration extended over a longer period, that higher whale densities were estimated, and that daily sighting rates were higher and peaked later in the season in light ice years as compared to heavy ice years.

Aerial surveys near the proposed Liberty development project in 1997 (BPXA, 1998) showed that the primary fall-migration route was offshore of the barrier islands, outside the proposed development area. Some bowheads may swim inside the barrier islands during the fall migration. For example Frank Long, Jr. reported that whales are seen inside the barrier islands near Cross Island nearly every year and are sometimes seen between Seal Island and West Dock (U.S. Army Corps of Engineers, 1999).

While factors such as prey concentrations, seismic activities, and localized vessel traffic may have dominating effects on site-specific distributions, broad-area fall distributions of bowhead whale sightings in the central Alaskan Beaufort Sea may be driven by overall sea-ice severity (Treacy, 2001). Treacy (2002) concluded that:

> Bowhead whales occur farther offshore in heavy-ice years during fall migrations across the Central Alaskan Beaufort Sea (142° W to 155° W longitudes). Bowheads generally occupy nearshore waters in years of light sea-ice severity, somewhat more offshore waters in moderate ice years, and are even farther offshore in heavy ice years. While other factors . . . may have localized effects on site-specific distributions, broad-area distributions of bowhead whale sightings in the central Alaskan Beaufort Sea are related to overall sea-ice severity.

Data are limited on the bowhead fall migration through the Chukchi Sea before the whales move south into the Bering Sea. J.C. George (cited in IWC, 2004b) noted that bowheads pass through the Bering Strait into the Bering Sea between October and November on their way to overwintering areas in the Bering Sea. Whaling captains from Wainwright reported that bowheads do not typically follow the Alaska coast southward in the autumn but bowheads have been seen a few times in October near Wainwright. Bowhead whales are commonly seen from the coast to about 150 km (93 mi) offshore between Point Barrow and Icy Cape, suggesting that most bowheads disperse southwest after passing Point Barrow and cross the central Chukchi Sea near Herald Shoal to the northern coast of the Chukotka Peninsula.

Sightings north of 72° N. latitude suggest that at least some whales migrate across the Chukchi Sea farther to the north. Mel'nikov, Zelensky, and Ainana (1997) argued that data suggest that after rounding Point Barrow, some bowheads head for the northwestern coast of the Chukotka Peninsula and others proceed primarily in the direction of the Bering Strait and into the Bering Sea. Mel'nikov (in USDOC, NOAA, and NSB, 2005) reported that abundance increases along northern Chukotka in September as whales come from the north. More whales are seen along the Chukotka coast in October. The timing, duration, and location of the fall migration along the Chukotka Peninsula are highly variable and are linked to the timing of freezeup (Mel'nikov, Zelensky, and Ainana, 1997). Whales migrate in "one short pulse over a month" in years with early freezeup, but when ice formation is late, whales migrate over a period of 1.5-2 months in 2 pulses (Mel'nikov, Zelensky, and Ainana, 1997:13.

Summary and evaluation of known use of the Beaufort Sea: Bowhead whales may occur in portions of the Beaufort Sea Planning Area from spring through late fall. Spatial distribution, length of residency, habitat use, and timing of use is variable among years. Currently, the whales are first seen at Barrow around April 9-10, and this early pulse is dominated by juveniles. The size/age composition of whales entering the Beaufort gradually switches so that by later in May (May 15-June) large whales and cow/calf pairs are seen. Most of the herd is believed to have migrated past Barrow by late May. After passing Barrow, whales travel in spring leads through heavy pack ice, generally in a northeasterly direction, eventually heading east toward the southeastern Beaufort Sea, reaching the Canadian Beaufort by July. The number of bowheads observed feeding in Canadian waters is variable as is the distribution and behavior of whale observed there. They range through the Beaufort Sea in the summer. Large numbers of whale have been observed in early September in western portions of the planning area. It is not clear whether these whales migrated west early or did not migrate into the eastern Beaufort. The extent and locations of feeding in portions of the Beaufort Sea Planning Area varies considerably among years. In late summer (typically early September, but sometimes beginning earlier), bowhead whales migrate west. Data indicate that bowheads occupy inner and outer shelf habitat in light and moderate ice years but occur in outer shelf and slope habitat in years of heavy ice.

Summary and evaluation of known use of the Camden Bay, Central Beaufort Sea Area (proposed ice gouge survey area): Koski and Miller (2009) concluded that the timing of bowhead use of this area varied among different size classes, with small subadults arriving in late August and departing in late September, and adults arriving last in late September. However, they found that mothers and calves arrived in early September and were common at until at least early October, when the study ended.

Bowheads clearly feed in this area. Lowry et al. (2004) reported that about 83% of the bowheads harvested in this area had food in their stomachs and about 39% of them had a substantial amount of food. Data indicate that most of the adults as well as subadults had been feeding. Würsig et al. (2002) reported that in September of most years, feeding was the most frequently observed activity of bowheads in the central Beaufort Seas. Richardson and Thomson (2002) concluded that the amount of feeding varied among years. Koski and Miller (2009) hypothesized that the apparent preference of subadults for shallower waters in years with light ice may be due, at least in part, to more extensive feeding by these animals in these areas in light ice years. They summarize that ". . . the overall higher proportion of subadults among the measured whales suggests that the central Beaufort Sea was more important for subadult bowheads than for adults during the years of our study."

The deeper waters of the central Beaufort Sea are important as an autumn migration corridor for adult whales in all years, and they are important feeding areas in some years. In 1999, for example, adult bowheads in waters deeper than 20 m spent an estimated 66% of their time in the study areas feeding (Koski and Miller 2009:145-146). While not addressed by these authors, the fact that an expected proportion of females with calves was photographed (not a lower than expected proportion) may indicate that this area is an important feeding areas for females with calves. BWASP surveys have long shown that areas within and on both sides of Camden Bay including, but not limited to, areas off of Kaktovik and Brownlow Point were, in many years, areas of high use by bowhead whales (e.g., Monnett and Treacy, 2005; MMS, 2006a; Clarke et al., 2010) including in 2008 and 2009 (Quakenbush 2009). Recently summarized data from many decades of the BWASP aerial surveys also demonstrates that the area just to the west, northwest, and southwest of the proposed Silvuliq ice gouge survey is a feeding area used by large numbers of whales in many years (Clarke and Ferguson, 2010). Kaktovik whaling captains also identified a feeding area just west of Kaktovik (see Fig. 1 in Huntington and Quakenbush, 2009). They stated that bowhead whales are occasionally seen in the Camden Bay area or other areas near Kaktovik in July or early August. However, they reported that the main migration begins in late August and continues through September and into October. As they stop whaling before the migration is over, they clarified that they did not know how long the migration continues. The whalers reported that the migration path is established by larger whales that come first. Some of the bowheads were reported as traveling close to shore, feeding in passes between barrier islands, and near barrier islands. They reported that whales were not seen close to shore every year. However, the fact that whales have long used nearshore areas is reflected in the Inupiat name for Arey Island, which means “place to listen for whales” (Huntington and Quakenbush, 2009).

In summary, the best available information indicates that the area near Camden Bay is an area of special significance to bowhead whales. Large numbers of whales have been documented feeding in the area in multiple years and females and calves have been documented using the area in approximately the same proportions as they exist in the population (Koski and Miller, 2009). Feeding aggregations of whales may be expected to occur in the area, especially just to the west, the southwest and the northwest of the ice gouge survey sites. In 2010, the Permits Division proposes to issue an IHA for this area for ice gouge surveys.

### Feeding

Bowheads filter prey from the water through baleen fibers in their mouth. They apparently feed throughout the water column, including bottom feeding as well as surface skim feeding (Würsig et al., 1989). Skim feeding can occur when animals are alone and conversely may occur in coordinated echelons of over a dozen animals (Würsig et al., 1989). Food items most commonly found in the stomachs of harvested bowheads include euphausiids, copepods, mysids, and amphipods. Euphausiids and copepods are thought to be their primary prey. Lowry, Sheffield, and George (2004) documented that other crustaceans and fish also were eaten but were minor components in samples consisting mostly of copepods or euphausiids.

The importance of the Alaskan Beaufort Sea is an important issue in evaluating the potential effects of industrial activities on these whales. It has been, and remains, an area of focused research. In the past it was a subject of considerable controversy. However, given the current combination of tagged whales, widespread aerial surveys, focused aerial surveys, photographic studies, oceanographic studies, and traditional ecological knowledge, there is greater consensus that feeding occurs in most years at multiple locations in the Alaskan Beaufort Sea, and in many years at other places.

Available data indicate that bowhead whales feed in both the Chukchi and Beaufort Sea Planning Areas and that this use varies in degree among years, among individuals, and among areas. It is likely that bowheads continue to feed opportunistically where food is available as they move through or about the Alaskan Beaufort Sea, similar to what they are thought to do during the spring migration. Feeding is more prevalent or at least better documented in the summer in the Canadian Beaufort, and in the autumn (e.g., Lowry et al., 2004), than in the spring.

Key feeding areas include: the eastern Beaufort sea, which Mocklin (2009) summarizes is an ". . . area long recognized as the main feeding ground for the BCB bowheads . . .", the Barrow feeding area (multiple references, including new findings by Mocklin, 2009; Ashjian et al., in press; Quakenbush et al., in press; Quakenbush and Huntington, 2010), and the area near Camden Bay (e.g., see Koski and Miller, 2009).

The bowhead feeding area north and northeast of Barrow is now documented and/or supported by information from Alaska Native hunters, long-term aerial surveys (e.g., Monnett and Treacy, 2005; Ferguson and Clarke, 2010; Clarke et al., 2010), focused aerial surveys during feeding studies, boat surveys (George 2009), stomach contents from harvested whales (e.g., Lowry, 1993; George and Sheffield, 2009), photographic studies (Mocklin, 2009), and results that integrate the aforementioned (e.g., Ashjian et al., in press). Mocklin (2009:41) found ". . . photographic evidence that 99% of all bowhead whales near Barrow in August and September of 2005, 2006, and 2007 were feeding, and of these, 97% were feeding epibenthically. In May near Barrow in 1985, 1986, 2003, and 2004, 61 % of the whales were feeding (of these 55% were feeding epibenthically)."

Feeding has also been observed near Barrow in the last week of July (although this behavior is believed to have been unusual) and in August, September, and October. Substantial amounts of epibenthic feeding have been observed in the feeding area near Barrow (Mocklin, 2009).

Observations from the 1980s also documented that some feeding occurs in the spring in the northeastern Chukchi Sea, but this feeding was not consistently seen (e.g., Ljungblad et al., 1987; Carroll et al., 1987). Wainwright whaling captains have identified feeding areas in the Chukchi Sea (Quakenbush and Huntington, 2010). Stomach contents from bowheads harvested between St. Lawrence Island and Point Barrow during April into June indicated it is likely that some whales feed during the spring migration (Carroll et al., 1987; Shelden and Rugh, 1995, 2002). Carroll et al. (1987) reported that the region west of Point Barrow seems to be of particular importance for feeding, at least in some years, but that whales may feed opportunistically at other locations in the lead system where oceanographic conditions produce locally abundant food. Lowry (1993) reported that the stomachs of 13 out of 36 spring-migrating bowheads harvested near Point Barrow between 1979 through 1988 contained food. Lowry estimated total volumes of contents in stomachs ranged from less than 1 to 60 liters (L), with an average of 12.2 L in eight specimens. Shelden and

Rugh (1995) concluded that "[i]n years when oceanographic conditions are favorable, the lead system near Barrow may serve as an important feeding ground in the spring (Carroll et al., 1997)." Richardson and Thomson (2002) concluded that some, probably limited, feeding occurs in the spring.

It is known that bowhead whales feed in the Canadian Beaufort in the summer and early fall (e.g., Würsig et al, 1985), and in the Alaskan Beaufort in late summer/early fall (Lowry and Frost, 1984; Ljungblad et al., 1986; Schell and Saupe, 1993; Lowry, Sheffield, and George, 2004; summarized in Richardson and Thomson, 2002). Available information indicates it is likely there is considerable inter-annual variability in the locations where feeding occurs during the summer and fall in the Alaska Beaufort Sea, in the length of time individuals spend feeding, and in the number of individuals feeding in various areas in the Beaufort Sea.

Richardson and Thomson (2002) pointed out that bowhead activity throughout the year needs to be considered when evaluating the importance of feeding in the eastern Alaskan Beaufort Sea in late summer and autumn. Although numerous observations have been made of bowheads feeding during both the spring migration north to the Beaufort Sea and the fall migration west across the Alaskan Beaufort Sea, quantitative data showing how food consumed in the Alaskan Beaufort Sea contributes to the bowhead whale population's overall annual energy needs is fairly limited. A study by Richardson (1987) concluded that food consumed in the eastern Beaufort Sea contributed little to the bowhead whale population's annual energy needs, although the area may be important to some individual whales. The study area for this 1985-1986 study extended from eastern Camden Bay to the Alaska/Canada border from shore to the 200-m depth contour for the intensive study area, and beyond this contour only for aerial survey data (Richardson and Thomson, 2002). The conclusion was controversial. The NSB's Science Advisory Committee (1987) believed the study was too short in duration (two field seasons, one of which was limited by ice cover), had a suboptimal sampling designs, and had difficulties in estimating food availability and consumption. The Committee did not accept the conclusion that the study area is unimportant as a feeding area for bowhead whales.

In 2002, Richardson and Thomson finalized a report from the MMS-funded feeding study entitled Bowhead Whale Feeding in the Eastern Alaskan Beaufort Sea: Update of Scientific and Traditional Information, which compiled and integrated existing traditional and scientific knowledge about the importance of the eastern Alaskan Beaufort Sea for feeding by bowhead whales. The project was an extension, with additional fieldwork (mainly in September of 1998, 1999, and 2000), of the previous study conducted in 1985 and 1986. The primary study area extended the westward boundary about 1° longitude from that of the 1985-1986 study. Thus the boundary for the latter study was near the middle of Camden Bay (145° W. longitude). With the concurrence of the NSB Scientific Review Board, efforts in deep offshore areas were de-emphasized in this latter study to concentrate efforts in shallow areas of particular concern to Kaktovik hunters and, potentially, to oil industry. Boat-based zooplankton sampling in 1998-2000 was limited to areas seaward of the 50-m contour. Aerial surveys extended to the 200-m contour, and MMS surveys extended further.

Both observations of whales and evaluations of feeding behavior indicate that the value of the Camden Bay area to bowheads as a feeding area likely varies among years. For example, Griffiths (1999) noted that the average zooplankton biomass in the study area was higher in 1986 than in 1998. In 1998, the principal feeding area within the eastern study area appeared to have been near Kaktovik. Griffiths, Thomson, and Bradstreet (2002) discussed zooplankton biomass samples collected in the Canadian Beaufort Sea during the 1980's and in the Alaskan Beaufort Sea in 1986, 1998, and 1999, where bowhead whales were either observed feeding or where whales had been observed feeding the previous day. Bowhead whales feed in areas with a higher than average concentration of zooplankton. The distribution of biomass values at locations with feeding bowheads indicates that the feeding threshold for bowheads may be a wet biomass of ~800 milligrams per cubic meter ($mg/m^3$). Most whales observed where zooplankton were sampled were subadults. "Adult bowheads tend to feed where large copepods predominate" (Richardson and Thomson, 2002:xxv).

Würsig et al. (2002) summarized that during September 1985, 1986, 1998, and 1999 (and early Oct in 1986) the most common activity of bowheads observed during aerial observation sessions in the eastern Alaskan Beaufort Sea was feeding, while in 2000 little feeding was observed. They noted that although feeding was the most common activity, there was considerable variability in the amount and type of feeding, other activities and specific behaviors, and the locations within the survey area where these activities occurred. Miller and Koski (2002) also reported substantial differences in the numbers, size classes, residence times, and distributions of bowheads recorded there during aerial behavioral and photogrammetric studies in these years.

Data indicate that the amount of time bowheads spend feeding in the fall in the eastern Alaskan Beaufort Sea is highly variable among years. Bowhead whales moved quickly through the area in 1998 and did not stop to feed for any great period of time. In contrast, during 1986, subadult whales stopped to feed in the study area for periods of at least several days. In 1999, adult whales stopped to feed in the Flaxman-to-Herschel zone for extended periods (Koski et al., 2002). In 1999, the main bowhead feeding areas were 20-60 km offshore in waters 40-100 m deep in the central part of the study area east and northeast of Kaktovik, between Kaktovik and Demarcation Bay (Koski, Miller, and Gazey, 2000).

Recently, Lee at al. (2005) published data from isotope ratio analyses of bowhead baleen from whales all except one of whom had been harvested in the autumn of 1997. Results of these samples were compared to data from baleen collected in past studies from both spring (predominantly) and autumn whales in 1986-1988 (see Table 1 in Lee et al., 2005:274). Lee et al. (2005:285) concluded that the new data continue to indicate that the ". . . bowhead whale population acquires the bulk of its annual food intake from the Bering-Chukchi system . . . Our data indicate that they acquire only a minority of their annual diet from the eastern and central Beaufort Sea . . . although subadult bowheads apparently feed there somewhat more often than do adults."

Thomson, Koski, and Richardson (2002) tried to reconcile the low estimates of summer feeding, as indicated by the isotope data of Lee and Schell, with other data: behavioral observations showing frequent feeding in the eastern Beaufort Sea during the summer and early autumn; zooplankton sampling near bowheads feeding in those areas shows that whales concentrate their feeding at locations with much higher than average biomasses of zooplankton; frequent occurrence of food in the stomachs of bowheads harvested in the Alaskan Beaufort Sea during late summer and autumn; and length-girth relationships show that subadult bowheads, and possibly adults, gain weight while in the Beaufort Sea in summer and lose weight while elsewhere; and lipid content of blubber, at least in subadults, is higher when they leave the Beaufort in fall than when they return in spring. Although some of this evidence suggests the importance of feeding in the Beaufort Sea during summer and early autumn, those types of data on summer and early fall feeding in the Beaufort Sea do not specifically show what fraction of the annual feeding occurs in the eastern and central Beaufort Sea. No comparable data on feeding, girth, or energy content have been obtained during and after the whales feed in the Chukchi sea in mid- to late fall. They concluded that bowheads fed for an average of 47% of their time in the eastern Alaskan Beaufort Sea during late summer and autumn. A substantial minority of the feeding occurred during travel. Among traveling whales, feeding as well as travel was occurring during a substantial percentage of the time, on the order of 43%.

One source of uncertainty that affected the analyses related to bowhead energetics is that the amount of feeding in the Chukchi Sea and Bering Strait in the fall is unknown as is the amount of feeding in the Bering Sea in the winter (Richardson and Thomson, 2002). In mid to late fall, at least some bowheads feed in the southwest Chukchi. Detailed feeding studies have not been conducted in the Bering Sea in the winter.

Thomson, Koski, and Richardson (2002) offered a feeding scenario, parts of which are speculative, that might be consistent with all these data. In this scenario, feeding occurs commonly in the Beaufort Sea in summer and early autumn, and bowheads gain energy stores while feeding there. However, zooplankton availability is not as high in the Beaufort Sea during summer as in the Chukchi and northern Bering seas during autumn. Also, feeding in the western Beaufort in autumn effectively may be on Chukchi prey advected to that area. Thus, bowheads might acquire more energy from Bering/Chukchi prey in autumn than from eastern and central Beaufort prey in summer/early autumn. Given this, plus an assumed low turnover rate of body components, the overall body composition of bowheads may be dominated by components from the Bering/Chukchi system, even at the end of the summer when leaving the Beaufort. Energy gained in the Beaufort and Chukchi seas during summer and fall presumably is used during winter when food availability is low, resulting in reduced girth and energy stores when returning to the Beaufort Sea in spring than when leaving in autumn.

Richardson and Thomson (2002) pointed out that the isotopic and behavioral and stomach content data might not be in conflict, if prey availability in the Chukchi and/or Bering Sea were "notably better" than in the eastern Beaufort Sea. However, they also point out that: ". . . it is difficult to understand why bowheads would migrate from the Bering-Chukchi area to the Beaufort Sea if feeding in the Beaufort Sea were unimportant." Richardson and

Thomson (2002) noted that while the study has provided many new data about bowhead feeding ecology and related biology, ". . . there are still numerous approximations, assumptions, data gaps, and variations of opinion regarding the interpretation of data. This is inevitable . . . The authors do not claim that the project has resolved all uncertainty about the importance of the eastern Alaskan Beaufort Sea for feeding by bowhead whales . . ."

**Vocalizations and Hearing**

Bowhead whales are believed to be most sensitive to lower frequency sound. It may be reasonable that whales are most sensitive to noise at the frequencies at which they vocalize. Most bowhead calls are at 50-400 Hz, although components may reach as low as 35 Hz or as high as 5 kHz (Burns et al. 1993). Bowhead whales produce various types of vocalizations, described as frequency modulated tonal calls in the 50-300 Hz range, complex calls which include pulsed sounds, squeals, growl-type sounds with abundant harmonic content, and call sequences. Bowhead whales are also known to sing during spring migrations. Source levels for bowhead calls have been estimated as high as 180-189 dB (Würsig and Clark, 1993). In addition to functioning with regard to communicating with others, bowheads may utilize vocalizations to maintain cohesion in migrations or to locate ice in order to migrate through the spring leads in the Chukchi and Beaufort seas. Bowhead vocalizations and hearing remain poorly understood, although call duration, frequency, and type appear dependent on life history, age, sex, behavior, time of year, and outside stimuli such as industrial noise.

No studies have directly measured the sound sensitivity of bowhead whales. In a study of the morphology of the mysticete auditory apparatus, Ketten (1997) hypothesized that large mysticetes have acute infrasonic hearing. Southall et al. (2007) assigned bowhead whales to the low-frequency cetacean functional hearing group. This group has an estimated auditory bandwidth of 7 Hz to 22 kHz. As is the case for all mysticetes, they pointed out that direct data on bowhead hearing sensitivity is not available, and so it has been estimated based on behavioral responses to sounds at various frequencies, favored vocalization frequencies, body size, ambient noise levels at favored frequencies, and cochlear morphometry.

## Fin Whale

Information provided herein expands, updates, and in some cases, summarizes information provided in previous recent biological opinions (i.e., NMFS 2006, 2008). All available information is considered in our update of our analyses of the potential effects of the proposed action on fin whales. Key new sources of information that underlie our evaluation of potential effects of the proposed action on fin whales include, but are not limited to: results from historic (1982-1991) (Moore and Clarke, 1992) and recent (2008 and 2009) (Clarke, 2009) aerial surveys of the Chukchi Sea; results from historic and recent aerial surveys of the Beaufort Sea (e.g., Clarke, 2009; Monnett and Treacy, 2005, and Moore and Clarke, 1992); and results from industry monitoring in the Chukchi and Beaufort seas (e.g., LGL, Greeneridge, and JASCO, 2010). The most recent stock assessment for the Northeast Pacific Stock of fin whales was revised November 20, 2008

(Allen and Angliss, 2010). We have also reviewed and considered information contained in the fin whale draft recovery plan (71 FR 38385; July 2, 2006).

### ESA Listing History and Status

The fin whale was listed as an endangered species under the Endangered Species Conservation Act on June 2, 1970 (35 FR 8495). The species was then listed as endangered under the ESA in 1973. On July 2, 2006, NMFS announced the availability of a draft recovery plan and requested public comment (71 FR 38385). On January 22, 2007, NMFS initiated a five-year status review of the fin whale (72 FR 2649). No critical habitat has been designated or proposed for fin whales in the North Pacific.

Under the 1994 amendments to the MMPA, fin whales are categorized as a strategic stock. They are listed in Appendix I of CITES (Reeves et al., 1998). Hunting of fin whales in the North Pacific was regulated under the 1946 International Convention for the Regulation of Whaling. The IWC began managing the commercial take of fin whales in the North Pacific in 1969 (Allen, 1980; Reeves et al., 1999) and prohibited their harvest in the North Pacific in 1976.

### Population and Stock Structure

NMFS currently considers stock structure of the fin whale to be equivocal (Allen and Angliss, 2010). Three population stocks of fin whales are currently recognized by NMFS for management purposes in U.S. waters: Alaska (Northeast Pacific) stock, California/Washington/Oregon, and Hawaii (Allen and Angliss, 2010). They note that this structure should be reviewed and updated, if appropriate, to reflect new information provided by Mizroch et al. (2009), who recently provided a comprehensive summary of historic whaling catch data, Discovery Mark recoveries, and opportunistic sightings data.

The estimated population abundance of the North Pacific population prior to commercial exploitation range was 42,000-45,000 fin whales (Ohsumi and Wada, 1974). Allen and Angliss (2010) cited a revised, unpublished February 2003 version of IWC Bureau of International Whaling Statistics data, stating that "Between 1925 and 1975, 47,645 fin whales were reported killed throughout the North Pacific." Annual catches in the North Pacific and Bering Sea ranged between 1,000 and 1,500 fin whales during the 1950's and 1960's. However, not all Soviet catches were reported. No reliable current population estimate exists for the North Pacific stock, but Allen and Angliss (2010) report a minimum estimate of 5,700 for the fin whale population west of the Kenai Peninsula based on incomplete surveys over a portion of their range.

### Reproduction, Survival and Non-Human Sources of Mortality

Fin whale mating and calving are believed to occur on wintering grounds (Perry, DeMaster, and Silber, 1999a). A single calf is born after a gestation of about 12 months and weaned between 6 and 11 months of age (Best, 1966; Gambell, 1985). Calving intervals range between two and three years (Agler et al., 1993).

Little is known about the natural causes of mortality in fin whales. Ice entrapment is known to have injured or killed some fin whales in the North Atlantic, particularly in the

Gulf of St. Lawrence (NMFS, 2006), and killer whales may attack fin whales, as has been reported for gray whales. Disease presumably plays a major role in natural mortality as well, and shark attacks on weak or young individuals are probably common, but have not been documented. Lambertsen (in NMFS, 2006) contended that crassicaudiosis in the urinary tract, was the primary cause of natural mortality in North Atlantic fin whales. Rates of natural mortality in fin whales generally are thought to range between 0.04 and 0.06 (based on studies of northeast Atlantic fin whales) (Aguilar and Lockyer, 1987).

### Distribution and Habitat Use

Fin whales are widespread throughout temperate oceans of the world (Leatherwood et al., 1982; Perry, DeMaster, and Silber, 1999a; Reeves, Silber and Payne, 1998). Most fin whales are believed to migrate seasonally from relatively low-latitude winter habitats where breeding and calving take place to relatively high latitude summer feeding habitats (Perry, DeMaster, and Silber, 1999a). The degree of mobility of local populations, and perhaps individuals, differs, presumably in response to patterns of distribution and abundance of their prey (Reeves et al., 1991; Mizroch et al., In prep.). Some populations migrate seasonally up to thousands of kilometers; whereas, others are resident in areas with adequate prey (Reeves et al., 1999). Data from marked fin whales indicate that at least some individuals make long movements between wintering areas off Mexico and California to summer feeding areas in the Gulf of Alaska (Mizroch et al., In prep.).

During the "summer" (defined by Mizroch et al., In prep., as April-October) fin whales inhabit temperate and subarctic waters throughout the North Pacific including the Gulf of Alaska, Bering Sea, and the southern Chukchi Sea (Mizroch et al., 1984). Mizroch et al.'s (2009) summary indicates that fin whales range across the entire North Pacific from April to October, but in July and August they concentrate in the Bering Sea-eastern Aleutian area. Fin whale concentrations in the northern North Pacific and Bering Sea generally form along frontal boundaries, or mixing zones between coastal and oceanic waters, which themselves correspond roughly to the 200-m isobath (shelf edge) (NMFS 2006). In September and October, sightings indicate that fin whales are in the Bering Sea, the Gulf of Alaska, and along the U.S. coast, with one sighting as far as Baja California (in October) (Mizroch et al., 2009).

NMFS (2006) reports that fin whales have been observed year-round off central and southern California, with peak numbers in summer and fall, in summer off Oregon, and in summer and fall in the Gulf of Alaska (including Shelikof Strait), and the southeastern Bering Sea. Their regular occurrence has also been noted in recent years around the Pribilof Islands in the northern Bering Sea. Data suggest that the migratory behavior of fin whales in the eastern North Pacific is complex: whales can occur in any one season at many different latitudes, perhaps depending on their age or reproductive state as well as their stock affinity. Movements can be either inshore/offshore or north/south.

Observations summarized by Mizroch et al. (2009) and reported elsewhere demonstrate that there are many fin whales in many locations in northerly waters as far north as 60° N. latitude in winter months. Fin whales have been observed near Kodiak Island and in Shelikof Strait in all seasons of the year (Mizroch et al, 2009; Wynne and Witteveen, 2005). Mizroch et al. (2009:221) reported that "Fin whales are seen predictably and regularly in winter months in the Kodiak region of the Gulf of Alaska, and some of the earliest winter surveys off the Commander Islands documented fin whales year-round." In January and February, fin whales have been sighted off Baja California, in the Aleutian area, and Bering Sea. Mizroch et al. (2009) pointed out, however, that fin whales with small calves have not been seen in northern latitudes during the winter months, and that it has not been demonstrated that individual whales are year-round residents in the northern areas.

Fin whales may occur seasonally in the southwestern Chukchi Sea, north of the Bering Strait along the coast of the Russian Chukotka (also referenced as the Chukchi) Peninsula. Their known current summer feeding habitat includes the southern portion, especially the southwestern portion, of the Chukchi Sea along the Asian coast. The species' current use of parts of its historic range probably is modified due to serious population reduction during commercial hunting. However, there have been only rare observations of fin whales into the eastern half of the Chukchi Sea. Three fin whales (including a mother and calf) were observed together in the southern Chukchi directly north of the Bering Strait in July 1981 (Ljungblad et al., 1982). No other sightings of fin whales were reported during aerial surveys of endangered whales in summer (July) and autumn (August, September and October) of 1979-1987 in the Northern Bering Sea (from north of St. Lawrence Island), the Chukchi Sea north of 66º N. latitude and east of the International Date Line, and the Alaskan Beaufort Sea from 157º 01' W. east to 140º W. longitude and offshore to 72º N. latitude (Ljungblad, 1988). Mizroch et al. (2009) summarized that no other sightings of fin whales had been reported from the Arctic Alaska coast. They were not observed during annual aerial surveys of the Beaufort Sea conducted in September and October from 1982-2004 (e.g., Treacy, 2002; Moore, DeMaster, and Dayton, 2000). Fin whales were also not observed during a research cruise in the Chukchi and Beaufort seas in the summer of 2003 (Bengston and Cameron, 2003).

With the resurgence of oil and gas activities in the Chukchi Sea and related monitoring and research, there have been a few sightings of fin whales in the eastern half of the Chukchi Sea. MMS (2008) and NMFS (2008) summarized that three adult fin whales were observed by marine mammal observers on a vessel in the southeast Chukchi Sea on September 23, 2006 (Patterson, et al., 2007). Clarke and Ferguson (2010) reported that one fin whale was seen swimming alone on 2 July 2008 at 69.228°N, 165.675°W (in the COMIDA survey Block 20). No fin whales were observed during COMIDA surveys in 2009. Haley et al. (2010) reported no sightings of fin whales during boat based monitoring in 2006 or 2007, but reported two sightings of fin whales in the Chukchi Sea, for a total of four fin individuals, in 2008. Thomas et al. (2010) did not report any sightings of fin whales during their sawtooth nearshore aerial surveys in the Chukchi Sea from 2006-2008.

With regards to the Beaufort Sea, fin whales were not observed during annual aerial surveys of the Beaufort Sea conducted in September and October from 1982-2008 (e.g., Clarke et al. 2010; Monnett and Treacy, 2005; Moore et al., 2000; Treacy, 2002; Monnett, 2008, pers. commun.).

Thus, for the purposes of our analyses, we assume that:

- Fin whales have been observed, but are not expected to routinely occur, in the northeastern Chukchi Sea, in the Chukchi Sea Planning Area, or in the Alaskan Beaufort Sea.
- Fin whales do occur south and west of the Chukchi Sea Planning Areas, and may expand northward in the future.

Continued arctic warming could result in changes in oceanographic conditions favorable to the distribution and abundance of fin whale prey species, and the extended distribution into waters of the Chukchi and possibly Beaufort Sea.

**Foraging Ecology and Feeding Areas**

Fin whales feed primarily on euphausiids, or "krill", but also consume substantial quantities of fish. Citing the IWC (1992), Perry, DeMaster, and Silber (1999a) reported that there is great variation in the predominant prey of fin whales in different geographical areas, depending on which prey are locally abundant. Nemoto and Kasuya (1965) and Kawamura (1982) indicated that in the North Pacific overall, fin whales preferred euphausiids (mainly *Euphausia pacifica*, *Thysanoessa longipes*, *T. spinifera*, and *T. inermis*) and large copepods (mainly *Calanus cristus*), followed by schooling fish such as herring, walleye pollock (*Theragra chalcogramma*), and capelin. Mizroch et al. (2009) summarized that fish, especially capelin, Alaska Pollock, and herring were the main prey documented in the stomachs of harvested whales taken north of 58° N. latitude in the Bering Sea. They also reported that fin whales appear to be able to make long-distance movements quickly to track prey aggregations and can switch their diet from krill to fish as they migrate northward.

Fin whales aggregate where prey densities are high (Piatt and Methven, 1992; Piatt et al., 1989; Moore et al., 1998, 2002). Foraging areas tend to occur along continental shelves with productive upwellings or thermal fronts. Fin whales tend to avoid tropical and pack ice waters (NMFS 2006), with the northern limit set by ice and the southern limit by warm water of approximately 15°C (60°F).

**Vocalizations and Hearing**

Underwater sounds of the fin whale are one of the most studied of the *Balaenopteras*. Fin whales produce a variety of low-frequency sounds in the 10 to 200 Hz band (NMFS 2005). The most typical signals are long, patterned sequences of short duration (0.5 to 2 seconds) infrasonic pulses in the 18 to 35 Hz range (Patterson and Hamilton 1964). Estimated source levels are as high as 190 dB re 1 μPa (McDonald and others 1995a; Patterson and Hamilton 1964; Thompson and others 1992; Watkins and others 1987), but Charif and others (2002) estimated source levels at 159 to 184 dB re 1 μPa after correcting for the Lloyd Mirror effect. In temperate waters intense bouts of long patterned sounds are very common from fall through spring, but also occur to a lesser extent during the summer in high latitude feeding areas (Clark and Charif 1998). Short sequences of rapid pulses in the 20 to 70 Hz band are associated with animals in social groups (McDonald and others 1995a). Each pulse lasts on the order of one second and contains twenty cycles (Tyack 1999).

Particularly in the breeding season, fin whales produce series of pulses in a regularly repeating pattern. These bouts of pulsing may last for longer than one day (Tyack 1999). The seasonality and stereotype of the bouts of patterned sounds suggest that these sounds are male reproductive displays (Watkins and others 1987), while the individual counter-calling data of McDonald and others (1995a) suggest that the more variable calls are contact calls. As with other mysticete sounds, the function of vocalizations produced by fin whales is unknown. As with blue whales, the low-frequency sounds produced by fin whales have the potential to travel over long distances, and it is possible that long-distance communication occurs (Edds-Walton 1997; Payne and Webb 1971).

No studies have directly measured the sound sensitivity of fin whales. In a study of the morphology of the mysticete auditory apparatus, Ketten (1997) hypothesized that large mysticetes have acute infrasonic hearing. Southall et al. (2007) assigned fin whales to the low-frequency cetacean functional hearing group. The estimated auditory bandwidth for this group is 7 Hz to 22 kHz. As is the case for all mysticetes, they pointed out that direct data on fin whale hearing sensitivity is not available, and so it has been estimated based on behavioral responses to sounds at various frequencies, favored vocalization frequencies, body size, ambient noise levels at favored frequencies, and cochlear morphometry.

## Humpback Whale

Due to the SPLASH project (the Structure of Populations, Levels of Abundance, and Status of Humpbacks), which was conducted throughout the North Pacific in 2004-2006, a considerable amount of information is available about humpback whales in the North Pacific that was not available during our previous consultations on arctic oil and gas activities. We have reviewed the final report from this study (Calambokidis et al., 2008) and more preliminary information (from extended abstracts from the SPLASH symposium held October 11, 2009 in Quebec at the 2009 Biennial Conference of the Society of Marine Mammalogy; see the symposium final report at: http://www.cascadiaresearch.org/SPLASH/Report-Symposium-Final.pdf ). Below we focus on those aspects of available new and other information that are relevant to understanding the potential effects of the proposed action on humpback whales, the environmental baseline, cumulative effects, and the significance of such effects on this listed species.

The most recent stock assessments for the Western North Pacific and Central North Pacific stocks of humpback whales were revised February 3, 2009 (Allen and Angliss, 2010).

### ESA Listing History, Current Status, and Protective Legislation

The humpback whale was listed as an endangered species under the Endangered Species Conservation Act on June 2, 1970 (35 FR 8495). The species was then listed as endangered under the ESA in 1973. No critical habitat has been designated for humpback whales. NMFS published a Final Recovery Plan for the Humpback Whale in November 1991 (NMFS, 1991b).

The IWC banned commercial hunting of humpbacks in the Pacific Ocean in 1965 (Perry, DeMaster, and Silber, 1999b) (but see below regarding illegal whaling). All stocks of humpbacks are classified as "Protected Stocks" by the IWC.

Since listing and the prohibition on commercial harvest, the Central and Western North Pacific humpback whale populations have increased substantially. The overall increasing trend (see below) for these populations is probably at least partially the result of protective legislation enacted in both the United States and Canada during the early 1970s that resulted in reduced mortality at a time when the population was below carrying capacity. The need for a status review under the ESA was recognized during discussions at the SPLASH symposium in October 2009 (Calambokidis et al. 2009).

On May 3, 2001, NMFS (66 *FR* 29502) published a final rule that established regulations applicable in waters within 200 n.mi. of Alaska that made it unlawful for a person subject to the jurisdiction of the U.S. to approach, by any means, within 100 yd (91.4 m) of a humpback whale. To prevent disturbance that could adversely affect humpbacks and to reduce threats from whale watching activities, NMFS also implemented a "slow, safe speed" requirement for vessels transiting near humpbacks. Exemptions to the rule were for commercial-fishing vessels during the course of fishing operations; for vessels with limited maneuverability; and for State, local, and Federal vessels operating in the course of official duty.

**Population Structure and Stock Definitions**

Three stocks of humpback whales have been designated in the North Pacific based on aerial, vessel, and photo-identification surveys, as well as genetics (Allen and Angliss, 2010):

1. the California/Oregon/Washington and Mexico stock, which consists of populations that occur winter/spring in coastal Central America and coastal Mexico, and migrate to the coast of California to southern British Columbia in summer/fall;
2. the Central North Pacific stock, which consists of populations that occur winter/spring in the Hawaiian Islands, and migrate seasonally primarily to northern British Columbia, Southeast Alaska, Prince William Sound, and the Bering Sea/Aleutian Islands in summer/fall; and
3. the Western North Pacific stock, which consist of populations that occur in winter/spring off Asia and migrate seasonally primarily to Russia and the Bering Sea/Aleutian Islands in summer/fall.

Allen and Angliss (2010) recently summarized that, in the North Pacific, humpback whales are currently found throughout their historic summer feeding range, including coastal and inland waters around the Pacific Rim from Point Conception, California, north to the Gulf of Alaska and the Bering Sea and west through the Aleutian Islands to the Kamchatka Peninsula and the Sea of Okhotsk and north of the Bering Strait.

Humpback whales are known to aggregate in 3 principal wintering locations in the north Pacific during the winter, including the Hawaiian Islands, Central America (waters from southern Mexico south along the Central America coast), and Asia (off the Ogasawara Islands, Ryukyu (Okinawa) Islands, Taiwan, the Philippines, and the Mariana Islands). In the Mexican Pacific, there are 3 main winter aggregations: the central portions of the Pacific coast of mainland Mexico, the southern end of Baja California Peninsula, and the Revillagigedo Archipelago (Urban and Aguayo, 1987; Calambokidis et al., 2008).

Preliminary analyses of the genetic data from SPLASH shows a high degree of maternally-directed fidelity to both breeding and feeding grounds. However, the relationship between seasonal habitats is complex. Calambokidis et al. (2008) reported that the rate of interchange among these three principal wintering regions was relatively low. A few individuals were seen in different major regions in different years (Table 6 in Calambokidis et al., 2008). Within these three larger regions, the interchange was more complex and varied by regions.

We assume that the California/Oregon/Washington stock would not be affected by the proposed action and that it is unlikely that whales from the Central North Pacific stock would be present in the northernmost Bering Sea near Bering Strait or seasonally be present within the southwestern Chukchi Sea.

In the Northern Hemisphere, peak densities on feeding grounds occur between June and August and peak densities on wintering or breeding grounds occur in February and March (Rosenbaum and Collins (2004).

Past and current abundance in the North Pacific.—The reliability of pre- and post-commercial exploitation and of current abundance estimates is uncertain. Based on whaling records (Perry, DeMaster, and Silber, 1999b), Rice (1978b) estimated there were above 15,000 humpbacks in the North Pacific prior to commercial exploitation. It is known that Soviet whalers under-reported their takes of certain species of whales in the North Pacific (Yablokov, 1994). Johnson and Wolman (1984) and Rice (1978a) made reported rough estimates of 1,200 and 1,000, respectively, of the numbers of humpback surviving in the North Pacific after the cessation of commercial whaling for humpbacks in 1966. However, Perry, DeMaster, and Silber (1999b) caution that it is unclear whether these estimates are for the entire North Pacific or only the eastern North Pacific. With respect to the estimate of Johnson and Wohlman and another post-commercial exploitation estimate of 1,400 by Gambell (1976), Calambokidis et al. (1997) concluded that "…the methods used for these estimates are uncertain and their reliability questionable."

Calambokidis et al. (1997) estimated the abundance of humpback whales in the mid-1990s in the wintering areas to be as follows: 394 (CV = 0.084) for the Western North Pacific Humpback whale stock; 4,005 (CV = 0.095) for the entire Central North Pacific stock on the wintering grounds in Hawaii; and about 1,600-4,200 for Mexico. Based on aerial surveys of the Hawaiian Islands, Mobley et al. (2001) estimated abundance in 2000 to be 4,491 (95% CI = 3,146-5,836) with an estimated rate of increase of 7% for the period 1993-2000). Based on surveys in the eastern Bering Sea in 2000, Moore et al. (2002) provided an abundance estimate of 102 (95% CI = 40-262).

In summer feeding areas of the North Pacific stock, photo-identification studies have been conducted in several locations in Alaska. In the central Bering Sea, 315 individual humpbacks have been identified in Prince William Sound between 1977-2001 (von Ziegesar et al., 2004, as cited in Angliss and Lodge, 2004). Waite et al (1999) estimated that the annual abundance of humpbacks in the Kodiak area to be 651 (95% CI: 356-1523). Based on mark-recapture estimates of humpbacks to the west of Kodiak, Witteveen, Wayne, and Quinn (2005) estimated 410 (95% CI = 241-683) humpbacks in this area. Straley, Quinn, and Gabriele (2002) estimated that the abundance of humpback whales in Southeast Alaska is 961.

Recent abundance estimates are now available from the SPLASH project. The best estimate (Calambokidis et al. 2008:3) of abundance for humpback whales (excluding calves) for all feeding and wintering areas in the North Pacific is 18,302. This estimate, an average of the estimate for abundance of 17,558 for wintering areas and 19,056 for the feeding areas, represents "…a dramatic increase in abundance from other post-whaling estimates for the overall North Pacific" (Calambokidis et al. 2009:9). This increase is consistent with an annual rate of increase of 4.9% since the last north Pacific-wide estimates for 1991-93.

Based on SPLASH findings, more than half of the over 18,000 humpbacks are believed to winter in the Hawaiian Islands. Large numbers also winter in Mexican waters. While the overall population estimate shows increase, the estimates of humpbacks that winter in Asia and in central America are relatively low (1,000 animals or less). Estimates of the abundance of humpbacks in different feeding areas varied considerably among models used in the estimation: Russia: 100-700; Bering Sea and Aleutian Islands: 6,000-14,000; Gulf of Alaska: 3,000-5,000; combined SE AK and northern British Columbia: 3,000-5,000; southern British Columbia-Northern Washington: 200-400; California-Oregon: 1,400-1,700 (Calambokidis et al., 2008; Calambokidis, 2009 in Calambokidis et al., 2009). As these estimates are contained in reports they should be considered preliminary. We note that figures shown in Wade (2009 in Calambokidis et al. 2009) depict estimates for feeding areas that are outside of this range, one of which we show above because of the proximity to the action area.

No areas north of the southernmost portion of the western Chukchi Sea were studied during SPLASH. Thus, uncertainty remains about the likely origin of the few humpback whales that have been observed in the NE Chukchi or southwestern Beaufort Seas.

## Distribution

Humpback whales are found primarily in coastal and continental shelf waters, but are known to migrate through deep waters between tropical/sub-tropical breeding and calving habitats during the winter and temperate/polar feeding habitats during the summer. Known breeding areas in the Pacific Ocean include Japan, the Hawaiian Islands, coastal Central America and Mexico, and Revillagigedo Archipelago. Humpback whales summer throughout the central and western portions of the Gulf of Alaska, including Prince William Sound, around Kodiak Island (including Shelikof Strait and the Barren Islands), and along the southern coastline of the Alaska Peninsula, as well as the coast of California. It is believed that minimal feeding occurs in wintering grounds (Salden 1987).

Use of the Beaufort Sea and Chukchi Sea.—Data collected during barge, boat, and aerial surveys since 2006 have documented humpback whales in both the Chukchi Sea and western Beaufort Sea Planning areas, although humpback whales were not observed during either the COMIDA or BWASP surveys between 2006-2008 (Clarke et al., 2010).

In 2006, marine mammal observers reported an observation of one humpback whale in the southern Chukchi Sea outside of the Chukchi Sea Planning Area (Patterson et al., 2007; also reported in MMS' 2008 BE as "unpublished MMS marine mammal-observer reports, 2006"). During marine mammal observations conducted during barging operations, Hashagen et al. (2009) observed an adult humpback and calf on August 1, 2007 about 87 km east of Barrow in the Beaufort Sea. This pair approached to within 75 m of the vessel (Hashagen et al., 2009). They were last observed swimming east. Noting that gray whales were also observed farther east in the Beaufort than usual in 2007, and that summer 2007 sea surface temperatures in the Beaufort and Chukchi seas were about approximately 5 degrees C above normal (Steele et al., 2008), Hashagen et al. (2009) suggested that the humpbacks and gray whales may have followed warm currents into the Beaufort Sea.

In the MMS (2008) Biological Evaluation, they summarize that during the summer and early autumn of 2007 (until October 16, 2007), there were six sightings of humpback whales in the eastern and southeastern Chukchi Sea (reported as unpublished MMS marine mammal-observer reports). Another sighting was made in the southern Chukchi Sea in 2007 (Sekiguchi, In prep.).

In their summary of Chukchi Sea vessel-based monitoring during 2006-2008 seismic surveys, Haley et al. (2010: Table 3.3) reported that: no humpback whales were reported in 2006, 5 humpbacks were observed in 2007, and 1 humpback was observed in 2008. Clarke and Ferguson (2010) reported that one humpback whale was seen feeding "very near shore" on 25 July 2009 during COMIDA surveys in the Chukchi Sea. Thomas et al. (2010) did not report any sightings of humpback whales during 2006-2008 sawtooth aerial surveys in the nearshore zone down the Alaskan Chukchi Sea coast.

There are references that indicate that both the historical and current summer feeding habitat of the humpback included, and at least in some years currently includes, the southern portion, especially the southwestern portion, of the Chukchi Sea. Mizroch et al. (In prep.: 14) cited Zenkovich, a Russian biologist who wrote that in the 1930's (quote in Mizroch et al., In prep.): "The Polar Sea, in areas near Cape Dezhnev…is frequented by large schools (literally hundreds…) of fin whales, humpbacks, and grays." Mel'nikov (2000) wrote:

> In the fall, humpback whales formed aggregations in the most southern part of the Chukchi Sea, in the Senyavin Strait, and in the northern part of the Gulf of Anadyr. The whales left the area of the survey prior to the start of ice formation. Both in the past and at present, these waters are the summer feeding ground of humpback

> whales. The regular character of the encounters with the humpback whales points to signs of the restoration in their numbers in the waters off Chukchi Peninsula.

NMFS (1991a) (citing Nikulin, 1946 and Berzin and Rovnin, both in Russian), summarized that the northern Bering Sea, Bering Strait, and southern Chukchi Sea along the Chukchi Peninsula are the northern extreme of the range of the humpback. Figure 38 of the most recent stock assessment for the Western North Pacific stock (WNPS) (Allen and Angliss, 2010) depicts the southwestern Chukchi Sea as part of the “approximate distribution” of humpback whales in the North Pacific.

Available information indicates that the presence of the humpback whale in the northern Chukchi and western Beaufort Sea is recent. No sightings of humpback whales were reported during aerial surveys of endangered whales in summer (July) and autumn (August, September, and October) of 1979-1987 in the Northern Bering Sea (from north of St. Lawrence Island), the Chukchi Sea north of 66º N. and east of the International Date Line, and the Alaskan Beaufort Sea from 157º 01’ W. east to 140º W. and offshore to 72º N. (Ljungblad et al., 1988). They have not been observed during annual aerial surveys of the Beaufort Sea conducted in September and October from 1982-2008 (e.g., Clarke et al., 2010; Monnett and Treacy, 2005; Moore et al., 2000; Treacy, 2002). In addition, during a research cruise in which all marine mammals observed were recorded from July 5 to August 18, 2003, in the Chukchi and Beaufort seas, no humpback whales were observed (Bengston and Cameron, 2003).

Thus, for the purposes of our analyses, we assume that:

- Humpback whales have been observed in recent years in MMS’s Chukchi Sea Planning area and in the western Beaufort Sea.
- Humpback whales encountered in recent years in the Chukchi and Beaufort seas most likely belong to WNPS, but individual photoidentification and genetic data are needed to confirm stock origin.
- It is unlikely that humpback whales from the Central North Pacific Stock would be present in the northernmost Bering Sea near Bering Strait or seasonally be present within the southwestern, southeastern, or eastern Chukchi Sea or the western Beaufort Sea.
- Humpback whales do not tend to occur farther north, but can and do occur within the Chukchi Sea and Western Beaufort Planning Areas, and may continue to do so in the future.
- Continued arctic warming could result in changes in oceanographic conditions favorable to the distribution and abundance of humpback whale prey species, and the seasonal distribution and movements of humpback whales.

<u>Use of the Bering Sea and Gulf of Alaska Regions</u>.—In the summer, humpback whales regularly are present and feeding in areas near and within the Bering Sea and Gulf of Alaska. Available information indicates that both the Central and Western North Pacific stocks overlap in their feeding areas in the Gulf of Alaska between the Shumagin Islands and Kodiak Island (Angliss and Outlaw, 2005).

Observations by Mel'nikov (2000) of humpback whales adjacent to the Chukotka Peninsula indicate that humpbacks whales are present and feeding in the most northerly portions of the northwestern Bering Sea in the summer and autumn prior to ice formation. Thus, for purposes of our analyses, we assume that humpbacks do occur seasonally just south of the Bering Strait and that these whales are the source of those observed in the U.S. Beaufort and Chukchi seas in 2006-2009 and likely to be of the WNPS.

In the summer, humpback whales regularly are present and feeding in areas near and within the Bering Sea (e.g., Calambokidis et al., 2008, 2009). During ship surveys in the summers of 1999 and 2000, humpbacks were seen only in the central eastern Bering Sea southwest of St. Lawrence Islands and a few sightings occurred in the southeast Bering Sea, primarily north of eastern Aleutian Islands and outside of Bristol Bay (Moore et al., 2002). These sightings indicate that portions of the Bering Sea are important feeding areas for humpbacks (Moore et al., 2002). During ship surveys of 2,032 km in the eastern Bering Sea from June 5-July 3, 2004, humpback whale sightings were scattered, with most seen nearshore from Akutan Island and west along the northern coast of the Alaska Peninsula (Waite, 2004:Fig. 3). Waite (2004) reported that the most northerly humpback sighting was about 300 km north of the Pribilof Islands. Thus, for the purposes of our analyses, we assume that humpbacks do occur seasonally just south of the Bering Strait, and that they transit between the Chukchi and Bering seas through the Bering Strait in the summer and autumn.

Within the Gulf of Alaska region, evidence indicates that portions of the Kodiak Archipelago area, including the area off Albatross Banks (Waite et al., 1999; Witteveen, Wynne, and Quinn, 2005; Wynne and Witteveen, 2005); Prince William Sound; the Barren Islands (Sease and Fadely, 2001); and adjacent waters are important feeding areas for humpback whales.

Portions of Southeast Alaska, including but not limited to Glacier Bay, Icy Strait, and Frederick Sound, are also important feeding habitat for humpback whales with abundance peaking in late summer. Most, but not all, of these whales winter in Hawaii.

**Reproduction, Survival, and Non-Human Related Sources of Mortality**
Humpbacks give birth and presumably mate on their wintering ground. Calving in the Northern Hemisphere takes place between January and March (Johnson and Wolman, 1984). Information about age of sexual maturity is of uncertain reliability (Perry, DeMaster, and Silber, 1999b). While calving intervals very substantially, most female humpbacks typically calve at 1- to 2-year intervals (Glockner-Ferrari and Ferrari, 1990; Straley, 1994). Gestation is about 12 months, and calves probably are weaned after about a year (Rice, 1967; Perry, DeMaster, and Silber, 1999b).

Causes of natural mortality in humpbacks in the North Pacific are relatively unknown, and rates have not been estimated. There are documented attacks by killer whales on humpbacks, but their known frequency is low (Whitehead, 1987; Perry, DeMaster, and Silber, 1999b). Lambertsen (1992) cited giant nematode infestation as a potential factor limiting humpback recovery.

Based on sighting histories of individually identified female humpback in the North Pacific compiled between 1979 and 1995, Gabriele et al. (2001) calculated minimal and maximal estimates of humpback whale calf survival in the North Pacific of 0.150 (95% confidence intervals = 0.032, 0.378) and 0.241 (95% confidence intervals = 0.103, 0.434), respectively.

**Feeding**

Humpbacks tend to feed on summer grounds and to not eat on winter grounds. However, some low-latitude winter feeding has been observed and is considered opportunistic (Perry, DeMaster, and Silber, 1999b). They engulf large volumes of water and then filter small crustaceans and fish through baleen plates. Humpbacks are relatively generalized in their feeding. In the Northern Hemisphere, known prey include: euphausiids (krill); copepods; juvenile salmonids (*Oncorhynchus* spp.); Arctic cod (*Boreogadus saida*); walleye pollock (*Theragra chalcogramma*); pollock (*Pollachius virens*); pteropods; and cephalopods (Johnson and Wolman, 1984; Perry, DeMaster, and Silber, 1999b).

**Diving and Social Behavior**

Maximum diving depths for humpbacks are approximately 150 m (492 ft) (but usually <60 m or 197 ft), with a very deep dive (240 m or 787 ft) recorded off Bermuda (Hamilton and others 1997). They may remain submerged for up to 21 min (Dolphin 1987). In southeast Alaska average dive times were 2.8 min for feeding whales, 3.0 min for non-feeding whales, and 4.3 min for resting whales (Dolphin 1987). In the Gulf of California humpback whale dive times averaged 3.5 min (Strong 1990). Because most humpback prey is likely found in waters shallower than 300 m most humpback dives are probably relatively shallow. Clapham (1996) reviewed the social behavior of humpback whales. They form small unstable groups during the breeding season. During the feeding season they form small groups that occasionally aggregate on concentrations of food. Feeding groups are sometimes stable for long periods of times. There is good evidence of some territoriality on feeding grounds (Clapham 1994; 1996), and on wintering grounds (Tyack 1981). On the breeding grounds males sing long complex songs directed towards females, other males or both.

**Vocalizations and Hearing**

Humpbacks produce a wide variety of sounds and are a particularly vocal species. During the breeding season males sing long, complex songs, with frequencies in the 25 to 5000 Hz range and intensities as high as 181 dB (Payne 1970; Thompson et al 1986). Source levels average 155 dB and range from 144 to 174 dB (Thompson et al. 1979). The songs appear to have an effective range of approximately 10 to 20 km (six to 12 mi). Animals in mating groups produce a variety of sounds (Silber 1986; Tyack 1981; Tyack and Whitehead 1983). Sounds are produced less frequently on the summer feeding grounds. Feeding groups produce distinctive sounds ranging from 20 Hz to 2 kHz, with median durations of 0.2 to 0.8 sec and source levels of 175 to 192 dB (Thompson and others 1986). Social sounds (Payne 1978a, b) include non-song vocal signals and surface generated signals such as tail-slapping and breaching (Dunlop et al. 2009). Dunlop et al. (2009) summarized that humpback vocalizations probably transmit information such as the identity of the signaler (species and sex) social and behavioral context, signaler location and size, and selection criteria and social integration.

As is the case for all large baleen whales, direct information about the hearing abilities of humpback whales is not available. In a study of the morphology of the mysticete auditory apparatus, Ketten (1997) hypothesized that large mysticetes have acute infrasonic hearing. Southall et al. (2007) assigned humpback whales to the low-frequency cetacean functional hearing group. This group has an estimated auditory bandwidth of 7 Hz to 22 kHz. The estimated auditory bandwidth for this group is 7 Hz to 22 kHz. However, Southall et al. (2007) also note that the harmonics of some humpback signals extend above 24 kHz. As is the case for all mysticetes, they pointed out that direct data on humpback whale hearing sensitivity is not available, and so it has been estimated based on behavioral responses to sounds at various frequencies, favored vocalization frequencies, body size, ambient noise levels at favored frequencies, and cochlear morphometry.

## III. ENVIRONMENTAL BASELINE

For the purposes of interagency consultations under Section 7 of the ESA, the environmental baseline is defined to include the past and present impacts of all Federal, State, or private actions and other human activities in an action area, the anticipated impacts of all proposed Federal projects in an action area that have already undergone formal or early Section 7 consultation, and the impact of State or private actions that are contemporaneous with the consultation in process [50 CFR §402.02].

The following factors, other than the proposed action, have had or are having potential effects on all or some of these endangered species of whales:

historic commercial whaling;
subsistence hunting;
oil- and gas-related activities;
non-oil and gas industrial development within the range of the bowhead;
research activities;
marine vessel-traffic and commercial-fishing;
pollution and contaminants; and
climate change.

There are no data available that indicate that, other than historic commercial whaling, any previous human activity has had a significant adverse effect at the population-level on the Western Arctic stock of bowheads or their recovery. The uncertainty of the stock structure adds some uncertainty to the status of bowhead populations that may be affected by the proposed actions. However, currently available information indicates that at the population level, bowheads using the Beaufort and Chukchi Sea Planning Areas are resilient at least to the level of human-caused mortality and disturbance that currently exists within their range, and has existed since the cessation of commercial whaling.

Data indicate that at least some bowheads are extremely long-lived (100+ years or more). Thus, many of the individuals in this population may already have been exposed to a high number of disturbance events in their lifetimes. The primary known current human-related cause of mortality in bowheads is a regulated subsistence hunt by Alaska Natives, which occurs at different times of the year in many of the coastal portions of its range. The existence of the bowhead hunt has focused Native, local, state, federal, international, and industry research and monitoring attention on this stock and the development of mitigation measures intended to ensure the stock's continued availability for subsistence take adequate to meet the needs of bowhead-hunting Native communities. Since the level of take is directly linked to the population abundance and status of this population, protection of the availability of whales for subsistence take is linked to protection needed to ensure the long-term viability of the population. Whether there are long-lasting behavioral effects from this activity is unknown, but overall habitat use appears to be relatively unaffected.

**Historical Commercial Whaling**

It is clear that commercial whaling between 1848 and 1915 was the human activity that had the greatest adverse effect on this population. Commercial whaling severely depleted bowhead whales. Woodby and Botkin (1993) estimated that the historic abundance of bowheads in this population was between 10,400 and 23,000 whales in 1848, before the advent of commercial whaling. Woodby and Botkin (1993) estimated between 1,000 and 3,000 animals remained in 1914, near the end of the commercial-whaling period. Commercial whaling also may have caused the extinction of some subpopulations and some temporary changes in distribution. Following protection from whaling, this population (but not some other bowhead populations) has shown marked progress toward recovery. Thus current population size is within the lower bounds of estimates of the historic population size.

**Subsistence Hunting**

Indigenous peoples of the arctic and subarctic regions of what is now Alaska have been hunting bowhead whales for at least 2,000 years (Stoker and Krupnik, 1993). Thus, subsistence hunting is not a new contributor to cumulative effects on this population. There is no indication that, prior to commercial whaling, subsistence whaling caused significant adverse effects at the population level. However, modern technology has changed the potential for any lethal hunting of this whale to cause population-level adverse effects if unregulated. Under the authority of the IWC, the subsistence take from this population has been regulated by a quota system since 1977. Federal authority for cooperative management of the subsistence hunt by Alaska natives is shared with the Alaska Eskimo Whaling Commission (AEWC) through a cooperative agreement between the AEWC and the United States Department of Commerce, National Oceanic and Atmospheric Administration (NOAA).

The sustainable take of bowhead whales by indigenous hunters represents the largest known human-related cause of mortality in this population at the present time. Available information suggests that it is likely to remain so for the foreseeable future. While there are other anthropogenic factors that have the potential to cause, or to be related to, behavioral or sublethal adverse effects to this population, or to cause the deaths of a small number of individuals, little or no evidence exists of other common human-related causes of mortality. Subsistence take, which all available evidence indicates is sustainable, monitored, managed, and regulated, helps to determine the resilience of the population to other impacts that could potentially cause lethal takes.

Currently, Alaskan Native hunters from 10 villages harvest bowheads for subsistence and cultural purposes under a quota authorized by the IWC. Chukotkan Native whalers from Russia also are authorized to harvest bowhead whales under the same authorized quota. The status of the population is closely monitored, and these activities are closely regulated. Strike limits are established by the IWC and set at a 5-year quota of 280 landings. The sustained growth of the Western Arctic bowhead population indicates that the level of subsistence take has been sustainable. Because the quota for the hunt is tied to the population size and population parameters, it is unlikely this source of mortality will contribute to a significant adverse effect on the recovery and long-term viability of this population.

There are adverse impacts of the hunting to bowhead whales in addition to the death of animals that are successfully hunted and the serious injury of animals that are struck but not immediately killed. Available evidence indicates that subsistence hunting causes disturbance to the other whales, changes in their behavior, and sometimes temporary effects on habitat use, including migration paths. Modern subsistence hunting represents a source of noise and disturbance to the whales. Whales in the vicinity of a struck whale could be disturbed by the sound of the explosive used in the hunt, the boat motors, and any sounds made by the injured whale. NMFS (2003a) pointed out that whales that are not struck or killed may be disturbed by noise associated with the approaching hunters, their vessels, and the sound of bombs detonating: "…the sound of one or more bombs detonations during a strike is audible for some distance. Acousticians, listening to bowhead whale calls as part of the census, report that calling rates drop after such a strike …" (NMFS, 2003). We are not aware of data indicating how far hunting-related sounds (for example, the sounds of vessels and/or bombs) can propagate in areas where hunting typically occurs, but this is likely to vary with environmental conditions. It is not known if whales issue an "alarm call" or a "distress call" after they, or another whale, are struck.

NMFS (2003) reported that:

> . . . whales may act skittish" and wary after a bomb detonates, or may be displaced further offshore (E. Brower, pers. com.). However, disturbances to migration as a result of a strike are temporary (J. George, 1996), as evidenced when several whales may be landed at Barrow in a single day. There is some potential that migrating whales, particularly calves, could be forced into thicker offshore ice as they avoid these noise sources. The experience of Native hunters suggests that the whales would be more likely to temporarily halt their migrations, turn 180 degrees away…(i.e., move back through the lead systems), or become highly sensitized as they continue moving (E. Brower, pers. com.).

Because evidence indicates that bowhead whales are long-lived, some bowhead whales may have been in the vicinity where hunting was occurring on multiple, perhaps dozens or more, occasions. Thus, some whales may have cumulative exposure to hunting activities. This form of noise and disturbance adds to noise and disturbance from other sources, such as shipping and oil and gas-related activities. To the extent such activities occur in the same habitats during the period of whale migration, even if the activities (e.g., hunting and shipping) themselves do not occur simultaneously, cumulative effects from all noise and disturbance could affect whale habitat use. However, we are not aware of information indicating long-term habitat avoidance has occurred with present levels of activity. Additionally, if whales become more "skittish" and more highly sensitized following a hunt, it may be that their subsequent reactions, over the short-term, to other forms of noise and disturbance are heightened by such activity. Data are not available that permit evaluation of this possible, speculative interaction.

### Commercial-Fishing, Marine Vessel-Traffic, and Research Activities

Based on available data, previous incidental take of bowhead whales apparently has occurred only rarely. The bowhead's association with sea ice limits the amount of fisheries activity occurring in bowhead habitat. However, the frequency of such interactions in the future would be expected to increase if commercial-fishing activities expand northward. There is some uncertainty about whether such expansion will occur. Increases in spatial overlap alone could result in increased interactions between bowheads and derelict fishing gear. In a discussion of population climate warming impacts on bowheads at the meeting of the Subcommittee on Bowheads, Right Whales and Gray Whales at the IWC's annual meeting, P. Wade (referred to in IWC, 2005b) reported that that the commercial crab fishery extended further north the previous winter (winter 2004-2005) than in previous years.

Between 1989 and 1994, logbook data on incidental take of bowheads are available, but after that time, the requirement is for fishers to self report. Angliss and Lodge (2002) reported that ". . . the records are considered incomplete and estimates of mortality based on them represent minimums." There are no observer program records of bowhead whale mortality incidental to commercial fisheries in Alaska (Angliss and Lodge, 2002). New information on entanglements of bowhead whales indicates that bowheads do have interactions with crab-pot gear. There have been two confirmed occurrences of entanglement in crab-pot gear, one in 1993 and one in 1999 (Angliss and Lodge, 2008). Table 41 in Angliss and Lodge (2008) details reports of scarring of bowhead whales attributed to entanglement in ropes. Citing a personal communication from Craig George of the NSB, Department of Wildlife Management, Angliss and Lodge (2008) report a preliminary result from reexamination of bowhead harvest records suggest that there may be more than 20 cases indicating entanglements or scarring attributable to ropes in the bowhead harvest records. Angliss and Lodge (2008) reported that the annual rate of bowhead entanglement in marine debris/gear for the period 2003-2008 is 0.4.

Potential effects on bowhead whales from commercial-fishing activities include incidental take in the fisheries and/or entanglement in derelict fishing gear resulting in death, injury, or effects on the behavior of individual whales; disturbance resulting in temporary avoidance of areas; and whales being struck and injured or killed by vessels. Bowheads have been entangled in ropes from crab pots, harpoon lines, or fishing nets; however, the frequency of occurrence is not known.

Marine vessel traffic, in general, can pose a threat to bowheads because of the risk of ship strikes. Shipping and vessel traffic is expected to increase in the arctic if warming continues. No substantial increase in shipping and vessel traffic is expected to occur during the limited duration of the IHAs that are the subject of this biological opinion. Additionally, noise associated with ships or other boats potentially could cause bowheads to alter their movement patterns or make other changes in habitat use. Pollution from marine vessel traffic, especially from large vessels such as large cruise ships, also could cause degradation of the marine environment and increase the risk of the whales' exposure to contaminants and disease vectors. The frequency of observations of vessel-inflicted injuries suggests that the incidence of ship collisions with bowhead whales is low but may be increasing. Between 1976 and 1992, only three ship-strike injuries were documented out of a total of 236 bowhead whales examined from the Alaskan subsistence harvest (George et al. 1994). The low number of observations of ship-strike injuries suggests that bowheads either do not often encounter vessels, or they avoid interactions with vessels, or that interactions usually result in the animals' death.

Increased use of vessels for ice management associated with oil and gas exploration may present concerns for bowhead whales. During icebreaking, extremely variable increases in broad-band (10-10,000 Hz) noise levels of 5-10 dB are caused by propeller cavitation. Richardson et al. (1995a) reported estimated source levels for icebreakers to range from 177-191 db re 1 μPa-m. Based on previous studies of bowhead response to noise, such sound could result in temporary avoidance of animals from the areas where the icebreakers were operating and potentially cause temporary deflection of the migration corridor, depending of the location of the icebreakers. Richardson et al. (1995) concluded that: "Ships and larger boats routinely use fathometers, and powerful side-looking sonars are common on many military, fishing, and bottom-survey vessels…. Sounds from these sources must often be audible to marine mammals and apparently cause disturbances in some situations."

Active sonars were used in commercial whaling after World War II, and whaling boats sometimes tracked whales underwater using active sonar. Ash (1962), cited in Richardson et al., 1995a) reported that this often caused strong avoidance by baleen whales. Reeves (1992) reported that ultrasonic pulses were used to scare baleen whales to the surface. Maybaum (1990, 1993) reported that humpback whales on the wintering grounds moved away from 3.3 kHz sonar pulses and increased their swimming speed and swim-track linearity in response to 3.1- to 3.6-kHz sonar sweeps. We have no information that active sonar is currently an issue within the action area.

Large research ships that are active in the range of the bowheads during periods when they are present have the potential to cause noise and disturbance to the whales, potentially altering their movement patterns or other behavior. However, available evidence does not indicate such disturbance will have a significant effect on this population over the approximate life of the project, even when added to the effects of other effectors. The Western Arctic bowhead has been the focus of research activities that could, in some instances, cause minor temporary disturbance of the whales. During research on the whales themselves, the reactions of the whales generally are closely monitored to minimize potential adverse effects. Additionally, research conducted primarily for reasons other than the study of the bowhead has also occurred within the range of the bowhead. In some cases, such research has the potential to adversely affect the whales through the introduction of additional noise, disturbance, and low levels of pollution into their environment.

### Pollution and Contaminants

Initial studies of bowhead tissues collected from whales landed at Barrow in 1992 (Becker et al., 1995) indicate that bowhead whales have very low levels of mercury, PCB's, and chlorinated hydrocarbons, but they have fairly high concentrations of cadmium in their liver and kidneys. The study concluded that the high concentration of cadmium in the liver and kidney tissues of bowheads warrants further investigation. Becker (2000) noted that concentration levels of chlorinated hydrocarbons in bowhead whale blubber generally are an order of magnitude less than what has been reported for beluga whales in the arctic. This probably reflects the difference in the trophic levels of these two species; the bowhead being a baleen whale feeding on copepods and euphausiids, while the beluga whale being toothed whale feeding at a level higher in the food web. The concentration of total mercury in the liver also is much higher in beluga whales than in bowhead whales.

Bratton et al. (1993) measured organic arsenic in the liver tissue of one bowhead whale and found that about 98% of the total arsenic was arsenobetaine. Bratton et al. (1997) looked at eight metals (arsenic, cadmium, copper, iron, mercury, lead, selenium, and zinc) in the kidneys, liver, muscle, blubber, and visceral fat from bowheads harvested from 1983-1990. They observed considerable variation in tissue metal concentration among the whales tested. Metal concentrations evaluated did not appear to increase over time between 1983 and 1990. Based on metal levels reported in the literature for other baleen whales, the metal levels observed in all tissues of the bowhead are similar to levels in other baleen whales. The bowhead whale has little metal contamination as compared to other arctic marine mammals, except for cadmium, which requires further investigation as to its role in human and bowhead whale health. The study recommended limiting the consumption of kidney from large bowhead whales pending further evaluation.

Cooper et al. (2000) analyzed anthropogenic radioisotopes in the epidermis, blubber, muscle, kidney, and liver of marine mammals harvested for subsistence food in northern Alaska and in the Resolute, Canada region. The majority of samples analyzed had detectable levels of $^{137}Cs$. Among tissues of all species of marine mammals analyzed, $^{137}Cs$ was almost always undetectable in the blubber and significantly higher in epidermis and muscle tissue than in the liver and kidney tissue. The levels of anthropogenic radioisotopes measured were orders of magnitude below levels that would merit public health concern. The study noted there were no obvious geographical differences in $^{137}Cs$ levels between marine mammals harvested in Resolute, Canada and those from Alaska. However, the $^{137}Cs$ levels in marine mammals were two to three orders of magnitude lower than the levels reported in caribou in northern Canada and Alaska.

Based on the use of autometallography (AMG) to localize inorganic mercury in kidney and liver tissues for five bowhead whales, Woshner et al. (2002) reported that "AMG granules were not evident in bowhead tissues, confirming nominal mercury (Hg) concentrations." Detected concentrations ranged from 0.011-0.038 micrograms per gram (µg/g) wet weight for total mercury. Mössner and Ballschmiter (1997) reported that total levels of 310 nanograms per gram (ng/g) polychlorinated biphenyls and chlorinated pesticides in bowhead blubber from the North Pacific/Arctic Ocean, an overall level many times lower than that of other species from the North Pacific or Arctic Ocean (beluga whales [2,226 ng/g]; northern fur seals [4,730 ng/g]) and than that of species from the North Atlantic (pilot whale [6,997 ng/g]; common dolphin [39,131 ng/g]; and harbor seal [70,380 ng/g]). However, while total levels were low, the combined level of 3 isomers of the hexachlorocyclohexanes was higher in the bowhead blubber (160 ng/g) tested than in either the pilot whale (47 ng/g), the common dolphin (130 ng/g), and the harbor seal (140 ng/g). These results confirmed results expected due to the lower trophic level of the bowhead relative to the other marine mammals tested.

In the Beaufort Sea multiple-sale EIS in 2003, MMS concluded that the levels of metals and other contaminants measured in bowhead whales appear to be relatively low, with the exception of cadmium. Since the finalization of the multiple-sale EIS, additional information (included in the review presented above) on contaminants in Western Arctic bowheads has become available. This information supports this same general conclusion.

### Offshore Oil- and Gas-Related Activities and other Industrial Activities

Offshore petroleum exploration, development, and production activities have been conducted in Alaska State waters or on the Alaska OCS in the Beaufort and Chukchi seas as a result of previous lease sales since 1979. Extensive 2D seismic surveying has occurred in both program areas. The MMS-permitted seismic surveys have been conducted in the Chukchi and Beaufort seas since the late 1960's and early 1970's. Much more seismic activity has occurred in the Beaufort Sea OCS than in the Chukchi Sea OCS. The 2D marine seismic surveys in the Beaufort Sea began with two exploration geophysical permits issued in 1968 and 4 in 1969. Both over-ice (29 permits) and marine 2D (43 permits) seismic surveys were conducted in the 1970's. With one exception, all 80 marine and 43 over-ice surveys permitted in the Beaufort Sea OCS by MMS in the 1980's were 2D. In the Beaufort Sea, 23 MMS G&G permits were issued in 1982 (11 marine and 12 over-ice 2D surveys) and 24 MMS G&G permits were issued in 1983 (1, 3D over-ice survey; 14, 2D over-ice surveys; and, 9, 2D marine surveys). The first 3-D on-ice survey occurred in the Beaufort Sea OCS in 1983. In the 1990's, both 2D (2 on-ice and 21 marine) and 3D (11 over-ice and 7 marine OBC) seismic surveys were conducted in the

Beaufort Sea. The first marine 3D seismic survey in the Beaufort Sea OCS occurred in 1996.

Thirty exploratory wells have been drilled in the Federal Beaufort over a 20+ year period between 1981 and 2002. This drilling occurred from a variety of drilling platforms (e.g., gravel islands, SSDC, drillships, etc.) and, during different seasons of the year, including the open water period. The last exploration well drilled in the Beaufort Sea OCS was drilled in the winter of 2002 at the McCovey prospect.

Compared to the North Slope/Beaufort Sea, there has been little oil- and gas-related activity in the Chukchi Sea. There is no existing OCS offshore development or production in the Chukchi Sea. Outer Continental Shelf Lease Sale 193 (Chukchi Sea OCS planning area) was held on February 6, 2008. Sale 193 offered approximately 12 million acres for leasing, and bids were received for over 1,100,000 acres. Five exploratory wells have been drilled in the Chukchi Sea from past lease sales, all using drillships. These wells were drilled between 1989 and 1991, inclusive. The last Chukchi Sea well was drilled in 1991 at the Diamond Prospect.

Many offshore activities also require ice management (icebreaking), helicopter traffic, fixed wing monitoring, other support vessels, and, in some cases stand-by barges.

Available information does not indicate that oil-and gas-related activities (or any recent activity) have had detectable long-term adverse population-level effects on the overall health, current status, or recovery of the Western Arctic population. Data indicate that the Western Arctic population has continued to increase over the timeframe that oil and gas activities has occurred. There is no evidence of long-term displacement from habitat. However, there are no long-term oil and gas developments in the offshore within bowhead high use areas. Northstar Island (an oil production facility) is at the southern end of the migratory corridor and Endicott (a near-shore oil facility) is within the barrier islands. Past behavioral (primarily, but not exclusively, avoidance) effects on bowhead whales from oil and gas activity have been documented in many studies. Inupiat whalers have stated that noise from seismic surveys and some other activities at least temporarily displaces whales farther offshore, especially if the operations are conducted in the main migration corridor. As noted in the section on effects, recent monitoring studies indicated that fall migrating whales avoid an area with a radius about 20-30 km around a seismic vessel operating in nearshore waters, and that bowhead calling rates are negatively associated with proximity to active seismic vessels. We are not aware of data that indicate that such avoidance is long-lasting after cessation of the activity.

The MMS study 2002-071 titled GIS Geospatial Data Base of Oil-Industry and Other Human Activity (1979-1999) in the Alaskan Beaufort Sea provided a compilation of available data on the location, timing, and nature of oil- and gas-related activities from 1979-1999. It was intended to provide a ". . . database to address concerns expressed by subsistence hunters and others living within . . . villages of the Beaufort Sea about the possible effects that oil and gas activity, particularly seismic activity, drilling, and oil and gas support vessel activities may have on the behavior of . . . especially the bowhead whale." However, "[S]uch an analysis requires an adequate level of detail . . .", ". . . there are significant gaps in the data for the period 1979-1989" (Wainwright, 2002) and "[V]ery limited information was obtained on ice management" (Wainwright, 2002). For all but 2 years, 1985-1986, during the period 1979-1989, inclusive, Wainwright (2002) assessed the availability of information about 2D/3D seismic surveys conducted under OCS permit as a 0 out of a possible 3. This score of 0 indicates: "Significant data sets are missing. These data are not suited for statistical analysis." During this same period, they also provide a rank of 0 out of 3 to categorize the completeness and adequacy of information on seismic surveys under state MLUP permit. For the entire period of study (1979-1998), they rate the completeness and adequacy of information on seismic and acoustic surveys in State waters without permits, ice management, and other vessel activity all as 0. Thus, while data on the bowhead status are adequate to determine that the Western Arctic population apparently continued to recover during the periods when past and current levels of oil and gas activities were occurring, we cannot adequately assess potential effects on patterns or durations of bowhead habitat use. Wainwright (2002) summarized that ". . . it was not possible to compile adequate data on seismic activity prior to 1990." Because of the inadequacy of the data on activities, and because of the limitations inherent in studying large baleen whales, we also cannot assess whether there were any adverse health effects to individuals during the period of relatively intensive seismic survey activity in the 1980s.

Data on past drilling in both federal and state waters is relatively complete, especially since 1990. Data on other activities, such as hunting activity, barge traffic, and shipping noise are incomplete. Thus, while it is clear there have been multiple noise and disturbance sources in the Beaufort Sea over the past 30 years, because of the incompleteness of data, even for the 1990s, for many types of activities, we cannot evaluate the totality of past effects on fin, humpback, or bowhead whales resulting from multiple noise and disturbance sources (e.g., 2D seismic in state and federal waters, drilling, ice-management, high-resolution acoustic surveys, vessel traffic, construction, geotechnical bore-hole drilling, aircraft surveys, and hunting).

### Climate Change

There is now widespread consensus within the scientific community that atmospheric temperatures on earth are increasing (warming) and that this will continue for at least the next several decades. There is also consensus within the scientific community that this warming trend will alter current weather patterns. The strongest warming is expected in the north, exceeding the estimate for mean global warming by a factor or 3, due in part to the "ice-albedo feedback", whereby as the reflective areas of arctic ice and snow retreat, the earth absorbs more heat, accentuating the warming (NRC 2003). The proximate effects of climate change in the arctic are being expressed as increased average winter and spring temperatures and changes in precipitation amount, timing, and type (Serreze et al. 2000). These changes in turn result in physical changes such as reduced sea ice, increased coastal erosion, changes in hydrology, depth to permafrost, and carbon availability (ACIA 2005).

The Intergovernmental Panel on Climate Change (IPCC) concluded in its synthesis report (IPCC 2007a), as part of its Fourth Assessment Report (IPCC 2007b), that:

- Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level.
- Global GHG [greenhouse gas] emissions due to human activities have grown since pre-industrial times, with an increase of 70% between 1970 and 2004.
- Most of the observed increase in global average temperatures since the mid-20th century is very likely due to the observed increase in anthropogenic GHG concentrations.
- There is now higher confidence than in the Third Assessment Report in projected patterns of warming and other regional-scale features, including changes in wind patterns, precipitation and some aspects of extremes and sea ice.

IPCC (2007b) reports that warming will be greatest over land and at most high northern latitudes. They also predict the continuation of recent observed trends such as contraction of snow cover area, increases in thaw depth over most permafrost regions, and decrease in sea ice extent. Projected surface temperature changes along the North Slope of Alaska may increase 6.0-6.5 ºC for the late 21st century (2090-2099), relative to the period 1980-1999 (IPCC 2007b).

The IPCC's projections using the Special Reports on Emissions Scenarios (SRES) emissions scenarios in a range of climate models result in an increase in globally averaged surface temperature of 1.4-5.8 ºC over the period 1990-2100 (IPCC 2007a). This is about 2-10 times larger than the central value of observed warming over the 20$^{th}$ century, and the projected rate of warming is very likely to be without precedent during at least the last 10,000 years, based on paleoclimate data.

A general summary of the changes attributed to the current trends of arctic warming indicate sea ice in the Arctic is undergoing rapid changes. There are reported changes in sea-ice extent, thickness, distribution, age, and melt duration. In general, the sea-ice extent is becoming much less in the arctic summer and slightly less in winter. The thickness of arctic ice is decreasing. The distribution of ice is changing, and its age is decreasing. The melt duration is increasing. These factors lead to a decreasing perennial arctic ice pack. It is generally thought that the Arctic will become ice free in summer, but at this time there is considerable uncertainty about when that will happen.

Predictions of future sea-ice extent, using several climate models and taking the mean of all the models, estimate that the Arctic will be ice free during summer in the latter part of the 21$^{st}$ century (IPCC, 2007a). There is considerable uncertainty in the estimates of summer sea ice in these climate models, with some predicting 40-60% summer ice loss by the middle of the 21$^{st}$ century (Holland, 2006). Using a suite of models, a 40% loss is estimated for the Beaufort and Chukchi seas (Overland and Wang, 2007). Some investigators, citing the current rate of decline of the summer sea-ice extent believe it may be sooner than predicted by the models, and may be as soon as 2013 (Stroeve et al., 2007).

Other investigators suggest that variability at the local and regional level is very important for making estimates of future changes.

> The sea ice was gone; there's no main ice pack anymore. All of its just floating ice. There are just small pieces of ice. When I first went out whaling, I saw big icebergs, but not now. The ice is too far out to see it. In the 1970s and 1980s the ice was close. You didn't have to go far to see it. Now you don't see any glacier ice at all. (Footnote 8, personal interview, October 5, 2004, as cited by McBeath and Shepro, 2007).

The extent of winter sea ice, generally measured at the maximum in March, began changing in the late 1990's and has declined through 2009 (Comiso, 2006; Stroeve et al., 2007; Francis and Hunter, 2007; National Snow and Ice Data Center, 2009). Comiso (2006) attributed the changes to corresponding changes in increasing surface temperature and wind-driven ice motion. The factors causing the reduction in the winter sea-ice extent are different from those in the summer. The reduction of the winter sea-ice extent in the Bering Sea preconditions the environment during the melt season for the Chukchi Sea. The end-of-winter perennial sea ice extent was the smallest on record in March 2007 (Nghiem et al., 2007). The six lowest maximum Arctic sea ice extents since 1979 occurred 2004 to 2009 (National Snow and Ice Data Center, 2009). The 2009 maximum extent was the fifth-lowest maximum extent in the satellite record (National Snow and Ice Data Center, 2009).

While changes in the reduction of summer sea-ice extent are apparent, the cause(s) of change are not fully established. The evidence suggests that it may be a combination of oceanic and atmospheric conditions that are causing the change. Incremental solar heating and ocean heat flux, longwave radiation fluxes, changes in surface circulation, and less multiyear sea ice all may play a role.

These changes are resulting, or are expected to result, in changes to the biological environment, causing shifts, expansion, or retraction of home range, changes in behavior, and changes in population parameters of plant and animal species. Much research in recent years has focused on the effects of naturally-occurring or man-induced global climate regime shifts and the potential for these shifts to cause changes in habitat structure over large areas. Although many of the forces driving global climate regime shifts may originate outside the Arctic, the impacts of global climate change are exacerbated in the Arctic (ACIA 2005). Temperatures in the Arctic have risen faster than in other areas of the world as evidenced by glacial retreat and melting of sea ice. Threats posed by the direct and indirect effects of global climatic change are or will be common to Northern species. These threats will be most pronounced for ice-obligate species such as the polar bear, walrus, and ringed seal.

However, not all arctic species are likely to be adversely influenced by global climate change. Conceptual models by Moore and Laidre (2006) suggested that, overall, reductions in sea ice cover should increase the Bering-Chukchi-Beaufort Sea stock of bowhead whale prey availability. This theory may be substantiated by the steady increase in the BCBS population during the nearly 20 years of sea ice reductions (Walsh, 2008).

Moore and Huntington (2008) anticipate that bowhead whales will alter migration routes and occupy new feeding areas in response to climate related environmental change. Sheldon et al. (2003) notes that there is a high probability that bowhead abundance will increase under a warming global climate. NMFS's Marine Mammal Laboratory has stated that there are insufficient data to make reliable predictions of the effects of Arctic climate change on bowhead whales (Angliss and Outlaw, 2008). Given the short duration of the IHAs, and our expectation that the principal effects will be temporary disturbance of whales, any adverse effects of Arctic climate change on bowhead whales would not be expected to have cumulative effects that would change the conclusions reached in this opinion.

The recent observations of humpback whales in the Beaufort and Chukchi seas may be indicative of seasonal habitat expansion in response to receding sea ice or increases in prey availability which these whales now exploit. Range expansions in response to habitat change are not uncommon among cetaceans. Gray whales in Alaska have shown pronounced change over the last several decades; overwintering at higher latitudes and occupying previously lesser-used feeding areas in the Beaufort Sea. Concentrations of the rare North Pacific right whale were first observed in the southeast Bering Sea in 1996 and have continued until recently, possibly reflecting changes in zooplankton distribution due to large-scale oceanographic change within the Bering Sea. Since humpback whales are not ice-obligate or ice-associated species, it is unknown how long this habitat will remain viable for the species. However, it is logical to assume these whales will continue to utilize these waters as long as the availability of prey remains.

## IV. EFFECTS OF THE ACTION

The primary concern associated with the impacts of the proposed actions on these endangered whales has to do with potential impacts due to noise. Exposure to anthropogenic noise may affect these whales by impacting their hearing (temporary threshold shifts or permanent threshold shifts indicating mechanical damage to the ear structure), by masking whale communications, or affecting their behavior (harassment).

There is still uncertainty about the potential impacts of sound on marine mammals, on the factors that determine response and effects, and especially, on the long-term cumulative consequences of increasing noise in the world's oceans from multiple sources (e.g., NRC, 2003, 2005). The NRC (2005) Committee on Characterizing Biologically Significant Marine Mammal Behavior concluded that it is unknown how or in what cases responses of marine mammals to anthropogenic sound rise to the levels of biologically significant effects. All of this specificity greatly complicates our ability, in a given situation, to predict the impacts of sound on a species or on classes of individuals within a species. While there is some general information available, evaluation of the impacts of noise on marine mammal species, particularly on cetaceans, is greatly hampered by a considerable uncertainty about their hearing capabilities and the range of sounds used by the whales for different functions (Richardson et al., 1995a; Gordon et al., 1998; NRC, 2003, 2005). This is particularly true for baleen whales. Very little is known about the actual hearing capabilities of the large whales or the impacts of sound on them, especially physical effects. While research in this area is increasing, it is likely that we will continue to have great uncertainty about physiological effects on baleen whales because of the difficulties in studying them. Baleen whale hearing has not been studied directly. There are no specific data on sensitivity, frequency or intensity discrimination, or localization (Richardson et al., 1995a). Thus, predictions about probable impact on baleen whales generally are based on assumptions about their hearing rather than actual studies of their hearing (Richardson et al., 1995a; Gordon et al., 1998; Ketten, 1998). Ketten (1998) summarized that the vocalizations of most animals are tightly linked to their peak hearing sensitivity. Hence, it is generally assumed that baleen whales hear in the same range as their typical vocalizations, even though there are no direct data from hearing tests on any baleen whale. Most baleen whale sounds are concentrated at frequencies less than 1 kHz, but the frequency range in bowhead songs can approach 4,000 Hz (Richardson et al., 1995a). Most calls emitted by bowheads are in the frequency range of 50-400 Hz, with a few extending to 1,200 Hz. Based on indirect evidence, at least some baleen whales are quite sensitive to frequencies below 1 kHz but can hear sounds up to a considerably higher but unknown frequency. Most of the manmade sounds that elicited reactions by baleen whales were at frequencies below 1 kHz (Richardson et al., 1995a). Some or all baleen whales may hear infrasounds, sounds at frequencies well below those detectable by humans. Functional models indicate that the functional hearing of baleen whales extends to 20 Hz, with an upper range of 30 Hz. Even if the range of sensitive hearing does not extend below 20-50 Hz, whales may hear strong infrasounds at considerably lower frequencies. Based on work with other marine mammals, if hearing sensitivity is good at 50 Hz, strong infrasounds at 5 Hz might be detected (Richardson et al., 1995a). Bowhead whales, as well as blue and fin whales, are predicted to hear at frequencies as low as 10-15 Hertz. McDonald, Hildebrand, and Webb (1995) summarize that many baleen whales produce loud low-frequency sounds underwater a significant part of the time. Thus, species that are likely to be impacted by low-frequency sound include baleen whales such as fin, humpback, and bowhead whales.

Most species also have the ability to hear beyond their peak range. This broader range of hearing probably is related to their need to detect other important environmental phenomena, such as the locations of predators or prey. Ketten (1998:2) summarized that, “The consensus of the data is that virtually all marine mammal species are potentially impacted by sound sources with a frequency of 500 Hertz or higher. This statement refers solely to the probable potential for marine mammal species to hear sounds of various frequencies. If a species cannot hear a sound, or hears it poorly, then the sound is unlikely to have a significant effect. Other factors, such as sound intensity, will determine whether the specific sound reaches the ears of any given marine mammal.” Little data are available about how most marine mammal species, especially large cetaceans, respond either behaviorally or physically to intense sound and to long-term increases in ambient noise levels, especially over the long term. Large cetaceans cannot be easily examined after exposure to a particular sound source.

Whales often continue a certain activity (for example, feeding) even in the presence of airgun, drilling, or vessel sounds. Such continuation of activity does not confirm that the sound is not harmful to the cetacean. In many or all cases, this may be true: it may not be harmful. However, this type of interpretation is speculative. Whales, other marine mammals, and even humans, sometimes continue with important behaviors even in the presence of noise or other potentially harmful factors. Whales often fast for long lengths of time during the winter. The need to feed or to transit to feeding areas, for example, is possibly so great that they continue with the activity despite being harmed or bothered by the noise. For example, Native hunters reported to Huntington (2000) that beluga whales often ignore the approach of hunters when feeding, but at other times will attempt to avoid boats of hunters.

Ketten (1998) reported that hearing loss can be caused by exposure to sound that exceeds an ear's tolerance (i.e., exhaustion or overextension of one or more ear components). Hearing loss could result in an inability to communicate effectively with other members of its species, detect approaching predators or vessels, or echolocate (in the case of the toothed whales). Some studies have shown that following exposure to a sufficiently intense sound, marine mammals may exhibit an increased hearing threshold, a threshold shift, after the sound has ceased (for example, Nachtigall et al., 2004; Kastak et al., 1999; Schlundt et al., 2000; Finneran et al., 2002). Thus, a threshold shift indicates that the sound exposure resulted in hearing loss causing decreased sensitivity. This type of hearing loss is called a temporary threshold shift if the individual recovers its pre-exposure sensitivity of hearing over time, or a permanent threshold shift if it does not.

Ketten (1998) reported that whether or not a temporary threshold shift or a permanent threshold shift occurs will be determined primarily based on the extent of inner ear damage the received sound and the received sound level causes. In general, whether a given species will tend to be damaged by a given sound depends on the frequency sensitivity of the species. There are no data on which to determine the kinds or intensities of sound that could cause a TTS in a baleen whale.

Permanent threshold shifts are less species dependent and more dependent on the length of time the peak pressure lasts and the signal rise time. Usually if exposure time is short, hearing sensitivity is recoverable. Noise can also cause modification of an animal's behavior (for example, approach or avoidance behavior, or startle).

Long-term impacts of seismic survey noise on the hearing abilities of individual marine mammals are unknown. Information about the hearing capabilities of large baleen whales is mostly lacking. The assumption is made that the area of greatest hearing sensitivity are at frequencies known to be used for intraspecific communication. However, because real knowledge of sound sensitivity is lacking, we assume in our analyses that sensitivities shown by one species of baleen whale also could apply to another. This assumption is conservative, especially when using studies on a species such as the humpback, which uses a large sound repertoire in intraspecific communication, to infer possible impacts on other species such as the fin whale.

When noise interferes with sounds used by the marine mammals (for example, interferes with their communication or echolocation), it is said to "mask" the sound (for example, a call to another whale might be masked by an icebreaker operating at a certain distance away). Noises can cause the masking of sounds that marine mammals need to hear to function (Erbe et al., 1999). In a given environment, the impact of a noise on cetacean detection of signals likely would be influenced by both the frequency and the temporal characteristics of the noise, its signal-to-noise ratio, and by the same characteristics of other sounds occurring in the same vicinity (for example, a sound could be intermittent but contribute to masking if many intermittent noises were occurring). It is not known whether (or which) marine mammals can (Erbe and Farmer, 1998) and do adapt their vocalizations to background noise.

Available evidence also indicates that behavioral reaction to sound, even within a species, may depend on the listener's sex and reproductive status, possibly age and/or accumulated hearing damage, type of activity engaged in at the time or, in some cases, on group size. For example, reaction to sound may vary depending on whether females have calves accompanying them, whether individuals are feeding or migrating. Response may be influenced by whether, how often, and in what context, the individual animal has heard the sound before. All of this specificity greatly complicates our ability, in a given situation, to predict the behavioral response of a species, or on classes of individuals within a species, to a given sound. Because of this, and following recommendations in McCauley et al. (2000) (discussed above), we attempt to take a conservative approach in our analyses and base conclusions about potential impacts on potential effects on the most sensitive members of a population. In addition, we evaluate the potential for effects on fin, humpback, and bowhead whales by making the implicit assumptions that sound may travel the maximums observed, rather than minimums and that whales engaged in a particular activity may respond at the maximum, not the minimum, distances observed in studies to date. These assumptions overestimate potential effect in many cases. However, since at least some of the airgun arrays being used in the Chukchi and Beaufort seas have greater total output than many of those in previous studies, we may also underestimate impact in some cases.

## Potential Exposure of Whales to Seismic Survey Activities

Bowhead whales have documented use of portions of both the Chukchi Sea and Beaufort Sea evaluation areas for: spring and fall migration; feeding; calving; resting; and limited breeding. Most of the calving for this population probably occurs between the Bering Strait and Point Barrow. Bowhead whales have a demonstrated sensitivity to some noise and disturbance, including noise and disturbance from seismic surveys. Fin whales distribution in the action area appears very limited, and restricted to the Chukchi Sea during summer months. Humpback whales are also likely to occur only seasonally, predominately within the Chukchi Sea, although humpback whales were observed in the western Beaufort Sea in 2007. Thus, both fin and humpback whales may occur in waters subject to seismic survey.

Sound from these seismic sources is a potential source of disturbance to bowheads in and near areas where the surveys may occur. Seismic airguns are meant to produce low-frequency noise, generally below 200 Hz. However, the impulsive nature of the collapse of the air bubbles inevitably results in broadband sound characteristics. Airgun arrays are designed to focus the sound energy downward. Despite this, sound pulses also are projected horizontally, with the distance traveled depending on many factors, such as those discussed by Richardson et al. (1995a) and McCauley et al. (2000). Airgun arrays produce short-duration (transient) noise pulses with very high peak levels. The high peak level and impulsive nature of airguns have caused concern in the scientific and environmental communities. Bowhead whales emit tonal frequency modulated sounds at 50-400 Hz. A few calls have energy extending to 1,200 Hz. Bowheads also emit impulsive sounds in the frequency range of 25-3,500 Hz, as well as songs of about 20-500 Hz (Richardson et al. 1995a).

The energy level to be used in SHELL's site clearance work is much lower than that used in the StatOil 2D/3D seismic survey; thus, the radius of noise exposure is many times smaller. Both surveys will employ other activities that may result in an increase in noise and disturbance to whales. Seismic ships have navigational equipment that produces noise, and the ships themselves introduce noise, cause disturbance and may strike cetaceans. Marine vessel traffic in support of the surveys and used in marine mammal monitoring introduce noise and disturbance into the marine environment, with potential adverse impacts on the whales.

The SHELL high-resolution seismic surveys are used to evaluate potential shallow hazards and identify seafloor features and resources (e.g., shipwrecks, potential archaeological sites). Vessels used for high-resolution seismic are typically smaller (about 37 to 47 m) than those used for 2D/3D seismic surveys. Some high-resolution seismic surveys, such as those using airguns, emit loud sounds; but the sounds would not be as loud as sounds from Statoil's 2D/3D seismic surveys. The sound also would not be likely to propagate as great a distance as sounds from 2D/3D seismic surveys.

Because high-resolution seismic surveys use relatively lower energy and sound would be less likely to travel as far as sound from 2D/3D seismic surveys, these activities are less likely to have significant effects on endangered bowhead, fin, and humpback whales. Bowheads appear to continue normal behavior at closer distances to high-resolution seismic surveys than to 2D/3D deep penetration seismic surveys. In the study by Richardson, Wells, and Würsig (1985), four controlled tests were conducted by firing a single 40 cubic inch ($in^3$) (0.66-metric liter) airgun at a distance of 2-5 kilometers (km) (1.2-3.1 mi) from the whales. Bowheads sometimes continued normal activities (skim feeding, surfacing, diving, and travel) when the airgun began firing 3-5 km (1.86-3.1 mi) away (received noise levels at least 118-133 dB re 1 µPa) root-mean-square (rms). Some bowheads oriented away during an experiment at a range of 2-4.5 km (1.2-2.8 mi) and another experiment at a range of 0.2-1.2 km (0.12-0.75 mi) (received noise levels at least 124-131 and 124-134 dB, respectively). Frequencies of turns, predive flexes, and fluke-out dives were similar with and without airgun noise; and surfacing and respiration variables and call rates did not change significantly during the experiments.

Responses of fin and humpback whales to high-resolution surveys are uncertain and data specific to these species is lacking. Because the site-clearance activities are of shorter duration and have a smaller zone of influence than 2D/3D deep penetration seismic surveys, we believe it unlikely they would result in a biologically significant effect on fin and humpback whales, and responses would be similar to that of bowhead whales. Our primary concern with respect to high-resolution surveys is the potential for these activities to add to the noise and disturbance footprint of concurrent 2D/3D seismic survey(s) and/or drilling activities, and to cause local effects within a specific area, if large numbers of whales are present. We are specifically concerned about potential effects that could occur if high-resolution seismic survey activity were inshore of 2D/3D seismic survey activities or drilling operations. A concentration of noise- and disturbance-producing factors may keep humpback whales from high-value areas. Humpback data for the planning areas currently are not sufficient to identify high-value areas.

Offshore geophysical exploration seismic surveys such as Statoil's emit loud sounds, which are pulsed rather than continuous, and can propagate long distances (in some habitats, very long distances) from their source. However, most energy is directed downward, and the short duration of each pulse limits the total energy. Received levels within a few kilometers typically exceed 160 dB re 1 μPa (Richardson et al. 1995a), depending on water depth, bottom type, ice cover, etc. While the seismic airgun pulses are directed towards the ocean bottom, sound propagates horizontally for several kilometers (Greene and Richardson 1988; Hall et al. 1994). In waters 25-50 m deep, sound produced by airguns can be detected 50-75 km away, and these detection ranges can exceed 100 km in deeper water (Richardson et al., 1995a). Sounds produced by seismic pulses can be detected by mysticetes and odontocetes that are from 10-100 km from the source (Greene and Richardson 1988; Bowles et al. 1994; Richardson et al. 1995a) or potentially further under some conditions.

Recent 3D seismic surveys in the Chukchi Sea, using a 24 gun array consisting of 3,147 $in^3$, produced sounds up to 160 dB out to a distance of over 8km, while the 120 dB isopleths often extended over 70 km from the source vessel (Funk et al., 2008). Similar propagation may be expected from the Statoil survey, which will use an array of similar capacity.

Potential effects of 2D/3D seismic surveys on whales.—Baleen whales generally tend to avoid operating airguns, but avoidance radii are quite variable. Whales are often reported to show no overt reactions to pulses from large arrays of airguns at distances beyond a few kilometers, even though the airgun pulses remain well above ambient noise levels out to much longer distances. However, baleen whales exposed to strong noise pulses from airguns often react by deviating from their normal migration route and/or interrupting their feeding and moving away. Studies of gray, bowhead, and humpback whales have determined that received levels of pulses in the 160–170 dB re 1 μPa rms range seem to cause obvious avoidance behavior in a substantial fraction of the animals exposed. In many areas, including areas of the Chukchi Sea, seismic pulses from large arrays of airguns diminish to those levels at distances of 4.5 to 14.5 km (2.4 to 7.8 n.mi.) from the source. Baleen whales within those distances may show avoidance or strong disturbance reactions to the airgun array. Subtle behavioral changes sometimes become evident at somewhat lower received levels, and recent studies have shown that some species of baleen whales, notably bowhead and humpback whales, at times show strong avoidance at received levels lower than 160–170 dB re 1 μPa rms.

Numerous studies have been conducted on the effects of noise from seismic surveys on bowhead whales. The results from these studies have varied, in some cases considerably. Among some of these studies important variables were different. These included the type of seismic survey (2D versus 3D), the location of the study, and the year in which the study was conducted. Ice (and other weather-related factors) also varies among years as does the use of total available habitat by bowhead whales. Some of the studies employed different methodologies, some of which have been criticized by peer reviewers and others of which are more widely adopted. Because of the importance of the issue of potential noise disturbance of bowhead whales, we provide considerable detail on these studies below. However, we preface this section with an observation: In numerous reports regarding whale response to sound, it has been shown that multiple factors may be important in the whale's response (e.g., McCauley et al., 2000). In some studies, these factors have been shown to include (but may not be limited to): the physical characteristics of the location into which the sound is released and the physical characteristics of the location where the whale is located at the time the sound is released; the whale's sex and reproductive condition (e.g., groups with or without calves); the behavior of the whale (e.g., migrating or feeding); specific characteristics of the sound (e.g., frequency, duration, whether impulsive or not, etc.), and prior exposure to the sound. Thus, the fact that results from different studies of bowhead response to oil and gas-related sound have varied is not surprising. The studies involving the response of bowheads to 3D marine streamer seismic surveys are most relevant to evaluating the potential effects of the proposed action.

During the 1980's, the behavior of bowhead whales exposed to noise pulses from seismic surveys was observed during the summer in the Canadian Beaufort Sea and during the fall migration across the Alaskan Beaufort Sea. In general, many of the seismic surveys conducted during the 1980's were 2D seismic surveys that covered fairly large areas in deeper waters. Additional studies on seismic surveys were conducted in the central Alaskan Beaufort Sea during the fall migration in 1996-1998. These surveys were 3D ocean bottom cable (OBC) seismic surveys that covered fairly small areas in relatively shallow water fairly close to shore. Reeves, Ljungblad, and Clarke (1983) conducted aerial surveys to observe bowhead whale behavior in the presence of active seismic vessels. Whales were observed as close as 3 km (1.86 mi) and as far away as 135 km (83.9 mi) from active seismic vessels. A pair of whales observed at a distance of 3 km (1.83 mi) were not moving while at the surface although the two whales' heads were in contact. This pair of whales was closer to a shooting seismic vessel than any other whales observed during the study. No obvious response was apparent, but the observation time was brief. (The received level of low-frequency underwater sound from an underwater source, generally is lower by 1-7 dB near the surface (depth of 3 m) than at deeper (greater than 9 m) depths (Richardson et al., 1995a). It is possible these whales may have been at the surface to avoid the louder noise in deeper water. For the group of 20 whales at a distance of approximately 135 km (83.9 mi), the blow frequency per surfacing and time at the surface were greater during the period immediately after the seismic vessel began shooting than before it began shooting. The authors stated that no major changes in whale behavior (such as flight reactions) were observed that could unequivocally be interpreted as responses to seismic noise. They noted a possible exception of "huddling behavior", which they thought may have been caused by the onset of seismic sounds. The authors concluded that although their results suggest some changes in behavior related to seismic sounds, the possibility that unquantified factors could be correlative dictates caution in attempting to establish causative explanations from the preliminary findings.

Ljungblad et al. (1985) also reported findings from early tests of bowhead reactions to active seismic vessels in the Beaufort Sea. However, methodological problems with this early study preclude us from drawing conclusions about probable bowhead reactions based on its findings. A subcommittee of the Scientific Committee of the IWC previously reviewed the data from this study and some members were critical of the methodology and analysis of the results. Comments included reference to: the small sample size; inconsistencies between the data and the conclusions; lack of documentation of calibration of sound monitoring; and possible interference from other active seismic vessels in the vicinity. The subcommittee acknowledged the difficulty of performing experiments of this kind, particularly in the absence of a control environment free of industrial noise. The subcommittee recommended that additional research taking into account the concerns expressed above be undertaken, and that the 1984 experimental results be subjected to rigorous reanalysis, before it could be used to draw any conclusions about the effects of seismic activity on this species (IWC, 1987).

In the May 25, 2001 Biological Opinion for Federal Oil and Gas Leasing and Exploration by the MMS within the Alaskan Beaufort Sea and its effects on the endangered bowhead whale, NMFS (2001:20) noted that early tests of bowhead reactions to active seismic vessels by Ljungblad et al. (1985):

> . . . were not conducted under controlled conditions (i.e., other noise sources were operating at the time), and approaches at greater ranges were not conducted, so results cannot be used to determine the range at which the whales first begin to respond to seismic activity.

In Fraker et al. (1985), an active seismic vessel traveled toward a group of bowheads from a distance of 19 km (11.8 mi) to a distance of 13 km (8.18 mi). The whales did not appear to alter their general activities. Most whales surfaced and dove repeatedly and appeared to be feeding in the water column. During their repeated surfacing and dives, they moved slowly to the southeast (in the same direction as seismic-vessel travel) and then to the northwest (in the opposite direction of seismic-vessel travel). The study first stated that a weak avoidance reaction may have occurred but then stated there is no proof that the whales were avoiding the vessel. The net movement was about 3 km (1.86 mi). The study found no evidence of differences in behavior in the presence and absence of seismic noise, but noted that observations were limited.

In another study (Richardson, Wells, and Würsig, 1985) involving a full-scale seismic vessel with a 47-L airgun array (estimated source level 245-252 dB re 1 μPa), bowheads began to orient away from the approaching ship when its airguns began to fire from 7.5 km

(4.7 mi) away. This airgun array had about 30 airguns, each with a volume of 80-125 $in^3$. The *Mariner* had been shooting seismic about 10 km to the west of a group of six whales. Prior to the start of the experimental seismic period, the whales were surfacing and diving and moving at slow to medium speed while at the surface. The vessel ceased shooting and moved within 7.5 km of the whales and began firing the airgun array while approaching the whales. The study reported no conspicuous change in behavior when the *Mariner* resumed shooting at 7.5 km away. The bowheads continued to surface and dive, moving at slow to medium speeds. The received level was estimated at 134-138 dB at 7 km (4.35 mi). Some near-bottom feeding (evidenced by mud being brought to the surface) continued until the vessel was 3 km (1.86 mi) away. The closest point of approach to any whale was approximately 1.5 km (0.93 mi), with the received level probably well over 160 dB. When the seismic vessel was within 1.5 km of whales at the original location, at least two of the whales were observed to have moved about 2 km to the south of the original location. The movements of the whales, at least while they were at the surface, were at the usual slow to moderate speeds. The study reported no conspicuous changes in behavior when the *Mariner* ceased shooting at 6 km beyond the whales. The bowheads were still surfacing and diving and moving at slow to medium speed. The most notable change in behavior apparently involved the cessation of feeding when the vessel was 3 km away. The whales began feeding again about 40 minutes after the seismic noise ceased.

While conducting a monitoring program around a drilling operation, Koski and Johnson (1987) noted that the call rate of a single observed bowhead whale increased after a seismic operation had ceased. During the 6.8 hours of observation, the whale was within 23-27 km (14.3-16.8 mi) from the drillship. A seismic vessel was reported to be from 120-135 km (74.58-83.9 mi) from the sonobuoy; the two loudest calls received were determined to be approximately 7 km (4.35 mi) and 9 km (5.6 mi) from the sonobuoy, with received levels of 119 and 118 dB, respectively. Approximate signal-to-noise ratios were 24 and 22 dB, respectively. No information is provided regarding the exact distance the whale was from the operating seismic vessel. The increase in call rate was noted within 25 minutes after seismic noise ceased. It also needs to be noted that there were few, if any, calls heard during the 2 hours prior to the start of seismic operations, so it is unclear whether the increase in call rate relates to cessation of seismic noise, the presence of the operating drillship, the combination of both activities, or some other factor that occurred in the late afternoon. During this same study a subgroup of four to seven whales within a larger group (15-20 whales) was noted moving rapidly away from an approaching seismic vessel at a distance of 22-24 km (13.7-14.9 mi). The received level of seismic pulses was 137 dB at 19 km (11.8 mi) from the sonobuoy and 22 km from the whales. The surfacing and diving were unusually brief, and there were unusually few blows per surfacing. No information was available regarding the time required for these whales to return to normal behavior.

The North Slope Borough (NSB) believes that many studies were different from the real-world situation, and various limitations have been pointed out. Most studies did not involve actively migrating whales; and those whales were being approached by the seismic ships whereas in the real world, the fall migrating whales are actively moving to the west and they are approaching a distant seismic boat that is firing. The MMS has noted that many studies were observational and involved opportunistic sightings of whales in the vicinity of seismic operations. The studies were not designed to show whether more subtle reactions are occurring that can displace the migration corridor, so no definitive conclusions can be drawn from them on whether or not the overall fall migration is displaced by seismic activity.

Based on early data, Richardson and Malme (1993) concluded that collectively, scientific studies have shown that most bowheads usually show strong avoidance response when an operating seismic vessel approaches within 6-8 km (3.8-5.0 mi). Strong avoidance occurs when received levels of seismic noise are 150-180 dB re 1 µPa (Richardson and Malme, 1993). Strong pulses of seismic noise often are detectable 25-50 km (15.5-31 mi) from seismic vessels, but in early studies, bowheads exposed to seismic sounds from vessels more than about 7.5 km (4.7 mi) away rarely showed avoidance. Seismic pulses can be detectable 100 km (62.2 mi) or more away. Bowheads also may show specific behavioral changes, such as reduced surfacing; reduced dive durations; changes in respiration rates, including fewer blows per surfacing, and longer intervals between successive blows; and they may temporarily change their individual swimming paths. The authors noted that surfacing, respiration, and dive cycles may be altered in the same manner as those of whales closer to the vessels. Bowhead surface-respiration-dive characteristics appeared to recover to pre-exposure levels within 30-60 minutes following the cessation of the seismic activity.

Inupiat whalers suggested that the fall bowhead migration tended to be farther offshore when there was abundant seismic work off northern Alaska. Aerial surveys have been conducted since 1979 to determine the distribution and abundance of bowhead whales in the Beaufort Sea during their fall migration. These surveys have been used for comparing the axis of the bowhead whale migration between years. Survey data from 1982-1987 were examined to determine whether industrial activity was resulting in displacement of bowhead whales farther offshore (Ljungblad et al., 1988). It was determined that a good indicator of annual shifts in bowhead distribution could be obtained by analyzing the distance of random bowhead sightings from shore (Zeh, as cited in Ljungblad et al., 1988). An analysis of the distance of random bowhead sightings from shore (a total of 60 bowhead sightings) was conducted, but no significant differences were detected in the bowhead migratory route between years. The axis of the bowhead migratory route near Barrow was found to fall between 18 and 30 km (7.76 and 18.6 mi) from shore. Although the analysis involved a relatively small sample size, these observations provide some insight into migration patterns during these years. The NSB, in a letter dated July 25, 1997, questioned the sample size and the precision of the Ljungblad et al. (1988) report to determine whether or not a displacement of fall migrating whales had occurred and how big a displacement would have to be before it could be detected. Using larger sample sizes (for which confidence intervals were calculated) obtained over a larger study area, the aerial survey project found many between-year (1982-1996) differences in the median water depth at whale sightings that were highly significant (P less than 0.05) (Treacy 1997). Median depths ranged between 18 m (59 ft) in 1989 and 347 m (1,138 ft) in 1983, with an overall cumulative depth of 37 m (121 ft, confidence interval = 37-38 m). The aerial survey project has reported a potential association between water depth of the bowhead migration and general ice severity, especially in 1983, when severe ice cover may have forced the axis of the migration into waters 347 m (1,138 ft) deep. To address short-term bowhead whale displacement within a given year from site-specific industrial noise, MMS and NMFS require industry to conduct site-specific monitoring programs when industrial activity occurs in the Beaufort Sea Planning Area during fall bowhead migrations.

Since 1996, many of the open water seismic surveys in State of Alaska waters and adjacent nearshore Federal waters of the central Alaskan Beaufort Sea were ocean-bottom cable surveys. These surveys were 3D seismic programs. The area to be surveyed is divided into patches, each patch being approximately 5.9 by 4.0 km in size. Within each patch, several receiving cables are laid parallel to each other on the seafloor. Seismic data are acquired by towing the airguns along a series of source lines oriented perpendicular to the receiving cables. While seismic-data acquisition is ongoing on one patch, vessels are deploying cable on the next patch to be surveyed and/or retrieving cables from a patch where seismic surveys have been completed. Airgun arrays have varied in size each year from 1996-1998 with the smallest, a 560 $in^3$ array with 8 airguns, and the largest, a 1,500 $in^3$ array with 16 airguns. A marine mammal and acoustical monitoring program was conducted in conjunction with the seismic program each year in accordance with provisions of the NMFS Incidental Harassment Authorization. Based on 1996-1998 data, there was little or no evidence that bowhead headings, general activities, or swimming speeds were affected by seismic exploration. Bowheads approaching from the northeast and east showed similar headings at times with and without seismic operations. Miller et al. (1999) stated that the lack of any statistically significant differences in headings should be interpreted cautiously. Changes in headings must have occurred given the avoidance by most bowheads of the area within 20 or even 30 km of active seismic operations. Miller et al. (1999) noted that the distance at which deflection began cannot be determined precisely, but they stated that considering times with operations on offshore patches, deflection may have begun about 35 km to the east. However, some bowheads approached within 19-21 km of the airguns when they were operating on the offshore patches. It appears that in 1998, the offshore deflection might have persisted for at least 40-50 km west of the area of seismic operations. In contrast, during 1996-1997, there were several sightings in areas 25-40 km west of the most recent shotpoint, indicating the deflection in 1996-1997, may not have persisted as far to the west.

LGL Ltd.; Environmental Research Assocs., Inc.; and Greeneridge Sciences Inc. conducted a marine mammal monitoring program for a seismic survey near the Northstar Development Project in 1996 (Miller et al., 1997). The marine mammal monitoring program was continued for subsequent seismic surveys in nearshore waters of the Beaufort Sea in 1997 and 1998 (Miller, Elliot, and Richardson, 1998; Miller et al., 1999). Details of these studies are provided in the Beaufort Sea multiple-sale final EIS. These studies indicated that the bowhead whale-migration corridor in the central Alaskan Beaufort Sea during 1998 was similar to the corridor in many prior years, although not 1997. In 1997, nearly all bowheads sighted were in relatively nearshore waters. The results of the 1996-1998 studies indicated a tendency for the general bowhead whale-migration corridor to be farther offshore on days with seismic airguns operating compared to days without seismic airguns operating, although the distances of bowheads from shore during airgun operations overlapped with those in the absence of airgun operations. Aerial-survey results indicated that bowheads tended to avoid the area around the operating source, perhaps to a radius of about 20-30 km. Sighting rates within a radius of 20 km of seismic operations were significantly lower during seismic operations than when no seismic operations were happening. Within 12-24 hours after seismic operations ended, the sighting rate within 20 km was similar to the sighting rate beyond 20 km. There was little or no evidence of differences in headings, general activities, and swimming speeds of bowheads with and without seismic operations. Overall, the 1996-1998 results show that most bowheads avoided the area within about 20-30 km of the operating airguns. Within 12-24 hours after seismic operations ended, the sighting rate within 20 km was similar to the sighting rate beyond 20 km.

The observed 20-30 km area of avoidance is a larger avoidance radius than documented by previous scientific studies in the 1980s and smaller than the 30 mi suggested by subsistence whalers, based on their experience with the types of seismic operations that occurred in the Beaufort Sea before 1996 (Richardson, 2000). The seismic activities in the 1980s were 2D in deeper water. Recent seismic activities were 3D OBC concentrated in shallow water.

Based on recordings of bowhead whale calls made during these same studies, Greene et al. (1999), summarized that results for the 3 years of study indicated that: (1) bowhead whales call frequently during the autumn migration through the study area; (2) calling continued at times when whales were exposed to airgun pulses; and (3) call-detection rates at some locations differed significantly when airguns were detectable versus not detectable. However, there was no significant tendency for the call-detection rate to change in a consistent way at times when airguns started or stopped.

Richardson provided a brief comparison between observations from seismic studies conducted in the 1980s and the 1996 seismic survey at the Arctic Seismic Synthesis Workshop in Barrow (USDOI, MMS 1997). Observations from earlier seismic studies during the summer and early autumn show that most bowhead whales interrupt their previous activities and swim strongly away when a seismic ship approaches within about 7.5-8 km. At the distances where this strong avoidance occurs, received levels of seismic pulses typically are high, about 150-180 dB re 1 μPa. The surfacing, respiration, and dive cycles of bowheads engaged in strong avoidance also change in a consistent pattern involving unusually short surfacing and diving and unusually few blows per surfacing. These avoidance and behavioral effects among bowheads close to seismic vessels are strong, reasonably consistent, and relatively easy to document. Less consistent and weaker disturbance effects probably extend to longer distances and lower received sound levels at least some of the time. Bowheads often tolerate much seismic noise and, at least in summer, continue to use areas where seismic exploration is common. However, at least one case of strong avoidance has been reported as far as 24 km from an approaching seismic boat (Koski and Johnson, 1987) and, as noted above, the aerial survey data (Miller et al., 1999) indicated that bowheads tended to avoid the area around the operating source, perhaps to a radius of about 20-30 km. Richardson noted that many of the observations involved bowheads that were not actively migrating. Actively migrating bowheads may react somewhat differently than bowheads engaged in feeding or socializing. Migrating bowheads, for instance, may react by deflecting their migration corridor away from the seismic vessel. Monitoring of the bowhead migration past a nearshore seismic operation in September 1996 provided evidence consistent with the possibility that the closest whales may have been displaced several miles seaward during periods with seismic activity.

With respect to these studies conducted in the Beaufort Sea from 1996-1998, the peer-review group at the Arctic Open-Water Noise Peer Review Workshop in Seattle from June 5-6, 2001, prepared a summary statement supporting the methods and results reported in Richardson (1999) concerning avoidance of seismic sounds by bowhead whales:

> Monitoring studies of 3-D seismic exploration (8-16 airguns totaling 560-1,500 $in^3$) in the nearshore Beaufort Sea during 1996-1998 have demonstrated that nearly all bowhead whales will avoid an area within 20 km of an active seismic source, while deflection may begin at distances up to 35 km. Sound levels received by bowhead whales at 20 km ranged from 117-135 dB re 1 μPa rms and 107-126 dB re 1 μPa rms at 30 km. The received sound levels at 20-30 km are considerably lower levels than have previously been shown to elicit avoidance in bowhead or other baleen whales exposed to seismic pulses.

A recent study in Canada provides information on the behavioral response of bowhead whales in feeding areas to seismic surveys (Miller and Davis, 2002). During the late summer and autumn of 2001, Anderson Resources Ltd. conducted an open-water seismic exploration program offshore of the Mackenzie Delta in the Canadian Beaufort Sea. The program consisted of streamer seismic surveys and associated bathymetric surveys conducted off the Mackenzie Delta. The bathymetric surveys were conducted by two medium-sized vessels equipped with side-scan sonar and single-beam echo sounders. The seismic vessel was the *Geco Snapper*. The acoustic sources used in the seismic operations were two 2,250 $in^3$ arrays of 24 sleeve-type airguns. Each 2,250 $in^3$ airgun array was comprised of 24 airguns with volumes ranging from 40-150 $in^3$. The two airgun arrays fired alternately every 8 seconds along the survey lines. The airgun arrays were operated at a depth of 5 m below the water surface. Water depths within the surveyed areas ranged from 6-31 m and averaged 13 m (Miller, 2002). Because marine seismic projects using airgun arrays emit strong sounds into the water and have the potential to affect marine mammals, there was concern about the acoustic disturbance of marine mammals and the potential effects on the accessibility of marine mammals to subsistence hunters. Although there are no prescribed marine mammal and acoustic monitoring requirements for marine seismic programs in the Canadian Beaufort Sea, it was decided that monitoring and mitigation measures in the Canadian Beaufort Sea should be as rigorous as those designed and implemented for marine seismic programs conducted in the Alaskan Beaufort Sea in recent years. The monitoring program consisted of three primary components: acoustic measurements, vessel-based observations, and aerial surveys. The NMFS-recommended criterion that exposure of whales to impulse sound not exceed 180 dB re 1 Pa rms (65 *FR* 16374) was adopted as a mitigation standard for this monitoring program. Estimates of sound-propagation loss from the airgun array were used to determine the designated 1,000-m safety radius for whales (the estimated zone within which received levels of seismic noise were 180 dB re 1μPa rms or higher).

Aerial and vessel-based surveys confirmed the presence of substantial numbers of bowheads offshore of the Mackenzie Delta from late August until mid-September. The distribution of bowheads in the study area was typical of patterns observed in other years and suggests that there were good feeding opportunities for bowheads in these waters during that period. A total of 262 bowheads were observed from the seismic vessel *Geco Snapper* (Moulton, Miller, and Serrano, 2002). Sighting rates during daylight hours were higher when no airguns were operating than during periods with airguns operating. During the period when bowheads were most abundant in the study area (August 23-September 19), the bowhead sighting rate during periods with no seismic (0.85 bowheads/hour) was about twice as high as that recorded during periods with seismic (0.40 bowheads/h) or all seismic operations combined (0.44 bowheads/h). Average sighting distances from the vessel were significantly (P <0.001) lower during no airguns (a mean radial distance of 1,368 m) versus line-seismic periods (a mean radial distance of 1,957 m). The observed difference in sighting rates and the significant difference in sighting distances suggest that bowheads did avoid close approach to the area of seismic operations. However, the substantial number of sightings during seismic periods and the relatively short (600 m) but significant difference in sighting distances suggests that the avoidance may have been localized and relatively small in nature. At a minimum, the distance by which bowheads avoided seismic operations was on the order of 600 m greater than the average distance by which they avoided general vessel operations. The lower sighting rates recorded during seismic operations suggest that some bowheads avoided the seismic operations by larger distances and, thereby, stayed out of visual range of the marine mammal observers on the *Geco Snapper*.

In this study, a total of 275 bowhead whale sightings were recorded during aerial transects with good lighting conditions (Holst et al., 2002). Bowheads were sighted at similar rates with and without seismic, although the no feeding-seismic sample was too small for meaningful comparisons. Bowheads were seen regularly within 20 km of the operations area at times influenced by airgun pulses. Of 169 transect sightings in good conditions, 30 sightings were seen within 20 km of the airgun operations at distances of 5.3-19.9 km. The aerial surveys were unable to document bowhead avoidance of the seismic operations area. The area of avoidance around the seismic operations area was apparently too small to be evident from the broadscale aerial surveys that were flown, especially considering the small amount of surveying done when seismic was not being conducted. General activities of bowheads during times when seismic operations were conducted were similar to times without seismic.

The bowheads that surfaced closest to the vessel (323-614 m) would have been exposed to sound levels of about 180 dB re 1 µPa rms before the immediate shutdown of the array (Miller et al. 2002). There were seven shutdowns of the airgun array in response to sightings of bowheads within 1 km of the seismic vessel. Bowheads at the average vessel-based sighting distance (1,957 m) during line seismic would have been exposed to sound levels of about 170 dB re 1 µPa rms. The many aerial sightings of bowheads at distances from the vessel ranging from 5.3-19.9 km would have been exposed to sound levels ranging from approximately 150-130 dB re 1 µPa rms, respectively.

The results from the study in summer 2001 are markedly different from those obtained during similar studies during the autumn migration of bowheads through the Alaskan Beaufort Sea (Miller et al., 2002). For example, during the Alaskan studies only 1 bowhead whale was observed from the seismic vessel(s) during six seasons (1996-2001) of vessel-based observations compared with 262 seen from the *Geco Snapper* in 2001. The zone of avoidance for bowhead whales around the airgun operations in 2001 was clearly much smaller (~2 km) than that observed for migrating bowhead whales in recent autumn studies in Alaskan waters (up to 20-30 km). Davis (1987) concluded that migrating bowheads during the fall migration may be more sensitive to industrial disturbance than bowheads on their summering grounds, where they may be engaged in feeding activities.

Inupiat subsistence whalers have stated that industrial noise, especially noise due to seismic exploration, has displaced the fall bowhead migration seaward and, thereby, is interfering with the subsistence hunt at Barrow (Ahmaogak, 1989). Whalers have reported reaction distances, where whales begin to divert from their migratory path, on the order of 10 mi (T. Albert cited in USDOI, MMS 1995) to 35 mi (F. Kanayurak in USDOI, MMS 1997. Kanayurak stated that the bowheads ". . . are displaced from their normal migratory path by as much as 30 miles." Also at the March 1997 workshop, Mr. Roxy Oyagak, Jr., a Nuiqsut whaling captain, stated in written testimony:

> Based on the industrial activity, there is an unmitigable adverse impact on the village of Nuiqsut on subsistence whaling. i.e., 1) by causing the whales to abandon the hunting area …and 3) placing physical barriers between the subsistence whalers and marine mammals, including altering the normal bowhead whale migration route.

Data available from MMS' BWASP surveys over about a 27 year period indicate that, at least during the primary open water period during the autumn (when open water seismic activities are most likely to occur), there are areas where bowheads are much more likely to be encountered and where aggregations, including feeding aggregations and/or aggregations with large numbers of females and calves, are more likely to occur in the Beaufort. Such areas include the areas north of Dease Inlet to Smith Bay, northeast of Smith Bay, and Northeast of Cape Halkett, as well as areas near Brownlow Point.

Feeding whales in these areas may abandon this habitat (temporarily or permanently) on exposure to seismic noise. The extent of avoidance will vary both due to the actual noise level radii around each seismic vessel, the context in which it is heard, and the motivation of the animal to stay within the area. It also may vary depending on the age, and most likely, the sex and reproductive status of the whale. It may be related to whether subsistence hunting has begun and/or is ongoing. Because the areas where large aggregations of whales have been observed during the autumn also are areas used, at least in some years, for feeding, it may be that the whales would show avoidance more similar to that observed in studies of whales on their summer feeding grounds. However, as noted above, it is not clear that reduced avoidance should be interpreted as a reduction in impact. It may be that bowheads are so highly motivated to stay on a feeding ground that they remain at noise levels that could, with long term exposure, cause adverse effects.

In the Canadian Beaufort Sea, bowheads observed in vessel-disturbance experiments began to orient away from an oncoming vessel at a range of 2-4 km (1.2-2.5 mi) and to move away at increased speeds when approached closer than 2 km (1.2 mi) (Richardson and Malme, 1993). Vessel disturbance during these experimental conditions temporarily disrupted activities and sometimes disrupted social groups, when groups of whales scattered as a vessel approached. Reactions to slow-moving vessels, especially if they do not approach directly, are much less dramatic. Bowheads often are more tolerant of vessels moving slowly or in directions other than toward the whales. Fleeing from a vessel generally stopped within minutes after the vessel passed, but scattering may persist for a longer period. After some disturbance incidents, at least some bowheads returned to their original locations (Richardson and Malme, 1993). Some whales may exhibit subtle changes in their surfacing and blow cycles, while others appear to be unaffected. Bowheads actively engaged in social interactions or mating may be less responsive to vessels.

Bowhead whales could encounter noise and disturbance from multiple seismic vessels and multiple support vessels as they migrate and feed in the Beaufort and Chukchi seas. The significance of such encounters is expected to depend on the area in which the vessels are transiting, the total number of vessels in the area, the presence of other vessels (see cumulative effects section), and variables already identified regarding the number, behavior, age, sex and reproductive condition of the whales. Depending on ice conditions, it is likely that vessels actively involved in ice management or moving from one site to another would be more disturbing to whales than vessels idling or maintaining their position. In either case, bowheads probably would adjust their individual swimming paths to avoid approaching within several kilometers of chase vessels supporting a seismic vessel and probably would move away from vessels that approached within a few kilometers. Vessel activities associated with exploration are not expected to disrupt the bowhead migration. Small deflections in individual bowhead-swimming paths and a reduction in use of possible bowhead-feeding areas near exploration units may result in adverse effects on the species. During their spring migration (April through June), bowheads likely would encounter few, if any, vessels along their migration route, because ice at this time of year typically would be too thick for seismic-survey ships and supply vessels to operate in. Because MMS is not allowing seismic shooting in the spring lead system until July 1 unless authorized by NMFS, we do not expect seismic survey vessel interaction to be an important source of disturbance during the northward migration.

Humpback whales summering in southeast Alaska did not exhibit persistent avoidance when exposed to seismic pulses from a 1.64-L (100 $in^3$) airgun (Malme and Miles, 1985). Some humpbacks seemed “startled” at received levels of 150–169 dB re 1 µPa on an approximate rms basis. McCauley et al. (1998, 2000) studied the responses of humpback whales off Western Australia to a full-scale seismic survey with a 16-airgun 2,678-$in^3$ array, and to a single 20 $in^3$ airgun with source level 227 dB re 1 µPa·m (p-p). They found that the overall distribution of humpbacks migrating through their study area was unaffected by the full-scale seismic program. McCauley et al. (1998) did, however, document localized avoidance of the array and of the single gun. Avoidance reactions began at 5–8 km (2.7–4.3 n.mi.) from the array and those reactions kept most pods about 3–4 km (1.6–2.2 n.mi.) from the operating seismic boat. Observations were made from the seismic vessel, from which the maximum viewing distance was listed as 14 km (7.6 n.mi.). Avoidance distances with respect to the single airgun were smaller but consistent with the results from the full array in terms of the received sound levels. Mean avoidance distance from the airgun corresponded to a received sound level of 140 dB re 1 µPa rms; this was the level at which humpbacks started to show avoidance reactions to an approaching airgun. The standoff range, i.e., the closest point of approach of the airgun to the whales, corresponded to a received level of 143 dB rms. The initial avoidance response generally occurred at distances of 5–8 km (2.7–4.3 n.mi.) from the airgun array and 2 km (1.1 n.mi.) from the single gun. However, some individual humpback whales, especially males, approached within distances 100–400 m (328–1312 ft), where the maximum received level was 179 dB re 1 µPa rms.

Data on short-term reactions (or lack of reactions) of cetaceans to impulsive noises do not necessarily provide information about long-term effects. It is not known whether impulsive noises affect reproductive rate or distribution and habitat use in subsequent days or years. However, gray whales continued to migrate annually along the west coast of North America despite intermittent seismic exploration and much ship traffic in that area for decades. Bowhead whales continued to travel to the eastern Beaufort Sea each summer despite seismic exploration in their summer and autumn range for many years (Richardson et al., 1987). Populations of both gray whales and bowhead whales grew substantially during this time. Humpback and fin whales which occur seasonally in the action areas are likely feeding or migrating. The observations summarized above indicate that any fin or humpback whale that is exposed to seismic pulses at particular levels may alter their behaviors. The responses of these whales are likely dependent on the received level and duration of the airgun pulses, but they may exhibit avoidance, suspend feeding, or shift their migration pathway. Avoidance responses or other behavioral disruptions could be expected to last during the exposure. Whales that are migrating may be diverted from their path or feeding whales may be interrupted, but these disruptions would be temporary. Although we do not have evidence to support this assumption for all baleen whales, gray whales have been observed to migrate annually along the west coast of North America despite intermittent seismic exploration (and much ship traffic) and bowhead whales continue to travel to the eastern Beaufort Sea each summer despite seismic exploration in the summer and autumn range for many years. Also, humpback whales exposed to LFA sonar changed song length but then returned to "normal" duration after exposure (Miller et al., 2000). Fin and humpback whales are expected to resume their behavior after the seismic vessel has moved out of their immediate area without impairment of feeding, migration, or other behaviors.

In addition to acting as a source of noise and disturbance, marine vessels could potentially strike whales, causing injury or death. As noted in the baseline section of this evaluation, available information indicates that current rates of vessel strikes of fin, humpback, and bowhead whales in these waters are low. At present, available data do not indicate that strikes by oil and gas-related vessels will become an important source of injury or mortality in the Chukchi or Beaufort Sea Planning Areas. Risk of strikes would increase as vessel traffic in whale habitat increases.

Seismic activity should have little effect on zooplankton. Bowheads feed on concentrations of zooplankton. Zooplanktons that are very close to the seismic source may react to the shock wave, but little or no mortality is expected (LGL Ltd., 2001). A reaction by zooplankton to a seismic impulse would be relevant only if it caused a concentration of zooplankton to scatter. Pressure changes of sufficient magnitude to cause zooplankton to scatter probably would occur only if they were very close to the source. Impacts on zooplankton behavior are predicted to be negligible and would have negligible effects on feeding bowheads (LGL Ltd., 2001).

**Summary of Potential Effects of Noise and Disturbance Sources**

Available information indicates that baleen whales, and bowhead whales in particular, are responsive (in some cases highly responsive) to anthropogenic noise in their environment. At present, the primary response that has been documented is avoidance, sometimes at considerable distance. Response is variable, even to a particular noise source and the reasons for this variability are not fully understood.

The observed response of bowhead whales to seismic noise has varied among studies. The factors associated with variability are not entirely clear. However, data indicate that fall migrating bowheads show greater avoidance of active seismic vessels than do feeding bowheads. Recent monitoring studies and traditional knowledge indicate that during the fall migration, most bowhead whales avoid an area around a seismic vessel operating in nearshore waters by a radius of about 20 km and may begin avoidance at greater distances. Received sound levels at 20 km ranged from 117-135 dB re 1 μPa rms and 107-126 dB re 1μ Pa rms at 30 km. This is a larger avoidance radius than was observed from scientific studies conducted in the 1980's. Avoidance did not persist beyond 12-24 hours after the end of seismic operations. In some early studies, bowheads also exhibited tendencies for reduced surfacing and dive duration, fewer blows per surfacing, and longer intervals between successive blows. Available data indicate that behavioral changes are temporary.

The proposed seismic exploration could result in considerable increase in noise and disturbance in the summer and autumn range of the Western Arctic bowhead whales, and to summering fin and humpback whales. Seismic noise from Statoil's activities in the Chukchi Sea could expose large numbers of bowhead whales, although the majority of this work may be completed prior to the main fall migration if they encounter few delays. It is unclear whether noise from the Statoil project would propagate to important feeding areas north and northeast of Barrow, or what the reaction of any whales in this area might be. However, as these areas are generally more than 125 miles from the Statoil work, the received sound levels at these distances should be low, and feeding whales have shown some tendency to show less displacement than migrating whales on exposure to seismic noise, we do not believe there is high probability for whales to abandon such habitat.

Exploration will result in an increase in marine vessel activity. Whales respond strongly to vessels directly approaching them. Avoidance of vessels usually begins when a rapidly approaching vessel is 1-4 km away, with a few whales possibly reacting at distances from 5-7 km. Received noise levels as low as 84 dB re 1 µPa or 6 dB above ambient may elicit strong avoidance of an approaching vessel at a distance of 4 km. Fleeing from a vessel generally stopped within minutes after the vessel passed, but scattering may persist for a longer period.

Overall, fin, humpback, or bowhead whales exposed to these surveys most likely would experience temporary, nonlethal effects. Data are sufficient to conclude that response to seismic noise is likely to vary with time of year; sex and reproductive status of individuals exposed; site (because of differences in noise propagation and use by bowheads); activity and the exact characteristics of that activity (e.g., seismic source, airgun array and configuration, etc.); the animal's motivation to be in an area; and options for alternative routes, places to feed, etc. While habituation is seen in some species, and behavioral studies have suggested that bowheads habituate to noise from distant, ongoing drilling or seismic operations, localized avoidance still occurred. Bowheads may be less likely to habituate to at least certain types of noise than fin or humpback whales because they are hunted annually, and thus, many individuals may have a strong negative association with human noise.

Available information does not indicate any long-term adverse effects on the Western Arctic stock from the high level of seismic surveys and exploration drilling during the 1980's in the Beaufort and Chukchi seas. While any sub-lethal impacts on health (such as reduced hearing or increased stress) could not be detected in this population through existing research, the rate of this population's increase in abundance does not indicate any sub-lethal effects (if they occurred) resulted in an effect on this population's recovery. There has been no documented evidence that noise from previous OCS operations has served as a barrier to migration. Because whales respond behaviorally to loud noise, they are less likely to suffer hearing loss from increased noise. However, whales appear to be more tolerant of noise when feeding, and future work is needed to determine potential effects on hearing due to long periods over many years of exposure to loud noise at distances tolerated in feeding areas. Similarly, concern needs to be given to other potential physiological effects of loud noise, including the potential for increased noise to cause physiological stress responses.

Concentrations of loud noise and disturbance activities during the open water period have the potential to cause large numbers of bowheads to avoid using areas for resting and feeding for long periods of time (days to months) while the noise producing activities continue. Because recent data are not sufficient to evaluate current habitat use by season or area in the Chukchi Sea by bowhead, humpback, or fin whales, we cannot fully estimate the consequence of industrial noise on these species.

## Project-Specific Considerations

**StatOil**

The area within which StatOil proposes to conduct 2-D and 3-D seismic surveys and the area that would be ensonified by the proposed activity is in or adjacent to the fall migration corridor of the BCB bowhead population. Unknown but likely small numbers of bowhead whales may occur in the Chukchi during the summer months. Summer aerial surveys in the Chukchi done for the Minerals Management Service in 2008-2009 reported four (4) sightings of bowhead whales during >8,699 miles of on-transect effort. Significant numbers would only be expected here after the fall migration begins, during late September and October. The StatOil survey will require approximately 90 days, and would be completed around September 15 if start-up begins in mid-July and no significant delays are encountered. If these timelines are met, there would be little overlap of the seismic work with the fall bowhead migration. If the work is delayed or extended, we would expect fall migrant bowhead whales to be exposed to seismic noise.

StatOil will have marine mammal observers on board the vessels. These observers will monitor for the presence of marine mammals during all daylight airgun operations and during any nighttime start-up of the airguns. In their IHA application, StatOil states that:

> When marine mammals are observed within, or about to enter, designated safety zones airgun operations will immediately be powered down (or shut down if necessary). The safety zones to prevent any hearing impairment are defined as the distance from the source to a received level of ≥190 dB for pinnipeds and ≥180 dB for cetaceans. A specific procedure to detect aggregations of baleen whales (12 or more) within the ≥160 dB zone will also be implemented.

StatOil clarifies that "Airgun activity will not resume until the marine mammal or aggregation of baleen whales has cleared the safety radius. In the case of baleen whales, the animal will be considered to have cleared the safety radius if it is visually observed to have left the safety zone, or it has not been seen within the zone for 30 min in case of mysticetes . . ."

StatOil proposes to follow "ramp up" procedures if the airgun has been operating for a period with reduced power or no power. However, the exact ramp up procedures have yet to be developed. They specify that they will follow NMFS guidelines. StatOil stated that:

> A ramp up procedure can be applied only in the following situations:
> • If, after a complete shut down, the entire 180 dB safety zone has been visible for at least 30 min prior to the planned start of the ramp up in either daylight or nighttime. If the entire safety zone is visible with vessel lights and/or night vision devices, then ramp up of the airguns from a complete shut down may occur at night.
> • If one airgun has operated during a power down period, ramp up to full power will be permissible at night or in poor visibility, on the assumption that marine mammals will either be alerted by the sounds from the single airgun and could move away, or may be detected by visual observations.

- If no marine mammals have been sighted within or near the applicable safety zone during the previous 15 min in either daylight or nighttime, provided that the entire safety zone was visible for at least 30 min.

As noted, Statoil plans to conduct 24-hour operations. They note that there will not be periods of total darkness until late August. However, sightability can be decreased by light conditions other than complete darkness. They do not propose to have observers operating at night during ongoing seismic operations at night, ". . . given the very limited effectiveness of visual observation at night. At night, bridge personnel will watch for marine mammals (insofar as practical) and will call for the airguns to be shut down if marine mammals are observed in or about to enter the safety zones. If a ramp up procedure needs to be conducted during nighttime, two marine mammal observers need to be present to monitor marine mammals near the source vessel and to determine if the proper conditions are being met for a ramp up."

There is potential for endangered baleen whales to be exposed to high levels of noise and resultant harm or disturbance if seismic surveys operate during darkness or during periods of limited visibility, especially during periods when very large numbers of whales are in the Chukchi Sea. However, past monitoring of similar seismic operations in the Arctic has found that whales tend to avoid the immediate areas around a seismic vessel, out to the limits of visual detection, normally less than 3 km. Further, acoustic research and monitoring also suggest whale calls are diminished when exposed to seismic noise, although it is not known whether this indicates reduced numbers of whales or simply a reduction in call rates of whales that remain in the area. We have no evidence to indicate that whale densities, avoidance behavior, or reactions to seismic noises are different during night or low-light conditions than during daylight. However, there have been several instances in which active seismic arrays in the Arctic have been powered down due to the observed presence of bowhead whales within the 180dB safety zone. Any diminishment in the capability of ship-based observers to detect these conditions may be expected to increase the numbers of whales so-exposed, and the level of PTS. In shooting approximately 800 km of high-energy seismic in the Beaufort Sea between September 18 and October 3, 2007, monitoring indicated seven (7) whales within the safety zone (three of which were identified as bowhead whales). The proposed Statoil program would shoot much more area, over 5,000 linear km, but in an area where whale densities would be lower (although densities would increase throughout the late fall). By extrapolating the SHELL data, and assuming none of the whales would be detected by ship-based observers, the StatOil program could result in the injurious take of up to 42 bowhead whales by permanent threshold shifts.

We note that StatOil has proposed to take the following measures at night or during periods of poor visibility:

- If during foggy conditions or darkness (which may be encountered starting in late August), the full 180 dB rms safety zone is not visible, the airguns cannot commence a ramp up procedure from a full shut down.

> • If one or more airguns have been operational before nightfall or before the onset of foggy conditions, they can remain operational throughout the night or foggy conditions. In this case ramp up procedures can be initiated, even though the entire safety radius may not be visible, on the assumption that marine mammals will be alerted by the sounds from the single airgun and have moved away.

These measures would provide additional protection from possible harassment or injury to whales by preventing any start up of an array when the safety zone is not visible. Here again, we assume the effectiveness of one or more air guns (e.g., the "mitigation" gun or partial array) in eliciting a behavioral avoidance reaction in whales that would place them outside zones in which they may be injured. While we believe it is very unlikely whales would be injured, and unobserved, during night time or low-visibility conditions, the inability of observers to detect whales under these conditions would mean the actual numbers of whales that may be exposed or harassed by this seismic operation will not be fully known, and that estimates of "takes" must be made from extrapolation of daytime data.

StatOil also clarified that it would adjust its speed and course to avoid harming marine mammals as follows:

> If a marine mammal . . . is detected outside the safety radius and, based on its position and the relative motion, is likely to enter the safety radius, changes of the vessel's speed and/or direct course should be considered if this does not compromise operational safety. For marine seismic surveys using large streamer arrays, course alterations are practically not really possible. The marine mammal activities and movements relative to the seismic vessel will be closely monitored to ensure that the marine mammal does not approach within the safety radius. If the mammal appears likely to enter the safety radius, further mitigative actions will be taken, i.e., power down or shut down of the airgun(s).

Based on this description, we assume that course corrections are not likely to occur and, thus, that shut down is the most likely mitigating measure to be put into place to prevent exposure to noise above the 180 dB threshold. Because course changes for a seismic vessel trailing a full array are not practical, any whales that may be in the path of the vessel are at risk of being struck by the vessel. However, we are aware of no records of whales being struck by seismic vessels in US waters, and consider such an impact to be very remote, particularly in view of the likely avoidance response of whales to seismic noise from the vessel.

In their IHA application, StatOil estimates the maximum total take due to exposure to noise levels greater than 160 dB as 316 bowhead whales, 10 fin whales, and 10 humpback whales, and finds little probability for permanent threshold shifts (above 180 dB) because of the very high noise levels required to produce this effect, the avoidance reactions of the whales, and the very brief period of exposure from a moving noise source. We believe the 160 dB exposure estimates are reasonable, but that potential exists for some whales to be exposed to levels that may cause PTS (although we agree the factors mentioned mitigate this possibility). We also note that an unknown number of whales may be exposed to noise greater than 118-136 dB, which has been shown to cause avoidance by fall migrating bowhead whales in the Beaufort Sea. The biological significance of such avoidance is also unknown.

**SHELL**

SHELL's proposed activities for 2010 include shallow hazards and site clearance surveys over a period of approximately 30 days within Harrison Bay in the Beaufort Sea, between July and October. Much of the acoustic instruments will be very high frequency, with lower ranges above 100 kHz, and would not be expected to have significant detectability to bowhead whales. Several profilers may be used also, and these utilize lower frequencies that would be detectable by bowheads. However, the bathymetric sonar equipment to be used will have a narrow beam width, reducing the probability for a whale to become ensonified by these signals. Also, SHELL reports that measurements of similar equipment in the Beaufort Sea found this equipment generated relatively small sound radii; the 160 dB isopleth extending to less than 14 meters and the 120 dB isopleths reaching 1360 meters. The equipment used for sub-bottom profiling was also low-energy, producing smaller radii (160 dB out to 260 meters). The small 40 inch air gun array would produce the highest noise levels proposed in SHELL's work, with its 160 dB sound isopleths extending to approximately 1,525 meters. All of these are estimates, and would be subject to change pending sound verification measurements.

Their proposed ice-gouge survey would occur in and west of Camden Bay in the eastern Beaufort Sea, in the Chukchi Sea offshore and between the villages of Wainwright and Point Lay, and may also utilize sub-bottom profilers operating at low frequencies. Finally, a proposed strudel scour survey in planned for a period of less than 5 days in the vicinity of Point Thomson. SHELL estimates a maximum of 394 bowhead whales, and 5 humpback whales, may be taken by exposure to noise greater than 160 dB during these surveys. Again, we note that an unknown number of whales may be exposed to noise greater than 118-136 dB, which has been shown to cause avoidance by fall migrating bowhead whales in the Beaufort Sea. The biological significance of such avoidance is also unknown.

SHELL proposes several mitigation measures, which include:

- Timing and locating survey activities to avoid interference with the annual fall bowhead whale hunts from Kaktovik, Nuiqsut (Cross Island), and Barrow;
- Identifying transit routes and timing to avoid other subsistence use areas and communicate with coastal communities before operating in or passing through these areas, and;
- Conducting pre-season sound propagation modeling to establish the appropriate safety and behavioral radii.

Marine mammal monitors on the source vessels will power down or shut down the array as necessary to prevent whales to be exposed to noise levels greater than 180 dB. Ramp up procedures will be followed, and an aerial monitoring effort will be conducted in the Beaufort Sea site clearance and shallow hazard areas from the start of the fall bowhead migration (~August 20). The aircraft will maintain minimum altitudes of 1,000 feet, which should avoid potential harassment of whales at the surface that might otherwise react to a passing aircraft. It is possible a few whales may detect the survey plane and show some reaction, but we do not expect this to result in any significant effects.

## V. CUMULATIVE EFFECTS

Cumulative effects are defined in 50 CFR 402.02 (Interagency Cooperation on the ESA of 1973, as amended): "…those effects of future State or private activities not involving Federal activities that are reasonably certain to occur within the action area of the Federal action subject to consultation." Reasonable foreseeable future federal actions and potential future Federal actions that are unrelated to the proposed action are not considered in the analysis of cumulative effects because they would require separate consultation pursuant to section 7 of the ESA. Cumulative effects are usually viewed as those effects that impact the existing environment and remain to become part of the environment. These effects differ from those that may be attributed to past and ongoing actions within the area since they are considered part of the environmental baseline. Additionally, most structures and major activities within the Chukchi and Beaufort Sea OCS require Federal authorizations from one or more agencies, such as the MMS, Army Corps of Engineers, and the Environmental Protection Agency. Such projects must consult under the ESA on their effects to the bowhead whale, and are therefore not addressed here as cumulative impacts.

The State of Alaska is currently leasing State-owned portions of the Beaufort Sea for oil and gas exploration and production. No sales have occurred nor are planned for the Chukchi Sea by the State. The current State of Alaska Five-Year Oil and Gas Leasing Program published in January 2006 lists Beaufort Sea area wide sales continuing annual sales in October 2006-2010. The State is currently conducting a "best interest finding" in anticipation of leasing over the period 2009-2019. The proposed sales consist of all unleased tide and submerged lands between the Canadian Border and Point Barrow as well as some upland acreage. If any of the scheduled sales occur, additional effects similar to those described for OCS lease sales could occur. All producing fields on the North Slope are onshore and on State leases, with the exception of the Duck Island Unit (which contains the Endicott field). Endicott is on State leases and was the first offshore production facility developed in the Beaufort Sea. Endicott has been producing oil since 1987. Endicott is located on a manmade gravel structure inside the barrier islands in relatively shallow water. Support traffic is over a gravel causeway that also contains the pipeline to shore. New production islands in State waters now include Northstar Island near Prudhoe Bay, and Oooguruk and Nikaitchuq Islands off Harrison Bay.

Oil and gas development is also underway in the Eastern Beaufort Sea off the Canadian Mackenzie Delta. This includes seismic surveys, drilling, and infrastructure and support facilities as described for the US OCS. Seismic programs have recently been conducted off the Mackenzie Delta.

Bowhead whales may be disturbed during the summer in the Canadian Beaufort Sea, if offshore oil and gas exploration and development and production activities occur there in the future. The main area of industry interest to date has centered around the Mackenzie River Delta and offshore of the Tuktoyaktuk Peninsula. This area comprises a minor portion of the bowhead's summer range. Possible disturbance to bowhead whales from helicopters, vessels, seismic surveys, and drilling would be as previously described.

Since offshore oil and gas activities in State waters are generally well shoreward of the bowheads' main migration route, and some of the activities occur inside the barrier islands, the overall effects on bowheads from activities on State leases is likely to be minimal. These impacts could be magnified, however, if construction activity associated with additional development projects were to occur simultaneously, rather than consecutively. For example, construction and drilling noise from multiple drilling sites could result in a long-term, offshore shift in bowhead migration routes. The extra distance and heavier ice encountered could result in slower migration or physiological stress that may noticeably affect the whales. However, the majority of bowhead whales are generally found offshore of State waters.

Some effects on bowhead whales may occur because of activities from lease sales within State waters (within 3 miles of shore). Generally, bowhead whales remain far enough offshore to be found mainly in Federal waters, but they may occur in State waters in some areas, such as the Beaufort Sea southeast and north of Kaktovik and near Point Barrow. If exploration and development and production activities occur on leases from previous or proposed State sales, noise effects on whales may occur as described previously. These effects could include behavioral responses, including local avoidance to noise from aircraft and vessel traffic; seismic surveys; exploratory drilling; construction activities, including dredging; and development drilling and production operations that occur within several miles of the whales.

Future exploration and development within the Canadian Beaufort would present concerns beyond those associated with leasing in the Alaskan Beaufort Sea. The main area of industry interest has been the Mackenzie Delta and offshore of the Tuktoyaktuk Peninsula (MMS 1995). The large estuarine front associated with the Mackenzie Delta and upwellings near the Tuktoyaktuk Peninsula provide conditions which concentrate zooplankton (Moore and Reeves, 1993). These areas are important feeding habitat to the Bering Sea stock. Current State leases with production, such as Endicott, Oooguruk, and Nikaitchuq, are well removed from the normal fall migration route of the bowhead whale. Bowhead whales are not likely to be affected by noise from the these projects due to their distance from the bowhead's fall migration route and the limited distance into the marine environment that noise travels from gravel structures.

Each of the projects described would require some equipment and supplies to be transported to the site by barge or sealift should development and production plans proceed. The process modules and permanent living quarters and other equipment and supplies likely would be transported to these sites on seagoing barges during the open-water season. Barge traffic around Point Barrow is likely to be limited to a short period from mid-August through mid-to-late September and should be completed before the bowhead whale migration reaches this area unless it encounters severe ice conditions. Barge traffic continuing into September is likely to disturb some bowheads during their migration. Whales may react briefly by diving in response to low-flying helicopters and they would seek to avoid close approach by vessels. Oil spill probabilities associated with exploration are extremely low. In the event an oil spill occurred on State leases during the fall bowhead migration, the effects of an oil spill on bowheads would be as have been described in the 2008 biological opinion for federal oil and gas leasing and exploration activities authorized by the Bureau of Ocean Energy Management within the Alaskan Beaufort and Chukchi seas. These effects include inhalation of hydrocarbon vapors, a loss of prey organisms, ingestion of spilled oil or oil-contaminated prey, baleen fouling with a reduction in feeding efficiency, and skin and/or sensory organ damage. These effects would be most pronounced whenever whales were confined to an area of freshly spilled oil. Of course, if the spill occurred over a prolonged period of time, more individuals could be contacted. Some individuals could be killed as a result of prolonged contact with freshly spilled oil, particularly if spills were to occur within ice-lead systems. While oil spills are not considered a direct or indirect effect of the proposed action, they are accounted for here as potential cumulative impacts. A comprehensive discussion of the effects of oil spills on these listed whales may be found in NMFS's 2008 Biological Opinion for Federal oil and gas leasing and exploration by the Minerals Management Service (MMS) within the Alaskan Beaufort and Chukchi Seas (NMFS, 2008).

Activities that are not oil and gas related also affect bowhead whales. Between 1976 and 1992, only three ship-strike injuries were documented out of a total of 236 bowhead whales examined from the Alaskan subsistence harvest (George et al., 1994). The low number of observed ship-strike injuries suggests that bowheads either do not often encounter vessels or they avoid interactions with vessels, or that interactions usually result in the death of the animals. However, there is recent evidence that interaction of bowhead whales with ships and fishing gear may be increasing.

Subsistence harvest by Alaska Natives is another non-OCS activity that affects the bowhead whale. Bowheads are taken in the northern Bering Sea and in the Chukchi Sea on their spring migration and in the Beaufort Sea on their fall migration. Barrow whalers harvest whales during both the spring and the fall migrations. Requests to harvest bowheads also have been made by Canadian and Russian Natives. The Canadian Government granted permission in 1991 to kill one bowhead, and a bowhead was harvested in Mackenzie Bay in the fall of 1991. Additional permits were granted in 1993 and 1994, but no bowheads were harvested in either year. There has been a renewed interest by villages along the Russian Chukchi Sea coast to hunt bowhead whales. At the 1997 IWC, the Commission approved a combined quota allowing an average of 56 bowheads to be landed each year to meet the needs of Eskimos in Alaska and Chukotka Natives of the Russian Far East. The annual number of bowheads landed by Alaskan Natives has ranged from 8 in 1982 to 55 in 2005 (USDOC, 2008). Struck-but-lost figures have been between 5 in 1999 to 82 in 1977.

There currently is a 5-year block quota of 280 bowhead whales landed, authorized by the IWC for 2008-2012. The number of bowheads struck in each year may not exceed 67, except that any unused portion of a strike quota from any year may be carried forward. No more than 15 strikes may be added to the strike quota for any one year. This level of harvest was approved by the IWC under the supposition that it still would allow for continued growth in the bowhead population. It is likely the bowhead whale population will continue to be monitored and that harvest quota will be set accordingly to maintain a healthy bowhead population level.

The cumulative effects of noise on bowheads from offshore oil and gas activities would be similar to that described and summarized for OCS leasing and exploration above and in the 2008 biological opinion for federal oil and gas leasing and exploration activities authorized by the Bureau of Ocean Energy Management within the Alaskan Beaufort and Chukchi seas. The effects from an encounter with aircraft generally are brief, and the whales should resume their normal activities within minutes. Bowheads may exhibit temporary avoidance behavior to vessels at a distance of 1-4 kilometers. Fleeing from a vessel generally stopped within minutes after the vessel passed, but scattering may persist for a longer period. Bowheads also exhibited tendencies for reduced surfacing and dive duration, fewer blows per surfacing, and longer intervals between successive blows. Bowheads appear to recover from these behavioral changes within 30-60 minutes following the end of seismic activity. However, recent monitoring studies indicate that bowhead whales during the fall migration avoid an area around a seismic vessel operating in nearshore waters by a radius of about 20 kilometers. Avoidance did not persist beyond 12 hours after the end of seismic operations. This work also stated that bowhead whales may begin to deflect around a seismic source at distances up to 35 kilometers.

Overall, bowhead whales exposed to noise-producing activities most likely would experience temporary, nonlethal effects. Some avoidance behavior could persist up to 12 hours.

## VI. SYNTHESIS and CONCLUSIONS

This Biological Opinion has considered the effects of authorizing small takes of endangered marine mammals under the Marine Mammal Protection Act for certain oil and gas exploration activities in the U.S. Chukchi and Beaufort seas for the year 2010 on the fin, humpback and bowhead whales. These actions are likely to adversely affect these whales due to vessel operations, noise from marine geophysical (seismic) exploration, and aircraft traffic.

The applicants for the activities considered in this opinion estimate the (maximum) total take of bowhead whales to be 710 with much lesser numbers of fin and humpback whales. The majority of these takes are likely to be by harassment due to acoustic exposure to seismic and vessel noise. A number of whales may be exposed to seismic noise exceeding 180 dB. These levels are believed to be capable of damaging hearing in whales by creating permanent threshold shifts. The numbers of whales expected to be so-exposed is very small, and should be mitigated to some extent by the likelihood the period of exposure would be brief, owing to the movement of both the whale and the seismic vessel. No lethal takes are expected. These estimates were derived through density estimates from various sources that may not reflect the actual numbers of whales in these particular areas, sound propagation figures which are derived from models that may differ from actual conditions, and an assumed "take" received sound level of 160 dB, which may be higher or lower than the actual levels that elicit biologically-significant response from the whales. However, the estimates appear reasonable in view of industry-reported data for past Arctic seismic survey activities. These estimates also represent cetaceans that would have been exposed had they not shown localized avoidance of the source vessel.

As discussed earlier, there is concern that received levels below 160dB are detectable by whales and may cause some behavioral reaction. The numbers of animals so-affected cannot be determined or estimated, depending on many factors including the specific sound propagation characteristics of the area and the age, sex and behavior of the receiving whales. The degree to which whales exposed to these lower received sound levels may react is not known, and will vary with age, sex, and behavior. While there is concern for whales abandoning feeding areas when exposed to seismic noise, it appears that most reaction by whales to seismic disturbance persists only for 12-24 hours, after which time whales would resume their pre-exposure behavior. We note, however, this is an area requiring further study.

Elevated noise levels in the marine environment could alter the hearing ability of whales, causing temporary or permanent threshold shifts. However, information suggests most continuous and impulsive underwater noise levels would be at levels or durations below those expected to injure hearing mechanisms. Nonetheless, marine seismic activities present concerns with respect to hearing, and should be closely conditioned and monitored to avoid these effects. Noise has also been shown to cause avoidance in migrating gray and bowhead whales. Available data do not indicate that noise and disturbance from oil and gas exploration and development activities since the mid-1970s had lasting population-level adverse effects on bowhead whales. Data indicate that bowhead whales are robust, increasing in abundance, and have been approaching (or have reached) the lower limit of their historic population size at the same time that oil and gas exploration activities have been occurring in the Beaufort Sea and, to a lesser extent, the Chukchi Sea.

Research on the effects of offshore seismic exploration in the Beaufort Sea, supported by the testimony of Inupiat hunters based on their own experience, has shown bowhead whales avoid these operations when within 20 km of the source and may begin to deflect at distances up to 35 km (Richardson, 1999a). While such deflections during migration may not be injurious to individual animals, concern is warranted for cumulative noise and multiple disturbances, the consequences of which might include long-term shifts in migrational paths or displacement from nearshore feeding habitats. However, it is unlikely that even these impacts would prevent the survival and recovery of this species, as the primary feeding habitat is considered to be in the Canadian Beaufort and, perhaps, the Bering Sea (Shell, 1998). The Alaskan Beaufort Sea certainly provides feeding habitat for bowhead whales, however the importance of this habitat is not fully understood at this time. Similarly, current data do not fully identify the importance of the Chukchi Sea to fin, humpback, or bowhead whales (it is known to be important as a migrational corridor for bowheads). Concern is warranted over the distribution in time and space of several noise-producing activities. While the activities considered in this opinion will produce in-water noise that will be detectable by endangered whales, there is little physical or acoustic overlap between them owing to the physical location of the activity, the timing of the activity, the relative operational frequency and energy of the devices, or all three. Also, most of the BCB bowhead whales will be east of the action area for much of the operational time of these activities, although the activities would occupy the time frames of at least part of the fall migration.

Similar seismic operations have occurred in the Beaufort and Chukchi seas throughout the last several decades. NMFS has issued MMPA small take authorizations for many of these programs and has required monitoring, which in some cases has employed acoustic arrays to detect whale vocalizations/locations in addition to the observations of ship based observers and aerial monitors. Thus, our consideration of these seismic operations is somewhat unique in that we have data and observations from past actions that are very similar to the proposed work. The monitoring from these efforts indicates varied responses among whales (the large majority of observations have been on bowhead whales), with migrating whales being more responsive to noise and feeding whales less so. Whale calling rates decline in the presence of seismic sounds, and all but a very few whales show localized avoidance of the area near the source vessel. To our knowledge, no whales or other marine mammals have been killed or injured by these past seismic operations, and the BCB population of bowhead whales continues to increase at an annual rate estimated over 3 percent.

Because the Western Arctic bowhead whale population is approaching its pre-exploitation population size and has been documented to be increasing at a roughly constant rate for over 20 years, the impacts of oil and gas industry on individual survival and reproduction in the past have likely been minor (Angliss and Outlaw, 2010). These activities are unlikely to have any effect on the other four stocks of bowhead whales. Similarly, only the western North Pacific stock of humpback whales and the Northeast Pacific stock of fin whales would be potentially affected by oil and gas leasing and exploration activities in the Chukchi and Beaufort seas. The described work would have no effect on the remaining worldwide stocks of humpback or fin whales. No injury or lethal takes are anticipated from these activities, nor are population-level consequences to the stocks expected. Most impacts would be due to harassment of whales, which may lead to behavioral reactions from which recovery is fairly rapid. Mitigative measures will be recommended to reduce harassment and the possibility of harm or lethal takes.

Our ability to study and to predict potential effects of these actions on this species is, and will remain, hampered due to the fact that bowheads are very large baleen whales (e.g., they cannot be measured and weighed when alive, cannot be brought into aquariums and studied, etc.). Data indicate that at least some bowheads are extremely long-lived (100+ years or more), and this longevity can affect the potential for a given individual to be exposed to a high number of acoustic disturbance and pollution events in its lifetime. There is, and will remain, considerable uncertainty about the long-term effects of oil and gas-related activities and cumulative effects on a species whose potential lifespan so exceeds our own. This species could be exposed to multiple anthropogenic stressors at many locations throughout its range and over very many years. This species also inhabits remote areas of the ocean, far (in many cases) from any human settlement, making logistics for many types of study challenging.

After reviewing the current status of the fin, humpback, and bowhead whale, the environmental baseline for the action area, the biological and physical impacts of these actions, and cumulative effects, and in consideration that the described actions are expected to impact only a single stock of each of these endangered whales, and not the species as a whole, it is NMFS's biological opinion that authorization of the described small takes of endangered marine mammals under the Marine Mammal Protection Act for oil and gas exploration activities in the U.S. Chukchi and Beaufort seas by StatOil and SHELL for the year 2010 is not likely to jeopardize the continued existence of the endangered fin, humpback, or bowhead whale. No critical habitat has been designated for these species, therefore none will be affected.

## VII. CONSERVATION RECOMMENDATIONS

Section 7(a)(1) of the ESA directs Federal agencies to utilize their authorities to further the purposes of the Act by carrying out conservation programs for the benefit of endangered and threatened species. Conservation recommendations are discretionary agency activities to minimize or avoid adverse effects of a proposed action on listed species or critical habitat, to help implement recovery plans, or to develop information.

The National Marine Fisheries Service should implement the following measures for these purposes:

1. Vessel operations in the Beaufort and Chukchi seas, including seismic geophysical exploration, should be scheduled to minimize operations in order to reduce potential harassment of bowhead whales. These activities should avoid migratory periods in the spring and fall. Vessel operators should maintain separation with the bowhead whale migrational corridor by remaining 35 miles offshore whenever possible.

2. NMFS should conduct research to describe the impact of exploration activities on the migrational movements and feeding behavior of the bowhead whale. Specific plans should be developed and implemented to monitor the cumulative effects of exploration, development, and production on the bowhead whale. These research designs and results should be reviewed annually to ensure that the information collected is addressing the concerns of NMFS and the affected Native communities.

3. To minimize potential harassment of fin, humpback, and bowhead whales, operators should be advised that aircraft (other than monitoring flights) should observe a minimum altitude of 1,000 feet, weather and safety factors permitting.

4. Upon learning of any unauthorized take of bowhead whales which occurs as a result of OCS exploratory activity, NMFS should immediately notify the assistant Regional Administrator for Protected Resources at (907) 586-7235 of this taking to determine the appropriate and necessary course of action.

5. NMFS should recommend IHA holders take the following measures during operating to reduce potential interference with listed whales:

(1) Reducing vessel speed when within 300 yards of whales, and those vessels capable of steering around groups of whales should do so;
(2) Avoiding multiple changes in direction and speed when within 300 yards of whales; and
(3) Requiring, when weather conditions require, such as when visibility drops, support vessels to adjust speed to avoid injury to whales.

6. NMFS should prohibit authorization of takes of endangered marine mammals due to vessel operation to access work sites through the spring lead system or requiring ice breaking, and require vessels to await open water conditions to avoid impacting bowhead whales during their spring migration (March through June).

## VIII. REINITIATION OF CONSULTATION

This concludes formal consultation on this action. As provided in 50 CFR §402.16, reinitiation of formal consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and if: (1) the amount or extent of incidental take is exceeded; (2) new information reveals effects of the agency action that may affect listed species or critical habitat in a manner or to an extent not considered in this Biological Opinion; (3) the agency action is subsequently modified in a manner that causes an effect to the listed species or critical habitat not considered in this Biological Opinion; or (4) a new species is listed or critical habitat designated that may be affected by this action. In circumstances where the amount or extent of incidental take is exceeded, any operations causing such take must cease pending reinitiation.

## IX. INCIDENTAL TAKE STATEMENT

Section 9 of the ESA and Federal regulations pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity.

Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this incidental take statement.

This opinion does not include an incidental take statement at this time. Pursuant to section 7(b)(4)(C) of the ESA and NMFS regulations at 50 C.F.R. § 402.14(i), NMFS will provide the incidental take statement for the described work following the issuance of regulations or authorizations under Section 101(a)(5) of the Marine Mammal Protection Act and/or its 1994 Amendments.

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