REQUEST FOR AN INCIDENTAL HARASSMENT AUTHORIZATION PURSUANT TO SECTION 101 (A) (5) OF THE MARINE MAMMAL PROTECTION ACT

Covering

Incidental Harassment of Marine Mammals during an OBC Seismic survey in the Liberty Prospect, Beaufort Sea, Alaska in 2008

Submitted by

BP EXPLORATION (ALASKA) INC.

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REQUEST BY BP TO ALLOW THE INCIDENTAL HARASSMENT OF MARINE MAMMALS DURING AN OBC SEISMIC SURVEY IN THE LIBERTY PROSPECT, BEAUFORT SEA, ALASKA, 2008

Summary

BP Exploration Alaska Inc. (BPXA) plans to conduct a 3D, ocean bottom cable (OBC) seismic survey in the Liberty area of the Alaskan Beaufort Sea in 2008. This survey will use a towed airgun array consisting of 8 operating airguns with a maximum discharge volume of 880 cubic inch (in^3) and will take place in shallow waters of maximum 30 ft deep inside the barrier islands. BPXA request that it be issued an Incidental Harassment Authorization (IHA) allowing non-lethal harassment of marine mammals, incidental to the planned seismic surveys. This request is submitted pursuant to Section 101 (a)(5)(D) of the Marine Mammal Protection Act (MMPA), 16 U.S.C. § 1371 (a)(5).

A total of three cetacean species and four species of pinnipeds are known to occur or may occur in the proposed survey area. Of these species, only the bowhead whale is listed as “Endangered” under the ESA. Five additional cetacean species – narwhal, killer whale, harbor porpoise, minke whale and fin whale – could occur in the Beaufort Sea, but each of these species is rare or extralimital and unlikely to be encountered in the Liberty area. BPXA is proposing a marine mammal monitoring and mitigation program to minimize potential impacts of the proposed activity on marine mammals and to document the nature and extent of any of such effects.

The items required to be addressed pursuant to 50 C.F.R. § 216.104, “Submission of Requests” are set forth below. This includes a description of the specific operations to be conducted, the marine mammals occurring in the survey area, proposed measures to mitigate against any potential injurious effects and a plan to monitor any behavioral effects on those marine mammals from the proposed operations.

1 DETAILED OVERVIEW OF OPERATIONS TO BE CONDUCTED

A detailed description of the specific activity or class of activities that can be expected to result in incidental taking of marine mammals.

BP Exploration Alaska Inc. (BPXA) plans to conduct a 3D, ocean bottom cable (OBC) seismic survey in the Liberty area of the Alaskan Beaufort Sea during ~40-60 survey days in July/August 2008, with an “as needed” extension into September/October (in compliance with the CAA). Section 2 provides more details on survey period, duration and factors that can influence those.

The Liberty field contains one of the largest undeveloped light-oil reservoirs near North Slope infrastructure, and the development of this field could recover an estimated 105 million barrels of oil. The field is located in Federal waters of the Beaufort Sea about 5.5 miles offshore in 20 ft of water and approximately 5 to 8 miles east of the existing Endicott Satellite Drilling Island (SDI) (Figure 1). The Liberty development project design and scope has been changed from an offshore stand-alone development (manmade production/drilling island and subsea pipeline) to the use of ultra-extended-reach drilling from the existing Endicott infrastructure involving an expansion of the SDI and use of existing processing facilities. As a result of this change in scope, BPXA believes that Liberty can be developed with a substantially reduced environmental footprint and impact than the originally proposed offshore stand-alone development. The currently available seismic data focused primarily on deeper targets and hence does not image the shallow overburden sections of the well bore optimally.

1.1 Purpose of the proposed OBC seismic survey

The acquisition of additional marine 3D seismic survey data increases the probability of successful implementation of the proposed ultra-extended-reach drilling techniques by providing higher resolution data to assist in imaging for well planning and drilling operations.

The dataset obtained with the proposed seismic survey will replace and augment the data from the Endicott 3D vibroseis survey (1983) and NW Badami (Liberty) 3D vibroseis survey (1995). Various seismic acquisition methods and sound source reduction technologies have been identified and assessed on their technical and environmental performance. The 3D OBC seismic survey method being proposed is the most appropriate for the specific survey goal and objectives of the current Liberty seismic survey.

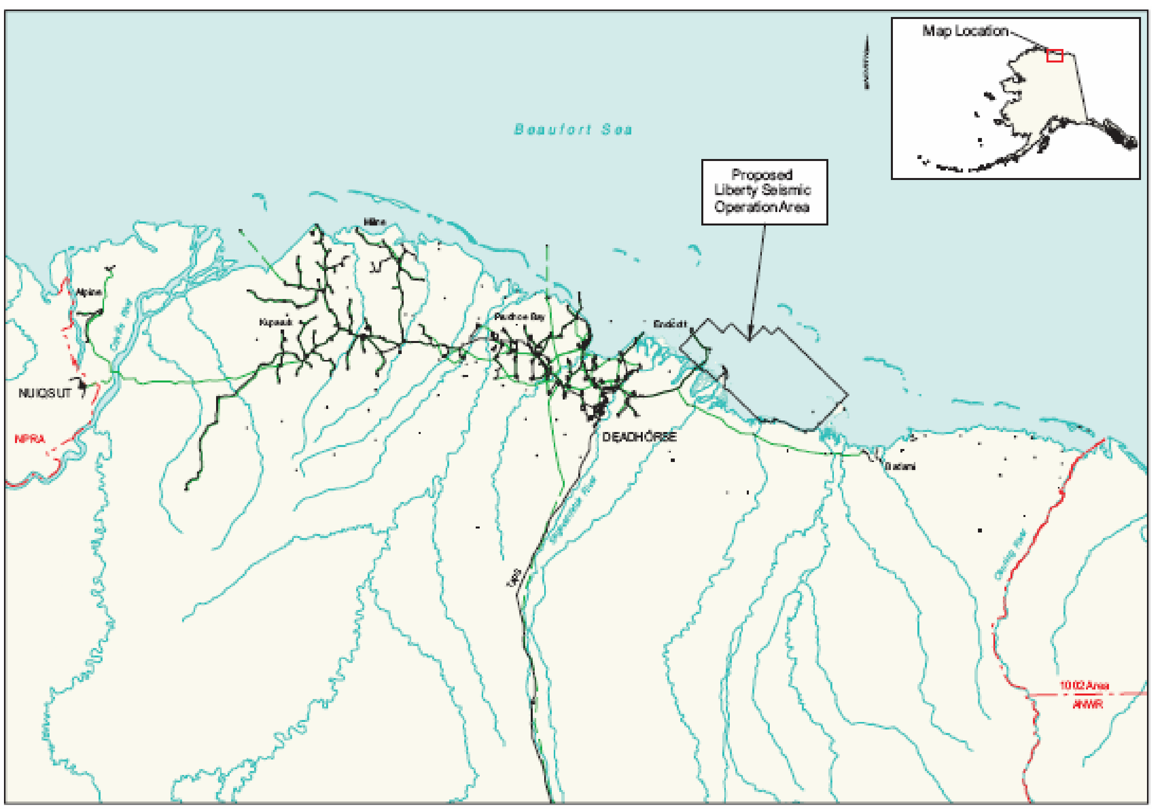

Figure 1. Overview of Liberty area.

1.2 Details of the proposed OBC seismic survey

OBC seismic surveys are used to acquire seismic data in water that is too shallow for large marine-streamer vessels and/or too deep to have grounded ice in the winter. This type of seismic survey requires the use of multiple vessels for cable deployment/recovery, recording, shooting, and utility boats. The planned 3D OBC seismic survey in the Liberty area will be conducted by

CGGVeritas. A detailed overview of the activities of this survey is provided below, with focus on the mobilization procedure, seismic and other sound sources, the deployment and retrieval of the receiver cables, and the recording procedure.

Mobilization

The proposed survey will take place in the Liberty prospect area located in Foggy Island Bay in the Beaufort Sea east of Prudhoe Bay (Figure 1). The vessel fleet involved in the seismic survey activities will consist of approximately eleven vessels as listed below. Details of these vessels (or equivalent vessels if availability changes) are provided in Appendix A.

- Two source vessels, the *M/V Peregrine* (90 x 24 ft) and the *M/V Maxime* (46 x 16 ft).
- One recorder boat/barge, with *M/V Alaganik* barge (80 x 24 ft) and *Hook Point* boat (32 x 15 ft).
- Four small bow picker vessels to deploy and retrieve the receiver cables; these are the *F/V Canvas Back* (32 x 14 ft), *F/V Cape Fear* (32 x 12 ft), *F/V Rumplemimz* (32 x 14 ft) and *F/V Sleep Robber* (32 x 14 ft). These vessels can operate in very shallow waters up to ~18 inch (0.5 m) water depth.
- HSE vessel *Weather or Knot* (38 x 15 ft).
- Crew transport vessel *M/V Qayak Spirit* (42 x 14 ft) and (Northstar's) hovercraft *M/V Arctic Hawk* (42 x 20 ft).
- Crew housing and fuel vessel *M/V Arctic Wolf* (135 x 38 ft).

To deploy and retrieve cables in water depths less than those accessible by the bow pickers, equipment such as swamp buggies and/or Jon boats will be used.

Most vessels will be transported by trucks to the North Slope in late May/early June, where they will be prepared at West Dock. The *Arctic Wolf* will sail around Barrow when ice conditions allow and the hovercraft will travel from West Dock. Vessel preparation will include assembly of navigation and source equipment, cable deployment and retrieval systems and safety equipment. The preparation process will require about 35 days to complete with most activities occurring at West Dock. Once assembled, the deployment, retrieval, navigation and source systems will be tested prior to departure to the project site.

Preparation of the cables ("cable dressing") will be conducted and completed at the CGGVeritas shop in Anchorage. Cable dressing includes attaching lead line and weighting systems to hydrophones to reduce any chance for movement on the sea floor. After completion of the final quality control check, the cables will be transported together with the vessels to West Dock where they will be loaded onto the vessels prior to departure to the project site. Some equipment might be staged at the Endicott facilities.

Seismic survey area details

The well path is the area of primary interest that needs to be fully covered by the seismic data. The size of this zone has been reduced to an absolute minimum of 35.6 mi^2 (92.1 km^2). To obtain full data coverage in this area of interest a larger zone needs to be surveyed to account for accurate migration of acoustic reflections. The total seismic survey extent is 135.8 mi^2 (351.8 km^2) and covers also some mudflat/ areas (Figure 2).

Receiver cable lines consist of a hydrophone and a Field Digitizing Unit (FDU) placed on the cables at 110 ft intervals and placed on the seafloor according to a predefined configuration to record the reflected source signals from the airguns. The cables that will be deployed on mudflats and in very shallow water will consist of marsh phones and are placed in a similar configuration as those deployed at the seabottom. The receiver cables will be oriented in a NE-SW direction. A total of approximately 66 NE-SW oriented receiver lines will be deployed with increasing line spacing from west to east of ~880 ft to ~2,000 ft. Total receiver line length will be ~490 miles (~788 km) of which ~10 miles (16 km) will be laid on mudflats. The source vessels will travel perpendicular over these receiver cables along lines which will have a NW to SE orientation and a varying total length of minimum 2 and maximum 3.5 miles (= 3.2 to 5.6 km). The total source line length is ~2000 miles (~3220 km) in water depths varying from 3 to 30 ft (1 to 9.1 m). The Liberty seismic survey design is planned such that the most critical data along the well path can be acquired as highest priority, before time becomes limited.

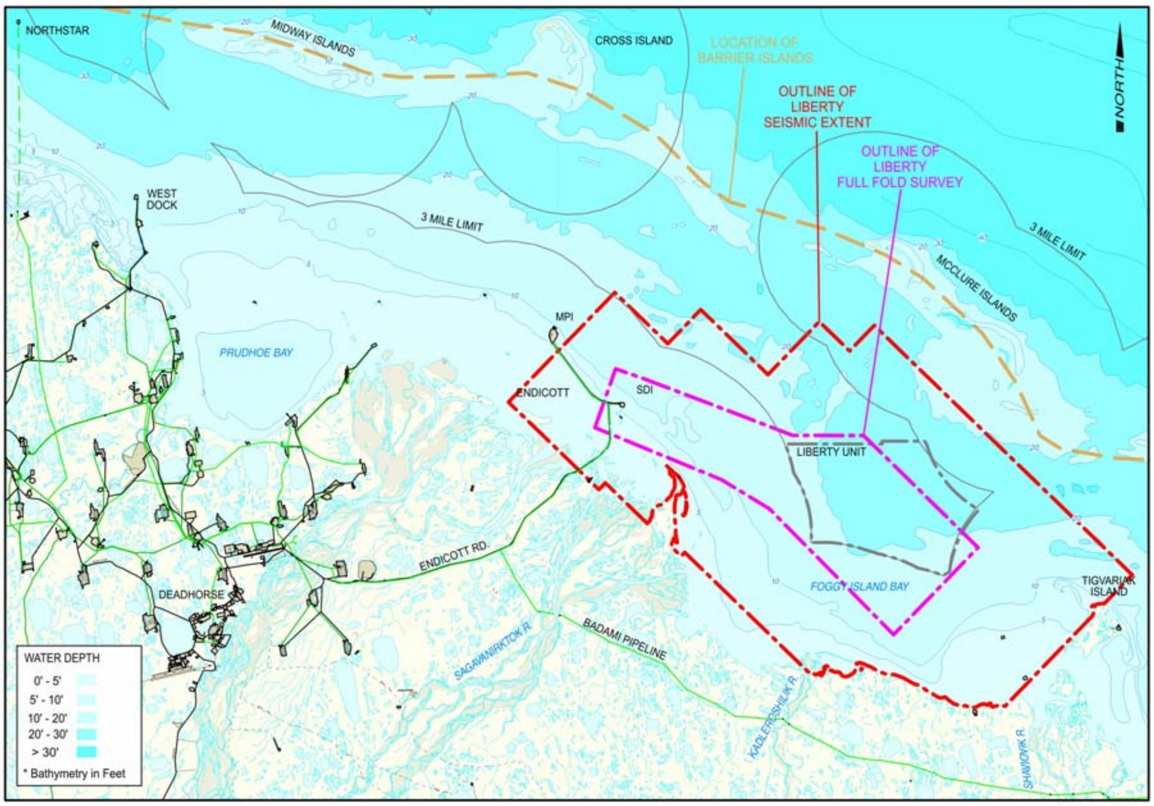

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FIGURE 2. Liberty seismic survey area. The pink line represents the area were data needs to be acquired and the red dashed line shows the outline of the Liberty seismic extent, which is the area covered by the receiver and source lines.

Seismic source

To limit the duration of the total survey, two source vessels will operate, alternating airgun shots. The source vessels will be the *M/V Peregrine* and *M/V Maxime* owned by Peregrine Marine. The sources used for seismic data acquisition will be sleeve airgun arrays with a total discharge volume of 880 cubic inch (in^3) divided over two arrays. Each source vessel will have two 440 in^3 arrays comprised of four guns in clusters of 2 x 70 in^3 and 2 x 150 in^3. The 880 in^3 array has an estimated source level of ~250 dB re 1 μPa.

The arrays will be towed at a distance of ~8-10 m (~26-32 ft) from the source vessel at depths varying from 1-4 m (3-13 ft), depending on the water depth. The vessel will travel along pre-determined lines at ~1 to 5 knots, mainly depending on the water depth. Each source vessel will fire shots every 8 seconds, resulting in 4 second shot intervals with two operating source vessels. The seismic data acquisition will occur over a 24 hr/day schedule.

A summary of the 8-airgun array specification (see Annex B for more details):

Energy Source	Eight 2000 psi Sleeve airguns of 70 in^3 and 150 in^3.
Source output (downward)	0-peak is 6.6 bar-m (236.4 dB re µPa @ 1m 0-pk) Peak-peak is 13.9 bar-m (242.9 dB re µPa @ 1 m pk-pk)
Towing depth of energy source	Between 1-4 m
Air discharge volume	880 in^3.
Dominant frequency components	5-135 Hz

Cable deployment and retrieval

The *M/V Peregrine*, *M/V Maxime* and 4 bow pickers (*Canvas Back, Cape Fear, Rumplemimz and Sleep Robber*) will be used for the deployment and retrieval of the receiver cables. Each of the cable vessels will be powered with twin jet diesels and are rigged with hydraulically driven deployment and retrieval systems ("Squirters"). The *M/V Peregrine* and *M/V Maxime* function both as source and cable vessel and will be capable of carrying 120 hydrophone stations. The receiver cables that will be used are extremely small while still allowing a pull of 800 pounds. The smaller bow picker cable vessels will also carry 120 hydrophone stations and are capable of beach landings. All cable vessels will maintain 24-hr operations.

Part of the receiver cables will be deployed on mudflats to pick up reflected source signals and allow for full interpretation of the data in the area of interest, i.e. well path (pink line in figure 2). The deployment of these receiver cables will be conducted by other equipment that can operate in shallow waters and marshy conditions (such as swamp buggies, Jon boats).

The positions of each receiver need to be established. Due to the variable bathymetry in the survey area, receiver positioning may require more than one technique. A combination of Ocean Bottom Receiver Location (OBRL), GPS and acoustic pingers will be used. For OBRL, the source vessel fires a precisely positioned single gun multiple times along either side of the receiver cables. Multiple gun locations are then calculated at a given receiver to triangulate an accurate position for the receiver. In addition, Dyne acoustical pingers will be located at predetermined intervals at the receiver lines. The pinger locations can be determined using a transponder and allow for interpolation of the receiver locations between the acoustical pingers and as calibration/verification of the OBRL method. The sonar Dyne pingers operate at 19-36 kHz and have a source level of 188-193 dB re µPa at 1m. Because OBRL methods are not accurate in shallow water (< 15 ft), the receiver locations at these depths will be recorded as “as laid” positions, which is the GPS location where the receivers are deployed.

Recording

A Sercel 428 FDU (Field Digitizer Unit) will be located at each hydrophone. This system is lightweight and robust and rated to 14 m (45 ft) of water depth, which will allow it to operate well in the water depths for this survey. For approximately each 30 recorder-hydrophone units one or two battery pack(s) will be deployed at the sea bottom. This battery pack will be equipped with a buoy (or acoustic release) and a pinger, to ensure that the battery packs can be located and retrieved when needed.

The data received at each FDU will be transmitted through the cables to a recorder for further processing. This recorder will be installed on a pin-together boat barge combination and positioned close to the area where data are being acquired. While recording, the pin-together boat barge is stationary and is expected to utilize a four point anchoring system.

Crew housing and transfer

The *M/V Peregrine* is partially self contained and able to house 10 crew including the MMOs. The *M/V Maxime* can accommodate 6 people, including the MMOs. These source vessels will maintain 24-hr operations; crew transfers will take place by crew boats and/or hovercraft. The four bow pickers are too small to house their crew and they will be accommodated at Endicott (MPI). The seismic activity is a 24-hr operation to allow for efficient data acquisition in the short time window available, so crew change vessels will transfer crews approximately every 12 hours. Shifts for crews on the source vessels and cable vessels will be staggered to maximize transport efficiency. Two vessels will be used for these crew transfers, a crew boat (*M/V Qayaq Spirit*) and, if available, the Northstar hovercraft (*Arctic Hawk*).

In addition to housing crew at Endicott facilities, there will be a mother ship mobilized, the *M/V Arctic Wolf.* This vessel will house up to 30 crew, store cable parts and fuel for the other vessels. The *M/V Arctic Wolf* is a propeller driven vessel. Because of its size, the vessel can not be transported by truck to Prudhoe Bay and will mobilize from either Homer or Anchorage and sail around Barrow to the survey area when ice conditions allow and in consultation with beluga whale hunters. Two marine mammal observers will conduct observations off of this vessel during the transits from and to Anchorage/Homer (see Section 13.1). Crew will be housed in other camps in Deadhorse or other operating areas if the *M/V Arctic Wolf* arrives after seismic acquisition begins.

The recorder barge/boat (*M/V Alaganik* and *Hook Point*) can currently accommodate 4 people on the boat portion, which could be increased slightly with 6 additional bunks to a total of 10. The barge portion is dedicated to recording and staging of cables, hydrophones and batteries and can not be used to create additional housing due US Coast Guard restrictions.

Refueling of vessels at sea will be conducted following approved US Coast Guard procedures. Refuel of the boat storage will take place at West Dock, Endicott dock or by delivery from an approved Crowley vessel.

2 DATES, DURATION AND REGION OF ACTIVITY

The date(s) and duration of such activity and the specific geographical region where it will occur.

BP seeks incidental harassment authorization for a period of 60 days in the period July/ August 2008, with an "as needed" extension of additional days after the whaling season (in accordance with the CAA), given the uncertainties in ice conditions and other factors that can influence the survey. Transportation of vessels to West Dock will occur in late May/early June where they will be prepared. The M/V Arctic Wolf will transit from Homer or Anchorage to the site when ice conditions allow and in consideration of the spring beluga hunt in the Chukchi Sea. Seismic data acquisition is planned to start on 1 July depending on the presence of ice. Open water seismic operations can only start when the project area is ice free (i.e. < 10% ice coverage), which in this area normally occurs around 20 July (+/- 14 days). Limited layout of receiver cables might be possible on the mudflats in the Sagavanirktok River delta areas before the ice has cleared.

The project area encompasses 135.8 mi^2 (351.8 km^2) in Foggy Island Bay, Beaufort Sea of which 1% is on mudflats, 18.5% in water depths of 1-5 ft, 12.5% in water depths of 5-10 ft, 43% in water depths of 10-20 ft, and 25% in water depths of 20-30 ft (Figure 2). The approximate boundaries of the total surface area are between 70°11’N and 70°23’N and between 147°10’W and 148°02’W (Figure 2).

Data acquisition will be prioritized. The acquisition order will be defined based on starting date of the survey and weather conditions.

3 SPECIES AND NUMBERS OF MARINE MAMMALS IN AREA

The species and numbers of marine mammals likely to be found within the activity area.

The marine mammal species that occur in the proposed survey area can be classified according to the taxonomic groups shown in Figure 3.

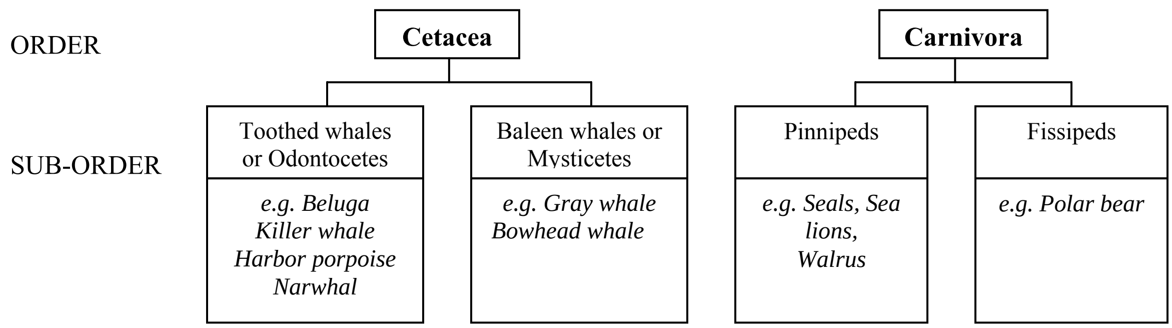

Figure 3. Taxonomic classification of marine mammals that occur in the Beaufort Sea.

Cetaceans and pinnipeds (except walrus) are the subject of this IHA Request to NMFS. In the U.S., the walrus and polar bear are managed by the U.S. Fish & Wildlife Service (USFWS). A separate Letter of Authorization (LOA) Request (under Title 50, Part 18 Subpart J, Non-lethal taking of marine mammals incidental to oil and gas exploration activities in the Beaufort Sea) for this survey will be submitted to USFWS specific to walruses and polar bears.

A total of three cetacean species, four species of pinnipeds, and one marine fissiped (polar bear) are known to occur or may occur in the Beaufort Sea in or near the Liberty area (Table 1). Of these species, only the bowhead whale is listed as “Endangered” under the ESA. Five additional cetacean species – narwhal, killer whale, harbor porpoise, minke whale and fin whale – could occur in the Beaufort Sea, but each of these species is rare or extralimital and unlikely to be encountered in the Liberty area. They are included in the table in light gray and their distribution is briefly discussed in Section 4.5.

To avoid duplication, more details on the number of each marine mammal species occurring in the area is provided in Section 4.

Table 1. Habitat, abundance and conservation status of marine mammals occurring in the Beaufort Sea. Species that are rare and extralimital for the Beaufort Sea and not likely to be encountered in the Liberty area are included in light gray.

Species	Habitat	Abundance	ESA[1]	IUCN[2]	CITES[3]
ODONTOCETES					
Beluga whale *(Delphinapterus leucas)*	Offshore, Coastal, Ice edges	50,000[4] 39,258[5]	Not listed	VU	II
Narwhal *(Monodon monoceros)*	Offshore, Ice edge	Rare[6]	Not listed	DD	II
Killer whale *(Orcinus orca)*	Widely distributed	Rare	Not listed	LR-cd	II
Harbor Porpoise *(Phocoena phocoena)*	Coastal, inland waters	Extralimital	Not listed	VU	II
MYSTICETES					
Bowhead whale *(Balaena mysticetus)*	Pack ice & coastal	10,545[7]	Endangered	LR-cd	I
Gray whale (eastern Pacific population) *(Eschrichtius robustus)*	Coastal, lagoons	488[8] 18,178[9]	Not listed	LR-cd	I
Minke whale *(Balaenoptera acutorostrata)*	Shelf, coastal	0	Not listed	LR-cd	I
Fin whale *(Balaenoptera physalus)*	Slope, mostly pelagic	0	Endangered	EN	I
PINNIPEDS					
Walrus *(Odobenus rosmarus)*	Coastal haul outs, pack ice, ice and water	201,039[10]	Not listed	–	II
Bearded seal *(Erignathus barbatus)*	Pack ice and water	300,000-450,000[11] 4863[12]	Not listed	–	–
Spotted seal *(Phoca largha)*	Pack ice and water	1,000[11] 59,214[13]	Not listed	–	–
Ringed seal *(Pusa hispida)*	Shore-fast ice, pack ice and water	Up to 3.6 million [15] 245,048[16] 326,500[17]	Not listed	–	–
CARNIVORA					
Polar bear *(Ursus maritimus)*	Coastal, ice	>2500[18] 15,000[19]	Not listed	LR-cd	–

Species	Habitat	Abundance	ESA[1]	IUCN[2]	CITES[3]

1. U.S. Endangered Species Act.
2. IUCN Red List of Threatened Species (2003). Codes for IUCN classifications: CR = Critically Endangered; EN = Endangered; VU = Vulnerable; LR = Lower Risk (-cd = Conservation Dependent; -nt = Near Threatened; -lc = Least Concern); DD = Data Deficient.
3. Convention on International Trade in Endangered Species of Wild Fauna and Flora (UNEP-WCMC 2004). Numbers I and II refer to the Cites Appendices, with Appendix I listing species that are threatened with extinction and for which trade is closely controlled and Appendix II species are not necessarily now threatened with extinction but may become so unless trade is closely controlled.
4. Total Western Alaska population, including Beaufort Sea animals that occur there during migration and in winter (Small and DeMaster 1995).
5. Beaufort Sea population (Angliss and Outlaw 2007).
6. Population in Baffin Bay and the Canadian arctic archipelago is ~60,000 (DFO 2004); very few enter the Beaufort Sea.
7. Abundance of bowheads surveyed near Barrow, as of 2001 (George et al. 2004); revised to 10,545 by Zeh and Punt (2005), with annual population growth of 3.4%.
8. Southern Chukchi Sea and northern Bering Sea (Clark and Moore 2002).
9. North Pacific gray whale population in 2001/02 (Rugh et al. 2005).
10. Pacific walrus population (Gilbert et al. 1992, referenced in Angliss and Outlaw 2007).
11. Alaska population (USDOI/MMS 1996).
12. Eastern Chukchi Sea population (NMML, unpublished data).
13. 1,000 is estimate of Alaska Beaufort Sea population (USDOI/MMS 1996). 59,214 is total Alaskan population estimate as in Angliss and Outlaw (2005), based on 1992/'93 aerial survey counts (Rugh et al. 1997) with correction factor applied (Lowry et al. 1998).
14. Bering Sea population (Burns 1981), no reliable estimate for the size of the Alaska ribbon seal stock is available (Angliss and Outlaw, 2005).
15. Alaska estimate (Frost et al. 1988 in Angliss and Lodge 2004).
16. Bering/Chukchi Sea population (Bengston et al. 2000).
17. Alaskan Beaufort Sea population estimate (Amstrup 1995).
18. Amstrup et al (2001).
19. NWT Wildlife and Fisheries, http://www.nwtwildlife.rwed.gov.nt.ca/Publications/speciesatriskweb/polarbear.htm

4 STATUS AND (SEASONAL) DISTRIBUTION OF THE AFFECTED SPECIES OR STOCKS OF MARINE MAMMALS

> A description of the status, distribution, and seasonal distribution (when applicable) of the affected species or stocks of marine mammals likely to be affected by such activities

This Section contains information on the population status of the marine mammal species that occur in the Beaufort Sea and that might be affected by the seismic survey in the Liberty area. It also provides more details on the temporal and spatial distribution and abundance taking into account the most recent data available. Bowhead whale (*Balaena mysticetus*) is the only marine mammal species listed as threatened or endangered under the ESA that is likely to occur in the project area.

The marine mammal species expected to be encountered most frequently throughout the seismic survey in the Liberty area is the ringed seal. The bearded and spotted seal can also be observed but to a far lesser extent than the ringed seal. Due to its distribution, encounters with the walrus are possible but not expected. However, anecdotal reports suggest that walrus may be occurring somewhat more frequently in the project area than they have in the past. Presence of beluga, bowhead and gray whales in the shallow water environment within the barrier islands is possible but expected to be very limited. More detailed information for each species is provided below.

4.1 Odontocetes

4.1.1 Beluga (Delphinapterus leucas)

Distribution

The beluga whale is an arctic and subarctic species with a circumpolar distribution in the Northern Hemisphere and occurs between 50º and 80ºN (Reeves et al. 2002). In Alaska, beluga whales comprise five distinct stocks: Beaufort Sea, eastern Chukchi Sea, eastern Bering Sea, Bristol Bay, and Cook Inlet (O'Corry-Crowe et al. 1997). For the proposed project, only individuals from the Beaufort Sea and possibly the eastern Chukchi Sea stocks may be encountered.

Beluga whales of the Beaufort stock winter in the Bering Sea, summer in the eastern Beaufort Sea, and migrate in offshore waters of western and northern Alaska (Angliss and Lodge 2007). The majority of belugas in the Beaufort stock migrate into the Beaufort Sea in April or May, although some whales may pass Point Barrow as early as late March and as late as July (Braham et al. 1984; Ljungblad et al. 1984; Richardson et al. 1995). The spring-migration routes through ice leads are similar to those of the bowhead whale. Much of the Beaufort Sea seasonal population enters the Mackenzie River estuary for a short period from July through August to molt their epidermis, but they spend most of the summer in offshore waters of the eastern Beaufort Sea, Amundsen Gulf and more northerly areas (Davis and Evans 1982; Harwood et al. 1996; Richard et al. 2001). Belugas are rarely seen in the central Alaskan Beaufort Sea during the early summer. During late summer and autumn, most belugas migrate westward far offshore near the pack ice (Frost et al. 1988; Hazard 1988; Clarke et al. 1993; Miller et al. 1999), with the main fall migration corridor ~100+ mi (~160+ km) north of the coast. Satellite-linked telemetry data show that some belugas of this population migrate west considerably farther offshore, as far north as 76º to 78ºN latitude (Richard et al. 1997, 2001). Small numbers of belugas have also been observed well south of the southern edge of the pack-ice, but always seaward of the barrier islands Johnson (1979).

Beluga whales from the eastern Chukchi stock are assumed to winter in the Bering Sea (Angliss and Lodge 2004). They are known to congregate in Kasegaluk Lagoon during summer; however, evidence from a small number of satellite-tagged animals suggests that some of these whales may subsequently range into the Arctic Ocean north of the Beaufort Sea. Suydam et al. (2005) put satellite tags on 23 beluga whales captured in Kasegaluk Lagoon in late June and early July from 1998 to 2002. Five of these whales moved far into the Arctic Ocean and into the pack ice to 79/80°N. These and other whales moved to areas as far as 680 miles (1,100 km) offshore between Barrow and the Mackenzie River delta spending time in water with 90% ice coverage. These results suggest possible overlap of the Chukchi and Beaufort Sea beluga whale populations.

In summary, most beluga whales migrate well offshore away from the proposed project area, although there is a possibility that they could occur near the project area.

Population status

The Beaufort Sea beluga whale population is estimated to contain 39,258 individuals with a minimum estimation for this stock at 32,453 (Angliss and Outlaw 2007). This estimate is based on the application of a sightability correction factor of 2× to the 1992 uncorrected census of 19,629 individuals made by Harwood et al. (1996). This estimate was obtained from a partial survey of the known range of the Beaufort Sea population and may be an underestimate of the true population size. The current population trend of the Beaufort Sea stock of beluga whales is unknown, but this population is not considered to be a strategic stock by NMFS (Angliss and Outlaw 2007).

The eastern Chukchi Sea population is estimated at 3,710 animals (Angliss and Outlaw 2007). This estimate is based on surveys conducted from 1989 to 1991 (Frost et al. 1993). Although other aerial survey counts have been conducted in 1998 and 2002 (DeMaster et al. 1998, Lowry and Frost 2002, cited in Angliss and Outlaw 2007), the abundance estimate from the 1989 to 1991 surveys is still considered to be the most reliable for the eastern Chukchi Sea beluga whale stock. Survey effort was concentrated on the 105 mile (170 km) long Kasegaluk Lagoon where belugas are known to occur during the open-water season. The actual number of beluga whales recorded during the surveys was much lower (1,200). Correction factors to account for animals that were underwater (2.62 x) and for the proportion of newborns and yearlings that were not observed due to their small size and dark coloration (1.18 x) were used to calculate the estimate. The estimate is considered to be a minimum population estimate for the eastern Chukchi stock because the surveys on which it was based did not include offshore areas where belugas are also likely to occur. This population is considered to be stable.

Subsistence hunt

Beluga whales are an important subsistence resource of Inuit Natives in Canada and are also important locally to Inupiat Natives in Alaska. The mean annual harvest of beluga whales by Alaska Natives in the Beaufort Sea was 53 whales between 1999 and 2003 (Angliss and Outlaw 2007 and references therein). The mean annual take of Beaufort Sea beluga whales in Canadian waters was 99 whales during the same time period. The Beaufort Sea beluga-whale stock is not considered to be "depleted" under the Marine Mammal Protection Act, or "threatened" or "endangered" under the ESA.

Beluga whales from the eastern Chukchi Sea stock are an important subsistence resource for residents of the village of Point Lay, adjacent to Kasegaluk Lagoon, and other villages in northwest Alaska. Each year, hunters from Point Lay drive belugas into the lagoon to a traditional hunting location. The belugas have been predictably sighted near the lagoon from late June through mid- to late July (Suydam et al. 2001). The annual subsistence take of eastern Chukchi Sea beluga whales by Alaska Natives averaged 65 during the period from 1999 to 2003. In August 2007 a total of 70 belugas were caught in Kotzebue. Hundreds of large male belugas suddenly appeared near the beach, two months early and in numbers not seen since 1996 (from Anchorage Daily news, 13 August 2007).

4.2 Mysticetes

4.2.1 Bowhead Whale (Balaena mysticetus)

Distribution

Bowhead whales only occur at high latitudes in the northern hemisphere and have a disjunct circumpolar distribution (Reeves 1980). They are one of only three whale species that spend their entire lives in the Arctic. Five stocks are recognized for management purposes (IWC 1992). The smallest of these stocks occur in Baffin Bay, Davis Strait, Hudson Bay (Canadian Arctic and West Greenland), Okhotsk Sea (Eastern Russia) and Northeast Atlantic from Spitzbergen westward to eastern Greenland. The largest stock is the western Arctic or Bering–Chukchi–Beaufort (BCB) stock, which occurs in or near the project area.

Whales from the western Arctic stock winter in the Bering Sea and migrate through the Bering Strait, Chukchi Sea and Alaskan Beaufort Sea to the Canadian Beaufort Sea, where they feed during the summer (Moore and Reeves 1993). Spring migration through the Chukchi and the western Beaufort Sea occurs through offshore ice leads, generally from March through mid-June

(Braham et al. 1984; Moore and Reeves 1993). Some bowheads arrive in coastal areas of the eastern Canadian Beaufort Sea and Amundsen Gulf in late May and June, but most remain among the offshore pack ice of the Beaufort Sea until mid summer. Bowheads generally start their westward migration towards the Bering Sea late August through mid- or late October. Fall migration period through Alaskan waters primarily occurs during September and October. However, in recent years a small number of bowheads have been seen or heard offshore from the Prudhoe Bay region during the last week of August (Treacy 1993; LGL and Greeneridge 1996; Greene 1997; Greene et al. 1999; Blackwell et al. 2004). Consistent with this, Nuiqsut whalers have stated that the earliest arriving bowheads have apparently reached the Cross Island area earlier in recent years than formerly (T. Napageak, pers. comm.). Westbound bowheads typically reach the Barrow area in mid-September, and remain in that area until late October (e.g., Brower 1996). However, over the years, local residents reported small numbers of bowhead whales feeding off Barrow during the summer. Bowhead whales of the western Arctic stock may also occur in small numbers in the Bering and Chukchi seas during the summer (Rugh et al. 2000 in Angliss and Lodge 2004).

The migration routes of bowheads appear to be correlated with ice coverage, with a shift farther offshore during years with higher-than-average ice coverage (Moore 2000; Treacy et al. 2006). During fall migration, most bowheads migrate west in water ranging from 15 to 200 m deep (Miller et al. 2002 in Richardson and Thomson 2002). Some individuals enter shallower water, particularly in light ice years, but few whales are ever seen shoreward of the barrier islands in the Alaskan Beaufort Sea.

Because the Liberty seismic survey will take place shoreward of the barrier islands in very shallow waters from 3 to 30 ft (1 to 9.1 m), few bowhead whales are likely to occur in the project area. Bowhead whales would be most likely to occur in or near the project area during fall migration in September and October.

Population status

The pre-exploitation population of bowhead whales in the Bering, Chukchi, and Beaufort seas is estimated to have been 10,400-23,000 whales in 1848 – compared to an estimate between 1,000 and 3,000 animals in 1914 near the end of the commercial whaling period (Woodby and Botkin 1993). Up to the early 1990s, the population size was believed to be increasing at a rate of about 3.2% per year (Zeh et al. 1996; Angliss and Lodge 2002) despite annual subsistence harvests of 14–74 bowheads from 1973 to 1997 (Suydam et al. 1995). The latest estimate from an additional census in 2001 suggests an annual population growth rate of 3.4% (95% CI 1.7–5%) from 1978 to 2001 and a population size (in 2001) of ~10,470 animals (George et al. 2004), recently revised to 10,545 by Zeh and Punt (2005). Assuming a continuing annual population net growth of 3.4%, the 2008 bowhead population may number around 13,330 animals. The large increases in population estimates that occurred from the late 1970s to the early 1990s were partly a result of actual population growth, but were also partly attributable to improved census techniques (Zeh et al. 1993).

The Western Arctic bowhead whale stock has been increasing in recent years; the current estimate of 10,545 is between 19% and 105% of the pre-exploitation abundance (estimates ranging roughly from 10,000 to 55,000) and this stock may now be approaching its carrying capacity (Brandon and Wade 2004, cited in Angliss and Outlaw 2007). However, the stock remains classified as a strategic stock because the bowhead whale is listed as "endangered" under the ESA and therefore also designated as "depleted" under the MMPA. For the next 5-year evaluation of stock status the criteria for recovery of large whales in general (Angliss et al. 2002) and bowhead whales in particular (Shelden et al. 2001) will be used to determine whether the western Arctic bowhead whale stock can be delisted. In a recent publication the evaluation of extinction risk for the western Arctic bowhead whale stock suggested that this population should be considered for reclassification under the ESA (Gerber et al. 2007).

Subsistence hunt

The spring and fall bowhead whale migrations are subject to important subsistence hunts by the local Inupiat people. The spring subsistence hunt occurs from March to June, with participation by people from villages located from St. Lawrence Island to Barrow. In autumn, westward-migrating bowhead whales reach the Kaktovik and Cross Island (Nuiqsut) areas in early September, and that is when the subsistence hunts for bowheads in these areas typically begin (Kaleak 1996; Long 1996; Galginaitis and Koski 2002; Galginaitis and Funk 2004, 2005; Koski et al. 2005). The hunt at those two locations continues until the end of September, depending on weather conditions and when/if the quota is reached. Autumn whaling near Barrow normally begins in mid-September, but may begin as early as August if whales are observed and ice conditions are favorable (USDOI/BLM 2005). Whaling near Barrow can continue into October, depending on the quota and conditions.

4.2.2 Gray Whale (Eschrichtius robustus)

Distribution

Gray whales originally inhabited both the North Atlantic and North Pacific oceans. The Atlantic populations are believed to have become extinct by the early 1700s. The North Pacific gray whales are divided into two populations, the western and eastern north Pacific gray whales that are treated as separate management units. Eastern Pacific gray whales breed and calve in the protected waters along the west coast of Baja California and the east coast of the Gulf of California from January to April (Swartz and Jones 1981; Jones and Swartz 1984). At the end of the breeding and calving season, most of these gray whales migrate about 8,000 km, generally in shallow waters along the west coast of North America, to the main summer feeding grounds in the northern Bering and Chukchi seas (Tomilin 1957; Rice and Wolman 1971; Braham 1984; Nerini 1984).

Most summering eastern Pacific gray whales have historically congregated in the northern Bering Sea, particularly off St. Lawrence Island in the Chirikov Basin (Moore et al. 2000a), and in the southern Chukchi Sea. It is believed that changing oceanographic conditions, resulting in a decline of the benthic prey base for gray whales in the Chirikov Basin, moved feeding gray whales to areas north of the Bering Strait (Moore et al. 2003). A satellite tagging study conducted in 2005 revealed that a majority of the whales spent most of their time in the Chukchi Sea, and primarily in Russian waters. The most favored feeding area was NNW of the Bering Strait in the Chukchi Sea, where three whales spent August through mid-November. One of these whales traversed the Chukchi west to Wrangell Island, where it spent the month of August, with its route taking it to 72ºN (Mate, 2006). In recent years gray whale sightings have increased at Point Barrow. Moore et al. (2000b) reported that during the summer feeding season, gray whales in the Chukchi Sea were clustered along the shore primarily between Cape Lisburne and Point Barrow and were associated with shallow, coastal shoal habitat. Gray whales were also observed clustered in near shore waters at Point Hope, southwest of Point Hope and between Icy Cape and Point Barrow, as well as in offshore waters northwest of Point Barrow at Hanna Shoal. In July 2005 tagged whales were observed to use the areas between Pt. Barrow and Icy Cape (Mate, 2006). In the spring of 2003 and 2004, a few tens of gray whales were seen near Barrow by early-to-mid June (LGL Ltd and NSB-DWM, unpubl. data). No gray whales were sighted during vessel observations north of Barrow in 2002 or 2005 (Harwood et al. 2005; Haley and Ireland 2006).

Historically only a small number of gray whales have been sighted in the Beaufort Sea east of Point Barrow. Hunters at Cross Island (near Prudhoe Bay) took a single gray whale in 1933 (Maher 1960). During the extensive aerial survey programs funded by MMS and industry, only one gray whale was sighted in the central Alaskan Beaufort Sea from 1979 to 1997. Small numbers of gray whales were sighted on several occasions in the central Alaskan Beaufort, mainly in the Harrison Bay area (Miller et al. 1999; Treacy 2000). One single sighting of a gray whale was made on 1 August 2001 near the Northstar production island (Williams and Coltrane 2002). Several single gray whales have been seen farther east in the Canadian Beaufort Sea (Rugh and Fraker 1981; LGL Ltd., unpubl. data), indicating that small numbers must travel through the Alaskan Beaufort during some summers. Given the infrequent occurrence of gray whales in the Beaufort Sea east of Point Barrow, it is possible but unlikely that gray whales will be encountered near the planned seismic activities in the Liberty area.

Population status

The larger eastern Pacific gray whale population recovered significantly from commercial whaling during its protection under the ESA and was delisted in 1994. In 1998 the population size was estimated to be 26,635 (Rugh et al. 1999; Angliss and Lodge 2002; NMFS 2002). However, abundance estimates since 1998 indicate a consistent decline, and Rugh (2003 in Keller and Gerber 2004; see also Rugh et al. 2005) estimated the population to be 17,500 in 2002. The lower population estimates were thought to be an indication that the abundance was responding to environmental limitations as the population approaches the carrying capacity of its environment, but there is still an ongoing debate around the cause of the decreasing gray whale population trend. The eastern Pacific stock is not considered by NMFS to be endangered or to be a strategic stock.

Subsistence hunt

Subsistence hunters in Alaska and Russia have traditionally harvested whales from the eastern Pacific gray whale population. The U.S. and Russia have agreed that the quota will be shared with an average annual harvest of 120 whales by the Russians in Chukotka and 4 whales by the Makah Indian Tribe. Inupiat subsistence hunters have permits to hunt bowhead whales but not gray whales. The only reported takes by subsistence hunters in Alaska during this decade occurred in 1995, and the Makah Tribe harvested one whale in 1999 (IWC 2001) and one (illegally) in 2007.

4.3 Pinnipeds

4.3.1 Pacific Walrus (Odobenus rosmarus divergens)

Although the walrus is managed by U.S. Fish & Wildlife Service and is not a subject of this IHA Request to NMFS, the following account is included for completeness. BP will submit a walrus and polar bear LoA request to USFWS for the proposed seismic survey in the Liberty area.

Distribution

There are two recognized subspecies of walrus: (1) the Pacific and (2) the Atlantic walrus. Walruses are migratory, moving south with the advancing ice in autumn and north as the ice recedes in spring (Fay 1981). The Pacific walrus spends the winter in the Bering Sea. Spring migration usually begins in April, and most of the walruses move north through the Bering Strait by late June. Females with calves comprise most of the early spring migrants and nearly all the adult females with dependent young migrate into the Chukchi Sea during the summer, while a substantial number of adult males remain in the Bering Sea. Although most of the population of Pacific walrus moves to the Chukchi Sea during summer, several thousands aggregate in the Gulf of Anadyr and in Bristol Bay (Angliss and Outlaw 2007). Two large arctic areas are occupied — from the Bering Strait west to Wrangell Island and along the northwest coast of Alaska from about Point Hope to north of Point Barrow. Although a few walruses may move east throughout the Alaskan portion of the Beaufort Sea to Canadian waters during the open-water season, the majority of the Pacific population occurs west of 155° W, with the highest seasonal abundance along the pack-ice front (Sease and Chapman 1988). With the southern advance of the pack ice in the Chukchi Sea during the fall (October-December), most of the walrus population migrates south through the Bering Strait. Solitary animals occasionally may overwinter in the Chukchi Sea and in the eastern Beaufort Sea.

Population status

The size of the Pacific walrus population has never been known with certainty and is believed to have fluctuated markedly in response to varying levels of human exploitation (Fay et al. 1989). The North Pacific walrus population was estimated at about 201,039 animals in 1990 (Gilbert et al., 1992 referenced in Angliss and Outlaw 2007), comprising about 80% of the world population. After 1990, aerial survey efforts to estimate population size were suspended due to unresolved problems with survey methods. Participants of the USFWS and U.S. Geological Survey workshop in 2000 on walrus survey methods recommended investing in research on walrus distribution and haul out patterns and exploring new survey tools, including remote sensing systems.

Subsistence hunt

Walruses are hunted primarily from June through mid-August in Chukchi waters to the west of Point Barrow and southwest to Peard Bay. Walruses rarely occur in the Beaufort Sea north and east of Barrow although there were some sightings of walrus hauling out at Northstar and Endicott. The harvest effort peaks in July and August and is often conducted simultaneously with the bearded seal hunt. The annual walrus harvest by Barrow residents ranged from 7 to 206 animals from 1990 to 2002, and ranged from 0 to 4 and 0 to 153 animals for Point Lay and Wainwright communities, respectively (Fuller and George 1997; Schliebe 2002 in USDOI/BLM 2005; USDOI/BLM 2003).

4.3.2 Bearded Seal (Erignathus barbatus)

Distribution

Bearded seals are associated with sea ice and have a circumpolar distribution (Burns 1981). During the open-water period, bearded seals prefer mainly relatively shallow areas no deeper than 200 m (e.g., Harwood et al. 2005), because they are predominantly benthic feeders (Burns 1981).

The bearded seal is the largest of the northern phocids. Bearded seals have occasionally been reported to maintain breathing holes in sea ice and broken areas within the pack ice, particularly if the water depth is <200 m. Bearded seals apparently also feed on ice-associated organisms when they are present, and this allows a few bearded seals to live in areas considerably more than 200 m deep.

Seasonal movements of bearded seals are directly related to the advance and retreat of sea ice and to water depth (Kelly 1988). During winter, most bearded seals in Alaskan waters are found in the Bering Sea. In the Chukchi and Beaufort seas, favorable conditions are more limited, and consequently, bearded seals are less abundant there during winter. From mid-April to June, as the ice recedes, some of the bearded seals that overwinter in the Bering Sea migrate northward through the Bering Strait. During the summer they are found near the widely fragmented margin of multi-year ice covering the continental shelf of the Chukchi Sea and in nearshore areas of the central and western Beaufort Sea. Bearded seal densities in the pack ice of the northern Chukchi Sea appear to be low as only three bearded seals were observed during a survey that passed through the proposed seismic survey area in early August of 2005 (Haley and Ireland 2006). Suitable habitat is more limited in the Beaufort Sea where the continental shelf is narrower and the pack ice edge frequently occurs seaward of the shelf and over water too deep for benthic feeding. The preferred habitat in the western and central Beaufort Sea during the open water period is the continental shelf seaward of the scour zone. Marine mammal observations conducted during seismic surveys in nearshore waters in the Alaskan Beaufort Sea from 1996 to 2001 identified 454 seals during the periods that no seismic guns were active. Of these seal species 4.4% were bearded seals (Moulton and Lawson 2002).

Population status

Early estimates of the Alaska stock of bearded seals range from about 300,000 to 450,000 individuals (MMS 1996). Surveys flown in the Eastern Chukchi Sea during May-June 1999 and 2000 indicated densities of 0.07 seals/km^2 and 0.14 seals/km^2, respectively, with consistently high densities along the coast to the south of Kivalina (Bengtson et al. 2005, referenced in Angliss and Outlaw 2007). Because no correction factor is available, these densities cannot be used to develop an abundance estimate and hence no reliable population estimate for the Alaska stock of bearded seals exists. The Alaska stock of bearded seals is not classified by NMFS as endangered or a strategic stock.

Subsistence hunt

Seals in general, and also bearded seals, are an important species for Alaskan subsistence hunters. As of August 2000, the subsistence harvest database indicated that the estimated number of bearded seals harvested for subsistence use per year in Alaska is 6,788.

4.3.3 Spotted Seal (Phoca largha)

Distribution

Spotted seals (also known as largha seals) occur in the Beaufort, Chukchi, Bering and Okhotsk seas, and south to the northern Yellow Sea and western Sea of Japan (Shaughnessy and Fay 1977). Spotted seals overwinter in the Bering Sea and inhabit the southern margin of the ice during spring (Shaughnessy and Fay 1977).

During spring when pupping, breeding, and molting occur, spotted seals are found along the southern edge of the sea ice in the Okhotsk and Bering seas (Quakenbush 1988; Rugh et al. 1997). In late April and early May, adult spotted seals are often seen on the ice in female-pup, male-female pairs, or in male-female-pup triads. Subadults may be seen in larger groups of up to two hundred animals. During the summer, spotted seals are found in Alaska from Bristol Bay through western Alaska to the Chukchi and Beaufort seas. They are primarily present in the Bering and Chukchi seas, and some range into the Beaufort Sea from July until September (Rugh et al. 1997; Lowry et al. 1998). At this time of year, spotted seals haul out on land part of the time, but also spend extended periods at sea. The seals are commonly seen in bays, lagoons and estuaries, but also range far offshore as far north as 69–72ºN. In summer, they are rarely seen on the pack ice, except when the ice is very near to shore. As the ice cover thickens with the onset of winter, spotted seals leave the northern portions of their range and move into the Bering Sea (Lowry et al. 1998).

Relatively low numbers are present in the Beaufort Sea. A small number of spotted seal haul outs are (or were) located in the central Beaufort Sea in the deltas of the Colville River and, previously, the Sagavanirktok River. Historically, these sites supported as many as 400–600 spotted seals, but in recent times <20 seals have been seen at any one site (Johnson et al. 1999). In total, there are probably no more than a few tens of spotted seals along the coast of the central

Alaska Beaufort Sea during summer and early fall. A total of 12 spotted seals were positively identified near the source vessel during open-water seismic programs in the central Alaskan Beaufort Sea during 6 years from 1996 to 2001 (Moulton and Lawson 2002, p. 317). Numbers seen per year ranged from zero (in 1998 and 2000) to four (in 1999).

Population status

Early estimates of the world population of spotted seals range from 370,000 to 420,000 (Burns 1973 cited in Angliss and Outlaw 2007), and the size of the Bering Sea population, including animals in Russian waters, was estimated to be 200,000–250,000 animals (Bigg 1981). Based on aerial survey counts conducted in 1992 over the Bering Sea pack ice in spring and in 1993 along known haul out sites on the western Alaska coast during summer, the population is estimated to be most likely between several thousand and several tens of thousands (Rugh et al. 1997).

A reliable estimation of the spotted seal populations in Alaskan waters is not available. When a preliminary correction factor is applied to the counts of the 1992/'93 aerial survey data, the Alaskan spotted seal population can be estimated at 59,214 animals (Angliss and Outlaw 2007). This correction factor is derived from a movement and behavior study of spotted seals in Kakegaluk Lagoon, where results from satellite transmitters on 4 spotted seals showed that seals spend 6.8% of their time at haul outs (Lowry et al., 1998). The Alaska stock of spotted seals is not classified as endangered or as a strategic stock by NMFS (Hill and DeMaster 1998).

Subsistence hunt

Spotted seals are an important species for Alaskan subsistence hunters, primarily in the Bering Strait and Yukon-Kuskokwim regions. As of August 2000, the subsistence harvest database indicated that the estimated number of spotted seals harvested for subsistence use per year is 5,265 (Angliss and Outlaw 2007).

4.3.4 Ringed Seal (Pusa hispida)

Distribution

Ringed seals have a circumpolar distribution and occur in all seas of the Arctic Ocean (King 1983). They are closely associated with ice, and in the summer they often occur along the receding ice edges or farther north in the pack ice. In the North Pacific, they occur in the southern Bering Sea and range south to the seas of Okhotsk and Japan. They are found throughout the Beaufort, Chukchi, and Bering seas (Angliss and Lodge 2004).

Ringed seals are year-round residents in the northern Chukchi and Beaufort Seas and, in years of extensive ice coverage, they can occur as far south as Bristol Bay (Angliss and Outlaw 2007). The ringed seal is the most frequently encountered seal species in the area. During winter, ringed seals occupy landfast (but not grounded) ice and offshore pack ice of the Bering, Chukchi and Beaufort seas preferably on large floes (i.e., > 48 m in diameter) (Simpkins et al. 2003). In winter and spring, the highest densities of ringed seals are found on stable landfast ice. However, in areas where there is limited fast ice but wide expanses of pack ice, including the Beaufort Sea, Chukchi Sea and Baffin Bay, total numbers of ringed seals on pack ice may exceed those on shorefast ice (Burns 1970; Stirling et al. 1982; Finley et al. 1983). Simpkins et al. (2003) observed that ringed seals are often found in the interior ice pack where the sea ice coverage is greater than 90%. Ringed seals maintain breathing holes in the ice and occupy lairs in accumulated snow (Smith and Stirling 1975). They give birth in lairs from mid-March through April, nurse their pups in the lairs for 5–8 weeks, and mate in late April and May (Smith 1973; Hammill et al. 1991; Lydersen and Hammill 1993). Ringed seals will likely be the most commonly observed marine mammal species in the area of the Liberty seismic survey.

Population size

No reliable estimate for the size of the Alaska ringed seal stock is currently available (Angliss and Outlaw 2007). During aerial surveys flown in the Alaskan Beaufort Sea between Barrow and Kaktovik in 1996-1999 observed seal densities ranged from 0.81-1.17/km2 (Frost et al. 2002, 2004) over an area of approximate 18,000 km^2. In combination with the average abundance estimate of 230,673 for the eastern Chukchi Sea (Bengtson et al. 2005), this results in a total of approximately 250,000 seals. This number should be considered as a minimum because it does not include the entire geographic range of the stock and the estimate for the Alaska Beaufort Sea has not been corrected for the number of ringed seals not hauled out at the time of the surveys. The Alaska stock of ringed seals is not endangered, and is not classified as a strategic stock by NMFS.

Subsistence hunt

Ringed seals are an important species for Alaska Native subsistence hunters. A recent report on ice seal subsistence harvest in three Alaskan communities indicated that the number and species of ice seals harvested in a particular village may vary considerably between years (Coffing et al. 1999). These interannual differences are likely due to differences in ice and wind conditions that change the hunters' access to different ice habitats frequented by different types of seals. As of August 2000, the subsistence harvest database indicated that the estimated number of ringed seals harvested for subsistence use per year is 9,567 (Angliss and Outlaw 2007).

4.4 Carnivora

4.4.1 Polar Bear (Ursus maritimus)

Although the polar bear is managed by the USFWS and is not a subject of this IHA Request to NMFS, the following account is included for completeness. BP will submit a LOA request for this species in the Liberty area, Beaufort Sea.

Distribution

Polar bears have a circumpolar distribution throughout the northern hemisphere (Amstrup et al. 1986) and occur in relatively low densities throughout most ice-covered areas (DeMaster and Stirling 1981). They are common in the Chukchi and Beaufort seas north of Alaska throughout the year, including the late summer period (Harwood et al. 2005). They also occur throughout the East Siberian, Laptev, and Kara Seas of Russia and the Barents Sea of northern Europe. They are found in the northern part of the Greenland Sea, and are common in Baffin Bay, which separates Canada and Greenland, as well as through most of the Canadian Arctic Archipelago. Polar bears typically range as far north as 88°N (Ray 1971; Durner and Amstrup 1995) above which their population thins dramatically. However, polar bears have been observed across the Arctic, including close to the North Pole (van Meurs and Splettstoesser 2003). Stirling (1990) reported that of 181 sightings of bears, only three were above 82°N. Three polar bears were observed from the Healy in the northern Chukchi Sea during a survey through this area in August of 2005 (Haley and Ireland 2006). These three sightings occurred along 2,401 km of observed trackline over 14 days between 70°N and 81°N.

Polar bears are divided into six major populations and many sub-populations based on mark-and-recapture studies (Lentfer 1983), radio telemetry studies (Amstrup and Gardner 1994), and morpho-metrics (Manning 1971; Wilson 1976). The Southern Beaufort Sea population ranges from the Baillie Islands, Canada, in the east to Point Hope, Alaska, in the west. The Bering/Chukchi Sea population ranges from Point Barrow, Alaska, in the east to the Eastern Siberian Sea in the west. These two populations overlap between Point Hope and Point Barrow, Alaska, centered near Point Lay (Amstrup 1995).

The Bering/Chukchi and Southern Beaufort populations have been extensively studied by tracking the movement of tagged females (Garner et al. 1990). Radio-tracking studies indicate significant movement within populations and occasional movement between populations (Garner et al. 1990; Amstrup 1995). For example, a female polar bear within sight of the Prudhoe Bay oilfields was captured, fitted with a satellite-tracking collar, and her movements monitored for 576 days. She traveled north and then south to Greenland, traversing ~7162 km in 576 days (Durner and Amstrup 1995).

Polar bears usually forage in areas where there are high concentrations of ringed and bearded seals (Larsen 1985; Stirling and McEwan 1975). This includes areas of land-fast ice, as well as moving pack ice. Polar bears are opportunistic feeders and feed on a variety of foods including not only seals but also beluga whales, arctic cod, geese and their eggs, walruses, bowhead whales, and reindeer (Smith 1985; Jefferson et al. 1993; Smith and Hill 1996; Derocher et al. 2000).

Females give birth to 1 to 3 cubs at an average interval of every 3.6 years (Jefferson et al. 1993; Lentfer et al. 1980). Cubs remain with their mothers for 1.4 to 3.4 years (Derocher et al. 1993; Ramsay and Stirling 1988). Mating occurs from April to June followed by a delayed implantation which occurs during September to December. Females give birth usually the following December or January (Harington 1968; Jefferson et al. 1993). In general, females 6 years of age or older successfully wean more cubs than younger bears; however, females as young as 4 years old can produce offspring (Ramsay and Stirling 1988). An examination of reproductive rates of polar bears indicated that 5% of four-year-old females had cubs, whereas 50% of five year-old females had cubs (Ramsay and Stirling 1988). The maximum reproductive age reported for Alaskan polar bears is 18 years (Amstrup and DeMaster 1988).

Population size

The total number of polar bears worldwide is estimated to be 20,000-25,000. Polar bears are not evenly distributed throughout the Arctic, nor do they comprise a single nomadic cosmopolitan population, but rather occur in 19 relatively discrete populations (Schliebe et al. 2006b). Amstrup (1995) estimated the minimum population of polar bears for the south Beaufort Sea subpopulation to be ~1500–1800 individuals, with an average density of about one bear per 38.6 to 77.2 mi^2 (100–200 km^2). The field work for an intensive capture-recapture effort in the SB region, coordinated between the U.S. and Canada, was completed in spring 2006 and a final population analysis and report will be expected in 2007. There are no reliable data on the population status of polar bears in the Bering/Chukchi Sea (Schliebe et al. 2006b).

Currently, polar bear populations are protected under the MMPA, as well as by the International Agreement on the Conservation of Polar Bears, ratified in 1976. Countries participating in the latter treaty include Canada, Denmark, Norway, Russia (former USSR), and the USA. The polar bear has been listed as "vulnerable" on the IUCN red list since 2005, based on the likelihood of an overall decline in the size of the total population of more than 30% within the next 35 to 50 years. Currently, USFWS proposes to list the polar bear as threatened under the Endangered Species Act (ESA) (Federal Register / Vol. 72, No. 5 / Tuesday, January 9, 2007 / Proposed Rules).

Based on polar bear sightings in previous years and also in 2007, polar bears could be present along the shore of the main land or the barrier islands during the Liberty seismic survey.

Subsistence hunt

The harvest quota for the southern Beaufort Sea population is 80 animals, 40 for Alaska and 40 for Northwest Territories (NWT). A joint users-group agreement sets harvest quotas and includes provisions to protect bears in dens and females with cubs. In 2004/2005, the harvest in

Alaska was 27 bears. The northern Beaufort Sea sub-population is harvested by hunters from Nunavut and NWT. The harvest quota is 6 bears for Nunavut and 65 for NWT of which Nunavut harvested 4 bears in 2004-2005 (Schliebe et al. 2006a).

4.5 Rare or extralimital species in Beaufort Sea

4.5.1 Narwhal (Monodon monoceros)

Narwhals have a discontinuous arctic distribution (Hay and Mansfield 1989; Reeves et al. 2002). A large population inhabits Baffin Bay, West Greenland, and the eastern part of the Canadian Arctic archipelago, and much smaller numbers inhabit the Northeast Atlantic/East Greenland area. Population estimates for the narwhal are scarce, and the IUCN-World Conservation Union lists the species as Data Deficient (IUCN Red List of Threatened Species 2003). The species is rarely seen in Alaskan waters or the Beaufort Sea generally and if they would be observed it would most likely be far offshore. Thus it is very unlikely that individuals will be encountered in the shallow waters of the Liberty seismic survey area.

4.5.2 Killer Whale (Orcinus orca)

Killer whales are cosmopolitan and globally fairly abundant. The killer whale is very common in temperate waters, but it also frequents the tropics and waters at high latitudes. Killer whales are known to inhabit almost all coastal waters of Alaska, extending from southeast Alaska through the Aleutian Islands to the Bering and Chukchi seas (Angliss and Lodge 2004). Killer whales probably do not occur regularly in the Beaufort Sea although sightings have been reported (Leatherwood et al. 1986; Lowry et al. 1987; George et al. 1994) of which one possible sighting at Endicott in 2006. Killer whales are, however, more common southwest of Barrow in the Southern Chukchi Sea and Bering Sea and it is very unlikely that they will be encountered in the Liberty area.

4.5.3 Harbor Porpoise (Phocoena phocoena)

The harbor porpoise is a small toothed whale that inhabits shallow, coastal waters—temperate, subarctic, and arctic—in the Northern Hemisphere (Read 1999). Harbor porpoises occur mainly in shelf areas where they can dive to depths of at least 220 m and stay submerged for more than 5 minutes (Harwood and Wilson 2001) feeding on small schooling fish (Read 1999). Harbor porpoises typically occur in small groups of only a few individuals and tend to avoid vessels (Richardson et al. 1995). The subspecies *P. phocoena vomerina* ranges from the Chukchi Sea, Pribilof Islands, Unimak Island, and the south-eastern shore of Bristol Bay south to San Luis Obispo, California. Point Barrow, Alaska, is the approximate northeastern extent of their regular ranges (Suydam and George 1992), though there are some extralimital records east to the mouth of the Mackenzie River in the Northwest Territories, Canada.

4.5.4 Minke Whale (Balaenoptera acutorostrata)

Minke whales have a cosmopolitan distribution at ice-free latitudes (Stewart and Leatherwood 1985), and also occur in some marginal ice areas. Angliss and Outlaw (2005) recognize 2 minke whale stocks in U.S. waters: (1) the Alaska stock, and (2) the California/Oregon/Washington stock. Minke whales from the Alaska stock are relatively common in the Bering and Chukchi Seas (Leatherwood et al. 1982) and are not considered to range into the Beaufort Sea.

4.5.5 Fin Whale (Balaenoptera physalus)

Fin whales are widely distributed in all the world's oceans (Gambell 1985), but typically occur in temperate and polar regions. Three stocks of fin whales are currently recognized in U.S. waters (Angliss and Outlaw 2007): (1) Alaska (Northeast Pacific), (2) California/Washington/Oregon, and (3) Hawaii. The North Pacific population summers from the Chukchi Sea to California (Gambell 1985), and there is no indication that fin whales inhabit the Alaskan Beaufort Sea or waters of the northern Chukchi Sea. The fin whale is listed as "Endangered" under the ESA and is classified as a strategic stock by NMFS.

5 INCIDENTAL HARASSMENT AUTHORIZATION REQUESTED

The type of incidental taking authorization that is being requested (i.e., takes by harassment only; takes by harassment, injury and/or death) and the method of incidental taking.

BP requests authorization for incidental (Level B) harassment of marine mammals pursuant to Section 101(a)(5)(D) of the MMPA during its planned seismic survey in the Liberty area, Beaufort Sea in July/August 2008, with an "as needed" extension into September/October (in compliance with the CAA).

Response of marine mammals to the activities described in Section 1 can occur due to:

- Exposure to pulsed sounds from an 8-gun 880 in^3 sleeve airgun array (estimated source level ~250 dB re µPa at 1m);
- Exposure to pulsed sounds from the Dyne pinger sonar (19-36 kHz, source level of 188-193 dB re µPa at 1m), Benthos acoustic releases (7-15 kHz, source level of ~192 dB re µPa at 1m) and vessel bathymetry sonar systems;
- Exposure to non-pulsed, continuous sounds from vessels (seismic survey and support/crew vessels);
- Physical presence of vessels in the area (collision risk between marine mammals and vessels).

The response of marine mammals to these activities depends on the species of cetacean or pinnipeds, the behavior of the animal at the time of reception of the stimulus, as well as the distance to and received level of the sound (see Section 7 and Appendix C). Disturbance reactions, such as avoidance, are very likely to occur amongst marine mammals in the vicinity of the source vessel. No serious injury to marine mammals is anticipated, for example due to collisions with vessels, given the nature of the activity in combination with the planned mitigation measures (see Section 11 for mitigation measures). No lethal injuries are expected.

This request focuses on the potential impact to marine mammals from pulsed sounds generated by the seismic airguns. The continuous sounds generated by routine vessel operations are not likely to have an additional impact on the marine mammals, as is the case for the use of vessel sonar system and the acoustic pingers given the considerations discussed in section 1 and 7, i.e., relatively high operating frequency, short pulse duration, and low duty cycle, and brief (if any) behavioral response.

6 NUMBERS OF MARINE MAMMALS THAT MAY BE HARASSED

By age, sex, and reproductive condition (if possible), the number of marine mammals (by species) that may be taken by each type of Incidental Take Authorization (ITA) request described in Section 5, and the number of times such takings for each type of ITA are likely to occur.

The anticipated harassments from the activities described in Section 1 involve temporary changes in behavior. There is no evidence that the planned activities could result in injury, such as damage to the hearing apparatus. Section 7 provides a summary of potential impacts from sounds on marine mammals (with more general background information in Appendix C). In any case, the mitigation measures to be implemented during this survey are based on level B harassment criteria using 160 dB and 170 dB re 1µPa rms, and will as such minimize any potential risk to injury.

This Section describes the methods used to estimate the numbers of marine mammals that might be affected during the proposed OBC seismic survey in the Liberty area, Beaufort Sea. The estimates are based on expected marine mammal density and anticipated area ensonified by levels of ≥170 and ≥160 dB re 1µPa.

Expected density of marine mammals in the survey area of operation and area of influence are based on best available data. Density data derived from studies conducted in or near the proposed survey area are used for calculations, where available. When estimates were derived from data collected in regions, habitats, or seasons that differ from the proposed seismic survey, adjustments to reported population or density estimates were made to account for these differences insofar as possible (Section 6.1).

The anticipated area to be ensonified by levels of ≥160 and ≥170 dB re 1µPa is a combination of the area covered by the ~3,219 km survey lines and the estimated safety radii. The close spacing of neighboring vessel tracklines within the planned seismic survey area results in a limited area exposed to sounds of ≥160 dB, while much of that area is exposed repeatedly. Section 6.2 describes in more detail the method used to calculate the safety radii and the area ensonified and potential numbers of marine mammals potentially affected is described in Section 6.3.

6.1 Marine mammal density estimates

Numbers of marine mammals that might be present and potentially disturbed are estimated, based on available data about mammal distribution and densities at different locations and times of the year. The proposed survey covers a small area in the nearshore shallow waters of the western Beaufort Sea within Barrier islands in the summer season (July/August 2008), with an "as needed" extension of additional days after the whaling season (in accordance with the CAA), given the uncertainties in ice conditions and other factors that can influence the survey.

The duration of the seismic data acquisition in the Liberty area is estimated to be ~40 days, based on a continuous 24-hr operation. This can extend to a maximum of 60 days taking into account unpredictable delays. It is expected that the data acquisition can be completed during the months July and August. However, if further data acquisition is required after August, the seismic activities may resume in September and/or October after completion of the whaling season and in accordance with the CAA. Therefore, the nearshore marine mammal densities for the summer period have been applied to 95% of the total trackline kilometers. The fall densities have been applied to the remaining 5% of tracklines.

Most marine mammals in the Alaskan Beaufort Sea are migratory, occupying different habitats and/or locations during the year. The densities can therefore vary greatly within seasons and for different locations. For the purpose of this IHA, different densities have been derived for the summer (late July through August) and the fall (September through early October). In addition to seasonal variation in densities, spatial differentiation is also an important factor for marine mammal densities, both in latitudinal and longitudinal gradient. Taking into account the size and location of the proposed seismic survey area and the associated area of influence, only the nearshore zone (defined as the area between the shoreline and the 50 m line of bathymetry) in the western part of the Beaufort Sea (defined as the area west of 141°W) is relevant for the calculation of densities. If the best available density data cover other zones than the nearshore zone or areas outside the western part of the Beaufort Sea, densities were derived based on expert judgment.

Ideally, when calculating densities from marine mammal distribution survey data, two correction factors need to be taken into account: (1) detectability bias [f(0)], and (2) availability bias [g(0)]. The detectability bias is associated with the diminishing sightability when the distance between the observation point and marine mammal increases. The availability bias refers to the fact that marine mammals may be present in the area but are not available to the observer to be sighted (i.e. beneath the water surface). The uncorrected number of marine mammals observed is therefore always lower than the actual numbers present. Unfortunately, for most density data not enough information is available of the survey specifics or of marine mammal behavior and movement patterns to calculate these two correction factors. The density estimates provided in this IHA request are based on uncorrected data, except for the beluga and bowhead whale densities. Correction factors were applied to the data from Moore et al. (2000b) and Miller et al. (2002) derived from Harwood et al 1996.

Because the available density data is not always representative for the area of interest, and correction factors were not always known, there is some uncertainty in the data and assumptions used in the density calculations. To provide allowance for these uncertainties, maximum estimates of the numbers potentially affected have been provided in addition to average densities. The marine mammal densities presented are believed to be close to, and in most cases higher than the densities that are expected to be encountered during the survey. Walruses and polar bears will be the subject of a separate request to USFWS for an LOA to be submitted by BP.

6.1.1 Density of Cetaceans in the Beaufort Sea

The densities of beluga and bowhead whales present in the Beaufort Sea are expected to vary by season and location. During the early and mid-summer, most belugas and bowheads are found in the Canadian Beaufort Sea or adjacent areas. During fall, both species migrate through the Alaskan Beaufort Sea, sometimes interrupting their migration to feed.

Beluga whales

Beluga density estimates for the Alaskan Beaufort Sea are derived from aerial survey data obtained by Moore et al. (2000b). The overall beluga whale density (i.e. total sightings from all depth regimes) was calculated with these data and this density was assumed to represent the average offshore density for the summer season in the eastern Beaufort Sea. During the summer season beluga whales are far more abundant in the offshore area, and so the densities for the nearshore area were (conservatively) estimated to be 10% of the offshore densities.

During the summer season, very few beluga whales are expected to be encountered in the western part of the Beaufort Sea, especially in the inshore waters of the Barrier islands. The average density of beluga whales for the proposed survey was therefore estimated to be 10% of the density of the eastern Beaufort Sea (Table 2).

In fall, during the westward migration, the offshore density is expected to be roughly equal across the eastern and western regions of the Alaskan Beaufort Sea. Also the depth distribution of migrating beluga whales is expected to be more equally distributed. For the autumn period, the density of beluga whales in the western Beaufort Sea was estimated to be 10% of the highest fall density calculated from Moore et al. (2000b) (Table 2).

The maximum density estimates of beluga whales were calculated as 4x the average estimates.

Bowhead whales

Bowhead sightings in the Alaskan Beaufort become more common as the whales start their westward migration in August. Peak sighting rates occur near Kaktovik (east of the Liberty area) in September. The density data used in this IHA request are derived from Miller et al. (2002) who calculated the seasonal distribution and numbers of bowheads observed in the eastern Alaskan Beaufort Sea and adjacent Canadian waters from aerial surveys conducted by various researchers during the late summer and autumn of 1979–2000. Correction factors (Thomas et al. 2002) were applied to these density estimates.

Bowheads in the eastern Alaskan Beaufort Sea and Canada occur in offshore habitats in summer. From late August-early September shallower habitats are selected during years with moderate and light ice-cover and deeper waters in years with heavy ice-cover. In the western Beaufort Sea during the period July-August very few bowhead whales are expected to be present in the nearshore zone. The densities calculated from 14 surveys in August in water depths of >50m in the eastern Alaskan and Canadian Beaufort Sea, were used as the basis for the summer density calculations in this IHA request. Because bowheads mainly occur in offshore waters during the summer season with decreasing abundance from east to west, density estimates for the proposed survey were estimated to be 10% of the reported densities by Miller et al. (2002)(Table 2).

Many of the bowhead whales will be migrating westward during the fall period, mostly in the nearshore and continental habitat zones. So, the fall densities of bowhead whales provided for the eastern Alaskan and Canadian Beaufort Sea are considered to be similar as those for the western Beaufort Sea. Average and maximum densities for the autumn period were based on calculated densities of 79 surveys conducted in the period September–October for the combined nearshore and continental zones (Miller et al. 2002). Because the whale density during the fall migration is in general higher in the nearshore area (<50m), the estimates provided were multiplied by two to obtain nearshore fall densities (Table 2). For the proposed survey 10% of these estimates were used.

Both the summer and autumn densities are assumed to be conservative given that the proposed survey takes place entirely inside the barrier islands.

Other cetacean species

For other cetacean species that may be encountered in the Beaufort Sea, densities are likely to vary somewhat by season, but differences are not expected to be great enough to estimate separate densities for the two seasons. Based on their known distribution Narwhal, harbor porpoise and gray whales are not likely to be encountered in the Liberty area. No densities have been provided, however, arbitrary numbers for harassment authorization were used, loosely based on historic opportunistic sightings in the region (Table 6).

6.1.2 Density of Pinnipeds in the Beaufort Sea

Pinnipeds in the polar regions are mostly associated with sea ice and most census methods count pinnipeds when they are hauled out on the ice. To account for the proportion of animals present but not hauled out (availability bias) or seals present on the ice but missed (detection bias), a correction factor should be applied to the "raw" counts. This correction factor is very dependent on the behavior of each species. To estimate the proportion of ringed seals visible resting on the ice surface, radio tags were placed on seals during the spring months during 1999-2003 (Kelly et al. 2006). Applying the probability that seals were visible to the data from past aerial surveys indicated that the fraction of seals visible varied from less than 0.40 to more than 0.75 between survey years. The environmental factors that are important in explaining the availability of seals to be counted were found to be time of day, date, wind speed, air temperature, and days from snow melt (Kelly et al. 2006). No correction factors have been applied to the seal densities reported here. The seismic activities covered by the present IHA request will occur during the open water season. Seal density during this period is generally lower than during spring when animals are hauled out on the ice. No distinction is made in density of pinnipeds between summer and autumn season.

Ringed seals

Seal counts through springtime aerial surveys, conducted in the period 1997-2002 in Prudhoe Bay and Foggy Island Bay area, reported (uncorrected) ringed seal densities ranging from 0.43 to 0.83 seals per km^2 in water over 3 m in depth (Moulton et al. 2002). Similar surveys in the Prudhoe Bay area conducted during the years 1997, 1998 and 1999 estimated consistent higher densities of seals (0.73 versus 0.43 seals/km^2 in 1997; 0.64 vs 0.39 seals/km^2 in 1998 and 0.87 vs 0.63 seals/km^2 in 1999) (Frost et al. (2002, 2004). It is not clear why such different results were obtained from similar surveys with considerable overlap in timing and methods. For this IHA request the average density was calculated from the combined 1997-2002 ringed seal densities from Moulton et al. (2003) and Frost et al. (2003). The highest observed density for the Prudhoe Bay and Liberty area was used as the maximum. Because these density estimates were calculated from spring data and the numbers of seals is expected to be much lower during the open water season, the densities used for the proposed survey were (conservatively) estimated to be 50% of the spring densities (Table 2). Due to the lack of open water seal density data, this number is considered to be realistic.

Bearded seals

During the 2002 spring aerial seal survey in the Prudhoe Bay area, a total of nine single bearded seal sightings were recorded. Four sightings were in the pack ice north of the ice edge and five were on the landfast ice. Of the bearded seals observed in the landfast ice, two were sighted south of the barrier islands. Several bearded seals were seen in 1999-2001, but none during 1997-1998. Density calculations were not conducted because of the small number of bearded seals recorded (Moulton et al. 2002). During a vessel based marine mammal survey for an OBC survey near and west of the Liberty area all three seal species were observed, with 92% ringed seals, 7% bearded seals and 1% spotted seals (Harris et al. 1997). The densities for bearded seals were therefore calculated as 7% of the ringed seal densities.

Spotted seals

Spotted seals have seldom been observed in the survey area. During a vessel based marine mammal survey for an OBC survey near and west of the Liberty area all three seal species were observed, with 92% ringed seals, 7% bearded seals and 1% spotted seals (Harris et al. 1997). The densities for spotted seals were therefore calculated as 1% of the ringed seal densities.

Table 2. Expected densities (average and maximum) of cetaceans and pinnipeds for the nearshore zone in the Liberty area for the summer and autumn season. Densities are provided per km².

Species	Summer densities (#/km²)		Autumn densities (#/km²)	
	Average	Maximum	Average	Maximum
Cetaceans				
Beluga whale	0.0003	0.0011	0.0027	0.0108
Bowhead whale*	0.0001	0.0003	0.0043	0.0240
Pinnipeds				
Ringed seal	0.3050	0.4350	0.3050	0.4350
Bearded seal	0.0214	0.0305	0.0214	0.0305
Spotted seal	0.0031	0.0044	0.0031	0.0044

* *endangered species*

6.2 Safety radii

As outlined in Section 5, impacts on marine mammals from the planned seismic survey focus on the sound sources of the seismic airguns. This Section describes the methodology used to estimate the safety radii for received levels of 190, 180, 170 and 160 dB re 1µPa for pulsed sounds emitted by the airgun array with a total discharge volume of 880 in^3 and the assumptions underlying these calculations (more specifications of this airgun array are included in Appendix B). The distances to reach received sound levels of 170 and 160 dB re 1 µPa (rms) will be used to calculate the potential numbers of marine mammals exposed to these sound levels (Section 6.3). The distances to received levels of 180 and 190 dB re 1 µPa (rms) are mainly relevant as safety radii for mitigation purposes (see Section 11).

Greeneridge estimated radii to specific received sound pressure levels from the airgun arrays that will be operated at BP's Liberty Site (in Foggy Island Bay) during the open water season in 2008. The results from transmission loss experiments conducted in 1997 (Greene 1998) during the open-water season at the Liberty prospect in Foggy Island Bay were used to calculate the estimated distances of received levels of the proposed airgun source. The following facts and assumptions have been used for this computation:

1 The received sound levels from a 56 in^3 4-gun array of sleeve guns were measured during operation at Liberty in water depths of ~21 ft (~6.4 m) in 1997 (Greene 1998). The array depth was 1 m, the array volume was 56 in^3 and the internal pressure of the sleeve guns was 2000 psi. The airguns in the current array are also sleeve guns which make them comparable.

2 For distances from ~110 to 10,000 m, the measured equation for received SPL in 1997 was $RL = 238.2 – 26.04\log(R) -0.0018R$. The constant term changes for different sources, but the coefficients of log(R) and R are dependent on the sound propagation at a site, not the source. Thus, those coefficients are retained in determining the distance estimates of received levels.

3 For estimation purposes, the sound pressures in the far field (>10x the array extent) from an airgun array increase with the number of airguns and with the cube root of the total volume. These two proportionalities are confounded (more guns generally increase the volume) but to be conservative they are used independently in the calculations. Changes

in pressure dependency from clusters of airguns were also (conservatively) ignored in the computations.

4 The array depth in 1997 was 1 m and the water depth 6.4 m. The operating array depths expected for the proposed Liberty survey will be from 1 to 4 m in water depths ranging from 3 to 30 ft (1 to 9.1 m). Generally, the transmission of sound into the water will improve with increasing array depth, leading to higher received levels of sound pressure at specific distances from the source. This is especially the case for low-frequency sources such as airgun arrays. For estimation purposes, array depths of both 1 m and 4 m were used.

The results of these computations are shown in Table 3. The sources used for seismic data acquisition are sleeve airgun arrays with a total discharge volume of 880 cubic inch (in^3) divided over two arrays. Each source vessel will have two 440 in^3 arrays each comprised of four guns in clusters of 2 x 70 in^3 and 2 x 150 in^3. The use of 2 separate arrays allows operations in shallow water depth. The safety radii are calculated for both the total discharge volume of 880 in^3 (8 guns) and for one 440 in^3 array (4 guns).

For the full 880 in^3 array, the volume change from the 1997 array is 880/56 = 15.71, the cube root of which is 2.5. The increase in pressure levels expected from the volume increase is 20log(2.5) = 8 dB. The number of guns for the full array is a factor of 2 higher than in 1997. The increase in pressure expected from doubling the number of guns is 20log(2) = 6 dB. Combining these two calculated changes in pressure level yields a total increase of 14 dB compared to the 1997 source, which is likely more than might actually be measured. So, with an estimated, extrapolated effective source level of ~252.2 dB re 1 µPa @ 1 m, the received levels for the 8-gun array at depth 1 m may be estimated from the equation:

(i) RL8 (dB re 1 µPa) = 252.2 – 26.04log(R) – 0.0018R (for R in meters).

For the smaller 440 in^3 array, the volume change from the 1997 array is 440/56 = 7.857, the cube root of which is almost 2, and the increase in pressure levels expected from the volume increase is 20log(2) = 6 dB. The number of guns is equal for both sources, so no additional pressure increase is expected due to the number of guns. Thus, the increase in pressure level compared to 1997 is 6 dB. So, with an estimated, extrapolated effective source level of ~244.2 dB re 1 µPa @ 1 m, the received level for the 4-gun array at depth 1 m may be estimated from the equation:

(ii) RL4 (dB re 1 µPa) = 244.2 – 26.04 log(R) – 0.0018R (for R in meters).

For source depth 4 m (4 times 1 m), the effective source level could increase by as much as 12 dB, but because of the shallow water environment only a 6 dB increase is assumed to occur. With the effective source level increase of 6 dB included into formula *(i)* and *(ii)* above, the estimated distances increase accordingly (see Table 3).

The estimated distances are based on transmission loss profiles within the barrier islands. It is expected that these islands will function as a sound barrier beyond which sound will not propagate much, although most propagation is expected through the channels between the islands. The estimated distances for 120 dB and maybe 160 dB (especially for the source lines closest to the islands) may be overestimations.

Table 3. Estimated distances for specified received levels from airgun arrays with a total discharge volume of 440 in^3 and 880 in^3. Note that the array depth is an important factor for sound propagation loss.

Received levels (dB re 1 µPa rms) [a]	Distance in meters[b] (array depth 1 m)		Distance in meters[b] (array depth 4 m)	
	440 in^3	880 in^3	440 in^3	880 in^3
190	~120	~235	~200	~390
180	~280	~545	~462	~880
170	~640	~1,190	~1,030	~1,830
160	~1,380	~2,380	~2,090	~3,430
120	~10,800	~13,700	~12,900	~16,000

[a] The distance in meters for each received level was calculated using the radius calculator available to the public at www.greeneridge.com (courtesy of W.C. Burgess, Ph.D.)

[b] Received levels of airgun sounds are expressed in dB re 1 µPa (rms, averaged over pulse duration).

The rms (root mean square) received sound pressure levels that are used as impact criteria for marine mammals are not directly comparable to the peak or peak-to-peak values normally used by geophysicists to characterize source levels of airguns (Appendix B). The measurement units used to describe airgun sources, peak or peak-to-peak dB, are always higher than the rms dB referred to in much of the biological literature and in the NMFS criteria. A measured broadband received level of 160 dB re 1 µPa (rms) in the far field would typically correspond to a peak measurement of about 170 to 172 dB re 1 µPa and to a peak-to-peak measurement of about 176 to 178 dB re 1 µPa, as measured for the same pulse received at the same location (Greene 1997; McCauley et al. 1998, 2000). The precise difference between rms and peak or peak-to-peak values for a given pulse depends on the frequency content and duration of the pulse, among other factors. However, the rms level is always lower than the peak or peak-to-peak level for an airgun-type source. Additional discussion of the characteristics of airgun pulses is included in Appendix C.

The distances from the source to specific received sound levels as summarized in Table 3 are estimates used for the purpose of this IHA request. These estimated distances will be verified with field measurements at the start of the survey (see Section 13).

6.3 Number of marine mammals potentially affected

The radii associated with received sound levels of 160 and/or 170 dB re 1 µPa (rms) or higher are used to calculate the number of potential marine mammal "exposures" to sounds that have the potential to impact their behavior. The 160 dB criterion is applied for all species and for pinnipeds additional calculations were made for the 170 dB criterion. Based on evidence summarized in Section 7 and Appendix C, these criteria are considered appropriate for those two groups.

The potential number of each species that might be exposed to received levels of ≥160 and ≥170 dB re 1 µPa (rms) is calculated by multiplying:

- The expected species density as provided in Table 2 of Section 6.1;
- The anticipated area to be ensonified to that level during airgun operations.

The area expected to be ensonified was determined by entering the seismic survey lines into a MapInfo Geographic Information System (GIS). GIS was than used to identify the relevant areas by "drawing" the applicable 160-dB buffer from Table 3 around each seismic source line and than to calculate the total area within the buffers. This method avoids the large overlap of buffer zones from each seismic source line, and hence an overestimation of the potential number of marine mammals exposed.

Some of the animals, particularly migrating bowhead whales, might show avoidance reactions before being exposed to sound levels of 160 dB re 1 µPa (rms) or higher. During autumn some migrating bowheads have been found to react to a noise threshold closer to 130 dB re 1 µPa (rms; Miller et al. 1999; Richardson et al. 1999). The numbers potentially impacted at thresholds ≥160 and ≥170 dB re 1 µPa (rms), however, are calculated as if no avoidance behavior takes place (Table 4).

6.3.1 Number of Cetaceans Potentially Exposed to ≥160 dB

The estimates show that one endangered cetacean species (the bowhead whale) is expected to be exposed to sound levels of ≥160 dB unless bowheads avoid the survey vessel before this received level is reached. Migrating bowheads are likely to do so, though many of the summering bowheads probably will not. Our respective average and maximum estimated numbers of exposed bowhead whales, as rounded numbers, are shown the two right-hand columns in Table 4. Note that 95 % of the survey coverage is expected in July and August, before the bowhead fall migration and only 5 % during fall migration when most bowheads are passing the area, offshore of the barrier islands.

Table 4. Number of bowhead and beluga whales potentially exposed to received sound levels of ≥160 dB. The numbers were calculated for a 880 in^3 array towed at 1 m and 4 m depth. Note that not all animals will change their behavior when exposed to these sound levels, and some might alter their behavior somewhat when levels are lower (see text).

Species	Summer		Autumn		Total	
	Average	Maximum	Average	Maximum	Average	Maximum
Array depth 1 m						
Beluga whale	0.1	0.5	1.3	5.1	1	6
Bowhead whale*	0.0	0.1	2.0	11.3	2	11
Array depth 4 m						
Beluga whale	0.1	0.5	1.3	5.2	1	6
Bowhead whale	0.0	0.1	2.1	11.6	2	12

* *endangered species*

Average and maximum estimates of the number of beluga whales potentially exposed are also summarized in Table 4. Species such as gray whale, narwhal, killer whale and harbor porpoise are not expected to be encountered but might be present in very low numbers; the maximum expected numbers exposed for these species are provided in Table 6 and are based on arbitrary estimates.

6.3.2 Number of Pinnipeds Potentially Exposed to ≥170 dB

Pinnipeds are not likely to react to seismic sounds unless the received levels are 170 dB re 1 µPa (rms), and many of those exposed to 170 dB will still not react overtly (Harris et al. 2001; Moulton and Lawson 2002; Miller et al. 2005). The ringed seal is the most widespread and abundant pinniped in ice-covered arctic waters, and there is a great deal of annual variation in population size and distribution of these marine mammals.

Ringed seals account for the majority of marine mammals expected to be encountered, and hence exposed to airgun sounds with received levels of ≥160 dB and ≥170 dB re 1 µPa (rms) during the proposed seismic survey. The average (and maximum) estimates of the number of ringed seals exposed to these received levels are summarized in Table 5.

The other two species that could be encountered are the bearded seal and spotted seal. The likelihood of encounters, however, is much lower than for ringed seals with average and maximum numbers potentially exposed to ≥160 and ≥170 dB re 1 µPa (rms) as shown in Table 5.

Table 5. Number of pinnipeds potentially exposed to received sound levels of ≥160 dB and ≥170 dB. The numbers were calculated for 880 in^3 array towed at 1 m and 4 m depth. Note that not all animals will change their behavior when exposed to these sound levels.

Species	Numbers potentially exposed to ≥160 dB*		Numbers potentially exposed to ≥170 dB*	
	Average	Maximum	Average	Maximum
Array depth 1 m				
Ringed seal	151	215	129	184
Bearded seal	11	15	9	13
Spotted seal	2	2	1	2
Array depth 4 m				
Ringed seal	156	222	141	201
Bearded seal	11	16	10	14
Spotted seal	2	2	1	2

* *no distinction in summer or autumn densities has been made*

6.4 Conclusions

Impacts of seismic sounds on cetaceans are generally expected to be restricted to avoidance of a limited area around the seismic operation and short-term changes in behavior, falling within the MMPA definition of “Level B harassment”. The requested “harassment authorization” for each species is based on the estimated maximum numbers exposed to ≥160 dB re 1µPa (rms) from an airgun array operating at 4 m depth (Table 6). This is the highest number of the various estimates.

Table 6. Summary of the number of marine mammals potentially exposed to received sound levels of ≥160 dB and ≥170 dB (for pinnipeds only) during BP's proposed seismic survey in the Liberty area, based on radii for 880 in^3 array and 4 m array depth. The two far right columns show the numbers of potentially affected marine mammals for which authorization is requested and the % of the population that these numbers constitute. Note that not all marine mammals will change their behavior when exposed to these sound levels, and some might alter their behavior somewhat when levels are lower (see text).

Species	Exposures to ≥160 dB		Exposures to ≥170 dB		Requested Authorization	Estimated % of population
	Average	Maximum	Average	Maximum		
Cetaceans						
Beluga whale	1	6	Not applicable		6 (50)*	0.02 (0.13)*
Bowhead whale	2	12			12	0.09
Gray whale					3	0.02
Narwhal		Not applicable			1	-
Killer whale					3	-
Harbor porpoise					3	-
Pinnipeds						
Ringed seal	156	222	141	201	225	0.07
Bearded seal	11	16	10	14	20	0.01
Spotted seal	2	2	1	2	5	0.01

* belugas are know to show aggregate behavior and can occur in large numbers in nearshore zones. For the unlikely event that a group of belugas appears in the Liberty area during the seismic survey this number is added to the requested authorization.

The estimated numbers of cetaceans and pinnipeds potentially exposed to sound levels sufficient to cause behavioral disturbance are very low percentages of the population sizes in the Bering–Chukchi-Beaufort seas. For the bowhead whale, a species listed as "Endangered" under the ESA, our estimates include ~12 bowheads. This is ~0.1% of the estimated 2008 Bering-Chukchi-Beaufort population of 13,330 (based on a population size of 10,545 in 2001 and an annual population growth of 3.4%, cf Table 1). The beluga whale is not expected to occur in or near the Liberty area, however some individuals might be observed. Beluga's also show aggregate behavior and so there is the unlikely event that if belugas will appear in this area it might be in a larger group. In both circumstances these numbers constitute very low percentages of the estimated population size (Table 6).

The many reported cases of apparent tolerance by cetaceans of seismic operations, vessel traffic, and some other human activities show that co-existence is possible. Mitigation measures such as controlled speed, look outs, non-pursuit, shut downs or power downs when marine mammals are seen within defined ranges, and avoiding migration pathways when animals are likely most sensitive to noise will further reduce short-term reactions, and minimize any effects on hearing sensitivity. In all cases, the effects are expected to be short-term, with no lasting biological consequence. Subsistence issues are addressed below in Section 8.

From the few pinniped species likely to be encountered in the study area, the ringed seal is by far the most abundant marine mammal that can be encountered. The estimated number of ringed seals potentially exposed to airgun sounds at received levels of ≥160 dB re 1 µPa (rms) during the seismic survey represent <0.1% of the Bering-Chukchi-Beaufort population, and these are even smaller portions for the bearded seal and spotted seal (Table 6). It is probable that at this received level, only a small percentage of these seals would actually be disturbed. As for cetaceans, the short-term exposures of pinnipeds to airgun sounds are not expected to result in any long-term negative consequences for the individuals or their populations.

7 ANTICIPATED IMPACT ON SPECIES OR STOCKS

The anticipated impact of the activity on the species or stocks of marine mammals.

This section summarizes the potential impacts on marine mammals of airgun operations and pinger systems. Note that for the completeness, examples or information is sometimes included for species that are not directly sometimes provided from species that are not

7.1 Summary of potential effects of airgun sounds

The effects of sounds from airguns might include one or more of the following: tolerance, masking of natural sounds, behavioral disturbance, and at least in theory, temporary or permanent hearing impairment, or non-auditory physical effects (Richardson et al. 1995). *In theory* is added because it is unlikely that temporary or especially permanent hearing impairment and non-auditory physical effects would occur.

Tolerance

Numerous studies have shown that pulsed sounds from airguns are often readily detectable in the water at distances of many kilometers. For a summary of the characteristics of airgun pulses, see Appendix C. Numerous studies have shown that marine mammals at distances more than a few kilometers from operating seismic vessels often show no apparent response. That is often true even in cases when the pulsed sounds must be readily audible to the animals based on measured received levels and the hearing sensitivity of that mammal group. Although various baleen whales, toothed whales, and (less frequently) pinnipeds have been shown to react behaviorally to airgun pulses under some conditions, at other times mammals of all three types have shown no overt reactions. In general, pinnipeds, small odontocetes, and sea otters seem to be more tolerant of exposure to airgun pulses than are baleen whales.

Masking

Masking effects of pulsed sounds (even from large arrays of airguns) on marine mammal calls and other natural sounds are expected to be limited, although there are very few specific data of relevance. Some whales are known to continue calling in the presence of seismic pulses. Their calls can be heard between the seismic pulses (e.g., Richardson et al. 1986; McDonald et al. 1995; Greene et al. 1999; Nieukirk et al. 2004). Although there has been one report that sperm whales cease calling when exposed to pulses from a very distant seismic ship (Bowles et al. 1994), a more recent study reports that sperm whales off northern Norway continued calling in the presence of seismic pulses (Madsen et al. 2002). That has also been shown during recent work in the Gulf of Mexico (Tyack et al. 2003). Bowhead whale calls are frequently detected in the presence of seismic pulses, although the number of calls detected may sometimes be reduced in the presence of airgun pulses (Richardson et al. 1986; Greene et al. 1999). Masking effects of seismic pulses are expected to be negligible given the low number of cetaceans expected to be exposed, the intermittent nature of seismic pulses and the fact that ringed seals (most probably to be present in the area) are not vocal during this period. Masking effects, in general, are discussed further in Appendix C.

Disturbance Reactions

Disturbance includes a variety of effects, including subtle changes in behavior, more conspicuous changes in activities, and displacement. Based on NMFS (2001, p. 9293), we assume that simple exposure to sound, or brief reactions that do not disrupt behavioral patterns in a potentially significant manner, do not constitute harassment or "taking". By potentially significant, we mean "in a manner that might have deleterious effects to the well-being of individual marine mammals or their populations".

Reactions to sound, if any, depend on species, state of maturity, experience, current activity, reproductive state, time of day, and many other factors. If a marine mammal does react briefly to an underwater sound by changing its behavior or moving a small distance, the impacts of the change are unlikely to be significant to the individual, let alone the stock or the species as a whole. However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on the animals could be significant. Given the many uncertainties in predicting the quantity and types of impacts of noise on marine mammals, it is common practice to estimate how many mammals were present within a particular distance of industrial activities, or exposed to a particular level of industrial sound. That likely overestimates the numbers of marine mammals that are affected in some biologically-important manner.

The sound criteria used to estimate how many marine mammals might be disturbed to some biologically-important degree by a seismic program are based on behavioral observations during studies of several species. However, information is lacking for many species. Detailed studies have been done on humpback, gray, and bowhead whales, and on ringed seals. Less detailed data are available for some other species of baleen whales, sperm whales, small toothed whales, and sea otters.

Baleen 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, as reviewed in Appendix C, 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. In the case of the migrating gray and bowhead whales, the observed changes in behavior appeared to be of little or no biological consequence to the animals. They simply avoided the sound source by displacing their migration route to varying degrees, but within the natural boundaries of the migration corridors.

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, seismic pulses from large arrays of airguns diminish to those levels at distances ranging from 4.5 to 14.5 km from the source. For the much smaller airgun array of this seismic survey distances to received levels in the 160–170 dB re 1 μPa rms range are 1.2 – 3.5 km (Table 3). Baleen whales within those distances may show avoidance or other strong disturbance reactions to the airgun array, however in the Liberty seismic survey area a limited number of baleen whales are expected to occur. Subtle behavioral changes sometimes become evident at somewhat lower received levels, and recent studies reviewed in Appendix C 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. Bowhead whales migrating west across the Alaskan Beaufort Sea in autumn, in particular, are unusually responsive, with avoidance occurring out to distances of 20–30 km from a medium-sized airgun source (Miller et al. 1999; Richardson et al. 1999). However, more recent research on bowhead whales (Miller et al. 2005) corroborates earlier evidence that, during the summer feeding season, bowheads are not as sensitive to seismic sources. In summer, bowheads typically begin to show avoidance reactions at a received level of about 160–170 dB re 1 μPa rms (Richardson et al. 1986; Ljungblad et al. 1988; Miller et al. 1999). The Liberty seismic project will be conducted in the summer and might occur partly in autumn, when the bowheads are commonly involved in migration. However, because the survey will be located nearshore of the barrier islands in shallow water and with seismic airguns of relatively small discharge volumes, the distance of received levels that might elicit avoidance behavior will likely not (or barely) reach the main migration corridor.

Malme et al. (1986, 1988) studied the responses of feeding eastern gray whales to pulses from a single 100 in^3 airgun off St. Lawrence Island in the northern Bering Sea. They estimated, based on small sample sizes, that 50% of feeding gray whales ceased feeding at an average received pressure level of 173 dB re 1 μPa on an (approximate) rms basis, and that 10% of feeding whales interrupted feeding at received levels of 163 dB. Those findings were generally consistent with the results of experiments conducted on larger numbers of gray whales that were migrating along the California coast, and on observations of the distribution of feeding Western Pacific gray whales off Sakhalin Island, Russia during a seismic survey (Yazvenko et al. 2007).

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 (Appendix A in Malme et al. 1984). 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. In any event, the brief exposures to sound pulses from the proposed airgun source are highly unlikely to result in prolonged effects.

Toothed Whales — Few systematic information is available about reactions of toothed whales to noise pulses. Few studies similar to the more extensive baleen whale/seismic pulse work summarized above and (in more detail) in Appendix C have been reported for toothed whales. However, systematic work on sperm whales is underway (Tyack et al. 2003), and there is an increasing amount of information about responses of various odontocetes to seismic surveys based on monitoring studies (e.g., Stone 2003; Smultea et al. 2004; Moulton and Miller 2005).

Seismic operators and marine mammal observers sometimes see dolphins and other small toothed whales near operating airgun arrays, but in general there seems to be a tendency for most delphinids to show some limited avoidance of seismic vessels operating large airgun systems. However, some dolphins seem to be attracted to the seismic vessel and floats, and some ride the bow wave of the seismic vessel even when large arrays of airguns are firing. Nonetheless, there have been indications that small toothed whales sometimes move away, or maintain a somewhat greater distance from the vessel, when a large array of airguns is operating than when it is silent (e.g., Goold 1996a,b,c; Calambokidis and Osmek 1998; Stone 2003). The beluga may be a species that (at least at times) shows long-distance avoidance of seismic vessels. Aerial surveys during seismic operations in the southeastern Beaufort Sea recorded much lower sighting rates of beluga whales within 10–20 km of an active seismic vessel. These results were consistent with the low number of beluga sightings reported by observers aboard the seismic vessel, suggesting that some belugas might be avoiding the seismic operations at distances of 10–20 km (Miller et al. 2005).

Captive bottlenose dolphins and (of more relevance in this project) beluga whales exhibit changes in behavior when exposed to strong pulsed sounds similar in duration to those typically used in seismic surveys (Finneran et al. 2002, 2005). However, the animals tolerated high received levels of sound (pk–pk level >200 dB re 1 μPa) before exhibiting aversive behaviors. With the presently-planned source, such levels would be limited to distances less than 200 m of the 8-airgun array in shallow water and encounters with beluga whales are not likely to occur within these distances.

Reactions of toothed whales to large arrays of airguns are variable and, at least for delphinids, seem to be confined to a smaller radius than has been observed for mysticetes (Appendix C). A ≥170 dB disturbance criterion (rather than ≥160 dB) is considered appropriate for delphinids (and pinnipeds), which tend to be less responsive than other cetaceans. However, based on the limited existing evidence, belugas should not be grouped with delphinids in the "less responsive" category.

Pinnipeds — Pinnipeds are not likely to show a strong avoidance reaction to the airgun sources that will be used. Visual monitoring from seismic vessels has shown only slight (if any) avoidance of airguns by pinnipeds, and only slight (if any) changes in behavior—see Appendix C. Ringed seals frequently do not avoid the area within a few hundred meters of operating airgun arrays (Harris et al. 2001; Moulton and Lawson 2002; Miller et al. 2005). However, initial telemetry work suggests that avoidance and other behavioral reactions by two other species of seals to small airgun sources may at times be stronger than evident to date from visual studies of pinniped reactions to airguns (Thompson et al. 1998). Even if reactions of the species occurring in the present study area are as strong as those evident in the telemetry study, reactions are expected to be confined to relatively small distances and durations, with no long-term effects on pinniped individuals or populations. As for delphinids, a ≥170 dB disturbance criterion is considered appropriate for pinnipeds, which tend to be less responsive than many cetaceans.

Hearing Impairment and Other Physical Effects

Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds, but there has been no specific documentation of this for marine mammals exposed to sequences of airgun pulses. Current NMFS policy regarding exposure of marine mammals to high-level sounds is that cetaceans and pinnipeds should not be exposed to impulsive sounds ≥180 and ≥190 dB re 1 μPa (rms), respectively (NMFS 2000). Those criteria have been used in defining the safety (shut down) radii planned for the proposed seismic survey. However, those criteria were established before there were any data on the minimum received levels of sounds necessary to cause temporary auditory impairment in marine mammals. As discussed in Appendix C and summarized here:

- The 180 dB criterion for cetaceans is probably quite precautionary, i.e., lower than necessary to avoid temporary threshold shift (TTS), let alone permanent auditory injury, at least for belugas and delphinids.
- The minimum sound level necessary to cause permanent hearing impairment is higher, by a variable and generally unknown amount, than the level that induces barely-detectable TTS.
- The level associated with the onset of TTS is often considered to be a level below which there is no danger of permanent damage.

NMFS is presently developing new noise exposure criteria for marine mammals that account for the now-available scientific data on TTS and other relevant factors in marine and terrestrial mammals (NMFS 2005; D. Wieting in http://mmc.gov/sound/plenary2/pdf/plenary2summaryfinal.pdf). New science-based noise exposure criteria are also proposed by a group of experts in this field, based on an extensive review and syntheses of available data on the effect of noise on marine mammals (Southall et al., in press) and this review seems to confirm that the current 180 dB and 190 dB are conservative.

Several aspects of the planned monitoring and mitigation measures for this project are designed to detect marine mammals occurring near the airguns to avoid exposing them to sound pulses that might, at least in theory, cause hearing impairment. In addition, many cetaceans are likely to show some avoidance of the area with high received levels of airgun sound (see above). In those cases, the avoidance responses of the animals themselves will reduce or (most likely) avoid any possibility of hearing impairment.

Non-auditory physical effects might also occur in marine mammals exposed to strong underwater pulsed sound. Possible types of non-auditory physiological effects or injuries that theoretically might occur in mammals close to a strong sound source include stress, neurological effects, bubble formation, and other types of organ or tissue damage. It is possible that some marine mammal species (i.e., beaked whales) may be especially susceptible to injury and/or stranding when exposed to strong pulsed sounds. However, as discussed below, there is no definitive evidence that any of these effects occur even for marine mammals in close proximity to large arrays of airguns and beaked whales do not occur in the present study area. It is unlikely that any effects of these types would occur during the present project given the brief duration of exposure of any given mammal, and the planned monitoring and mitigation measures (see below). The following subsections discuss in somewhat more detail the possibilities of TTS, permanent threshold shift (PTS), and non-auditory physical effects.

Temporary Threshold Shift (TTS) — TTS is the mildest form of hearing impairment that can occur during exposure to a strong sound (Kryter 1985). While experiencing TTS, the hearing threshold rises and a sound must be stronger in order to be heard. At least in terrestrial mammals, TTS can last from minutes or hours to (in cases of strong TTS) days. For sound exposures at or somewhat above the TTS threshold, hearing sensitivity in both terrestrial and marine mammals recovers rapidly after exposure to the noise ends. Few data on sound levels and durations necessary to elicit mild TTS have been obtained for marine mammals, and none of the published data concern TTS elicited by exposure to multiple pulses of sound.

For toothed whales exposed to single short pulses, the TTS threshold appears to be, to a first approximation, a function of the energy content of the pulse (Finneran et al. 2002, 2005). Given the available data, the received level of a single seismic pulse might need to be ~210 dB re 1 µPa rms (~221–226 dB pk–pk) in order to produce brief, mild TTS. Exposure to several seismic pulses at received levels near 200–205 dB (rms) might result in slight TTS in a small odontocete, assuming the TTS threshold is (to a first approximation) a function of the total received pulse energy. Seismic pulses with received levels of 200–205 dB or more are usually restricted to a radius of no more than 200 m around a seismic vessel operating a large array of airguns. For the smaller airgun array used in the proposed survey this radius will be no more than 100 m.

For baleen whales, there are no data, direct or indirect, on levels or properties of sound that are required to induce TTS. However, no cases of TTS are expected given the moderate size of the source, and the strong likelihood that baleen whales (especially migrating bowheads) would avoid the approaching airguns (or vessel) before being exposed to levels high enough for there to be any possibility of TTS.

In pinnipeds, TTS thresholds associated with exposure to brief pulses (single or multiple) of underwater sound have not been measured. Initial evidence from prolonged exposures suggested that some pinnipeds may incur TTS at somewhat lower received levels than do small odontocetes exposed for similar durations (Kastak et al. 1999, 2005; Ketten et al. 2001; cf. Au et al. 2000). In the harbor seal, which is closely related to the ringed seal, TTS onset apparently occurs at somewhat lower received energy levels than for odontocetes (see Appendix C).

A marine mammal within a radius of ~60 m (~197 ft) around the proposed airgun array might be exposed to a few seismic pulses with levels of ≥205 dB, and possibly more pulses if the mammal moved with the seismic vessel. (As noted above, most cetacean species tend to avoid operating airguns, although not all individuals do so.) However, several of the considerations that are relevant in assessing the impact of typical seismic surveys with arrays of airguns are not directly applicable here:

- "Ramping up" (soft start) is standard operational protocol during startup of large airgun arrays in many jurisdictions. Ramping up involves starting the airguns in sequence, usually commencing with a single airgun and gradually adding additional airguns. This practice will be employed when either airgun array is operated.
- It is unlikely that cetaceans would be exposed to airgun pulses at a sufficiently high level for a sufficiently long period to cause more than mild TTS, given the relative small airgun array and the movement of both the vessel and the marine mammal. In this project, most of the planned seismic survey will be in very shallow water nearshore of the barrier islands. The propagation of the sounds generated is expected to be very limited offshore of the islands, where most of the baleen whales are expected to occur.
- With a large array of airguns, TTS would be most likely in any odontocetes that bow-ride or in any odontocetes or pinnipeds that linger near the airguns. In the present project, BP anticipates the 190 and 180 dB distances to be 390 m and 880 m, respectively, for the 8-gun array (Table 3). Only seals could be expected to be potentially close to the airguns and no species that occur within the project area are expected to bow-ride.
- There is a possibility that a small number of seals (which often show little or no avoidance of approaching seismic vessels) could occur close to the airguns and that they might incur slight TTS if no mitigation action (shutdown) were taken.

NMFS (1995, 2000) concluded that cetaceans and pinnipeds should not be exposed to pulsed underwater noise at received levels exceeding, respectively, 180 and 190 dB re 1 μPa (rms). The 180 and 190 dB distances for the airguns operated by BP may be found to vary with array depth, however, conservative estimates have been used (390 m and 880 m, respectively; see Table 3) until results from field measurements are available (see Section 13.2). Furthermore, established 190 and 180 dB re 1 μPa (rms) criteria are not considered to be the levels above which TTS might occur. Rather, they are the received levels above which, in the view of a panel of bioacoustics specialists convened by NMFS before TTS measurements for marine mammals started to become available, one could not be certain that there would be no injurious effects, auditory or otherwise, to marine mammals. As summarized above, data that are now available imply that TTS is unlikely to occur unless bow-riding odontocetes are exposed to airgun pulses much stronger than 180 dB re 1 μPa rms (Southall et al., in press). Since no bow-riding species occur in the study area, it is unlikely such exposures will occur.

Permanent Threshold Shift (PTS) — When PTS occurs, there is physical damage to the sound receptors in the ear. In some cases, there can be total or partial deafness, whereas in other cases, the animal has an impaired ability to hear sounds in specific frequency ranges.

There is no specific evidence that exposure to pulses of airgun sound can cause PTS in any marine mammal, even with large arrays of airguns. However, given the possibility that mammals close to an airgun array might incur TTS, there has been further speculation about the possibility that some individuals occurring very close to airguns might incur PTS. Single or occasional occurrences of mild TTS are not indicative of permanent auditory damage in terrestrial mammals. Relationships between TTS and PTS thresholds have not been studied in marine mammals, but are assumed to be similar to those in humans and other terrestrial mammals. PTS might occur at a received sound level at least several decibels above that inducing mild TTS if the animal were exposed to the strong sound pulses with very rapid rise time—see Appendix C.

It is highly unlikely that marine mammals could receive sounds strong enough (and over a sufficient duration) to cause permanent hearing impairment during a project employing the airgun sources planned here. In the proposed project, marine mammals are unlikely to be exposed to received levels of seismic pulses strong enough to cause more than slight TTS. Given the higher level of sound necessary to cause PTS, it is even less likely that PTS could occur. In fact, even the levels immediately adjacent to the airgun may not be sufficient to induce PTS, especially because a mammal would not be exposed to more than one strong pulse unless it swam immediately alongside the airgun for a period longer than the inter-pulse interval. Baleen whales, and apparently belugas as well, generally avoid the immediate area around operating seismic vessels. The planned monitoring and mitigation measures, including visual monitoring, power downs, and shut downs of the airguns when mammals are seen within the "safety radii", will minimize the already-minimal probability of exposure of marine mammals to sounds strong enough to induce PTS.

Non-auditory Physiological Effects — Non-auditory physiological effects or injuries that theoretically might occur in marine mammals exposed to strong underwater sound include stress, neurological effects, bubble formation, and other types of organ or tissue damage. However, studies examining such effects are very limited. If any such effects do occur, they probably would be limited to unusual situations when animals might be exposed at close range for unusually long periods. It is doubtful that any single marine mammal would be exposed to strong seismic sounds for sufficiently long that significant physiological stress would develop. That is especially so in the case of the proposed project where the airgun configuration focuses most energy downward and the source vessels are moving at 4–5 knots.

In general, little is known about the potential for seismic survey sounds to cause auditory impairment or other physical effects in marine mammals. Available data suggest that such effects, if they occur at all, would be limited to short distances and probably to projects involving large arrays of airguns. However, the available data do not allow for meaningful quantitative predictions of the numbers (if any) of marine mammals that might be affected in those ways. Marine mammals that show behavioral avoidance of seismic vessels, including most baleen whales, some odontocetes (including belugas), and some pinnipeds, are especially unlikely to incur auditory impairment or other physical effects. Also, the planned monitoring and mitigation measures include shut downs of the airguns, which will reduce any such effects that might otherwise occur.

Stranding and Mortality

Marine mammals close to underwater detonations of high explosive can be killed or severely injured, and the auditory organs are especially susceptible to injury (Ketten et al. 1993; Ketten 1995). Airgun pulses are less energetic and have slower rise times, and there is no proof that they can cause serious injury, death, or stranding even in the case of large airgun arrays. However, the association of mass strandings of beaked whales with naval exercises and, in one case, a seismic survey, has raised the possibility that beaked whales exposed to strong pulsed sounds may be especially susceptible to injury and/or behavioral reactions that can lead to stranding (more details are provided in Appendix C). However, no beaked whales are found within this project area. The shallow water environment, small airgun arrays and planned monitoring and mitigation measures of the proposed survey are not expected to result in mortality of other marine mammal species.

7.2 Summary of potential effects of pinger signals

A pinger system (Dyne Acoustical Pingers) and acoustic releases/transponders (Benthos) will be used during seismic operations to position the receivers and locate and retrieve the batteries. Sounds from these pingers are very short pulses. The Dyne pinger has a source level ranging from ~188-193 dB re 1 µPa at 1 m in a frequency range of 19-36 kHz and the benthos has source levels ~192 dB re 1 µPa at 1 m in a frequency range of 7-15 kHz. Pulses are emitted on command from the operator aboard the source vessel.

Masking

The pinger produces sounds within the frequency range that could be detected by some seals and baleen whales, as they can hear sounds at frequencies up to 36 kHz. However, marine mammal communications will not be masked appreciably by the pinger signals. This is a consequence of the relatively low power output, low duty cycle, and brief period when an individual mammal is likely to be within the area of potential effects.

Behavioral Responses

Marine mammal behavioral reactions to other pulsed sound sources are discussed above, and responses to the pinger are likely to be similar to those for other pulsed sources if received at the same levels. However, the pulsed signals from the pinger are much weaker than those from the airgun. Therefore, behavioral responses are not expected unless marine mammals are very close to the source. The maximum reaction that might be expected would be a startle reaction or other short-term response. NMFS (2001) has concluded that momentary behavioral reactions "do not rise to the level of taking".

Hearing Impairment and Other Physical Effects

Source levels of the pinger are much lower than those of the airguns, which are discussed above. It is unlikely that the pinger produces pulse levels strong enough to cause temporary hearing impairment or (especially) physical injuries even in an animal that is (briefly) in a position near the source.

8 ANTICIPATED IMPACT ON SUBSISTENCE

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

Subsistence remains the basis for Alaska Native culture and community. Marine mammals are legally hunted in Alaskan waters by coastal Alaska Natives. In rural Alaska, subsistence activities are often central to many aspects of human existence, including patterns of family life, artistic expression, and community religious and celebratory activities. The main species that are hunted include bowhead and beluga whales, ringed, spotted, and bearded seals, walruses and polar bears[1]. The importance of each of these species varies among the communities and is largely based on availability.

In the Beaufort Sea, bowhead and beluga whales are the marine mammal species primarily harvested during the open water season, when the proposed seismic survey is planned. Bowhead whale hunting is the key activity in the subsistence economies of Barrow and two smaller communities, Nuiqsut and Kaktovik. The whale harvests have a great influence on social relations by strengthening the sense of Inupiat culture and heritage in addition to reinforcing family and community ties. Barrow residents focus hunting efforts on bowhead whales during the spring; however, can also conduct bowhead whale hunts in the fall. The communities of Nuiqsut and Kaktovik participate only in the fall bowhead harvest. Few belugas are present or harvested from Nuiqsut or Kaktovik.

Subsistence bowhead whale hunt

The Nuiqsut subsistence hunt has the potential to be impacted by the proposed seismic survey due to its proximity to Cross Island. Around late August the hunters from Nuiqsut establish camps on Cross Island from where they undertake the fall bowhead whale hunt. The hunting period starts normally in early September and lasts until around mid-October depending mainly on ice and weather conditions and the success of the hunt. Most of the hunt occurs offshore in waters east, north and northwest of Cross Island where bowheads migrate and not inside the barrier islands (Galginaitis 2007). Hunters prefer to take bowheads close to shore to avoid a long tow, but Braund and Moorehead (1995) report that crews may (rarely) pursue whales as far as 80 km offshore. The proposed seismic survey takes place within the barrier islands in very shallow water (<10 m) and has the potential to interfere with the hunt in two ways:

1 Deflection of whales further offshore from sounds generated by seismic airguns. Due to the relatively small airgun array in combination with the shallow water environment of the survey and presence of barrier islands, most low frequency sounds are not expected to propagate into the main bowhead migration corridor.

2 Interference with the hunt due to the presence of vessels near Cross Island.

Both concerns will be discussed with the native communities, and the survey will be conducted in compliance with the mitigation measures outlined in the CAA as a result of these communications.

Subsistence seal hunt

Ringed seals are hunted mainly from October through June. Hunting for these smaller mammals is concentrated during the ice season because of larger availability of seals on the ice. In winter, leads and cracks in the ice off points of land and along the barrier islands are used for hunting ringed seals. Although ringed seals are available year-round, the seismic survey will not occur during the primary period when these seals are typically harvested.

The more limited seal harvest that takes place during the open water season starts around the second week of June. Hunters take boats on routes in the Colville River and much of Harrison Bay. The main seal hunt occurs in areas far west from the Liberty area so impacts on the subsistence seal hunt are not expected. The potential for impacts on the seal hunt will however be discussed with the Nuiqsut community and specific provisions will be integrated in the survey in compliance with the CAA where applicable.

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[1] The subsistence hunt of walrus and polar bear and the anticipated impact of the proposed seismic survey activity on subsistence hunting is subject of the polar bear and walrus LOA request to USFWS.

9 ANTICIPATED IMPACT ON HABITAT

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

The proposed seismic survey will not result in any permanent impact on habitats used by marine mammals, or to the food sources they utilize. The proposed activities will be of short duration in any particular area at any given time; thus any effects would be localized and short-term. The main impact issue associated with the proposed activity will be temporarily elevated sound levels and the associated direct effects on marine mammals, as discussed in Section 6 and 7 above.

10 ANTICIPATED IMPACT OF LOSS OR MODIFICATION OF HABITAT ON MARINE MAMMALS

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

The proposed airgun operations will not result in any permanent impact on habitats used by marine mammals, or to the food sources they use. The main impact issue associated with the proposed activities will be temporarily elevated sound levels and the associated direct effects on marine mammals, as discussed above.

During the seismic study only a small fraction of the available habitat would be ensonified at any given time. Disturbance to fish species would be short-term and fish would return to their pre-disturbance behavior once the seismic activity ceases. Thus, the proposed survey would have little, if any, impact on the abilities of marine mammals to feed in the area where seismic work is planned.

Some mysticetes, including bowhead whales, feed on concentrations of zooplankton. Some feeding bowhead whales may occur in the Alaskan Beaufort Sea in July and August, and others feed intermittently during their westward migration in September and October (Richardson and Thomson [eds.] 2002; Lowry et al. 2004). A reaction by zooplankton to a seismic impulse would only be relevant to whales if it caused concentrations of zooplankton to scatter. Pressure changes of sufficient magnitude to cause that type of reaction would probably occur only very close to the source, if any would occur at all. Impacts on zooplankton behavior are predicted to be negligible, and that would translate into negligible impacts on feeding mysticetes. More importantly, bowhead whales are not expected to occur of feed in the shallow area covered by the seismic survey.

Thus, the proposed activity is not expected to have any habitat-related effects that could cause significant or long-term consequences for individual marine mammals or their populations.

11 MITIGATION MEASURES

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

The introduction of pulsed sounds generated by seismic airguns is the main source of potential impacts on marine mammal species and the focus of this request. The response of the animal depends on various factors, but short term behavioral responses are the most likely to occur. No serious and lethal injuries are expected. Implementation of the mitigation measures as described below will reduce the potential impacts to marine mammals. This section describes the measures that have been implemented in the survey design and those that will be implemented during the survey.

11.1 Mitigation measures within the survey design

Mitigation measures to reduce any potential impact on marine mammal species that have been considered and implemented in the planning and design phase are as follows:

- The area for which seismic data is required, i.e. the well path from SDI to the Liberty prospect, has been minimized by re-analyzing and re-interpreting existing data (to the extent available and usable). This has led to a reduction in size from ~85 mi^2 to ~35 mi^2. Note that this is not the total seismic area extent that includes the seismic source vessels and receiver lines, although they are related.
- The total airgun discharge volume has been reduced to the minimum volume needed to obtain the required data. The total volume for the proposed survey is 880 in^3 (consisting of two 4-gun arrays of 440 in^3).
- Two seismic source vessels will be used simultaneously (alternating their shots) to minimize the total survey period. This will allow the survey to be completed prior to the start of the whale fall migration and whaling season (weather depending).

11.2 Mitigation measures during operation

The seismic survey will take place inside the barrier islands in nearshore shallow waters. The survey period will be July-August, prior to the bowhead whale migration season, with some contingency to obtain data in September/October after the whaling season if necessary in compliance with the CAA. It is unlikely that whales will be present in the nearshore zone where the seismic survey is taking place and if they are present the numbers will be low. The main marine mammal species to be expected in the area is the ringed seal. With the proposed mitigation measures (see below), any effect on individuals are expected to be limited to short term behavioral disturbance with negligible impact on the species or stock.

The mitigation measures are an integral part of the survey in the form of specific procedures, such as: *i*) speed and course alterations; *ii*) power-down, ramp up and shutdown procedures; and *iii*) provisions for poor visibility conditions. For the implementation of these measures it is important to first establish and verify the distances of various received levels that function as safety zones and second to monitor these safety zones and implement mitigation measures where required.

Establishment and monitoring of safety zones

Greeneridge Sciences, Inc. estimated for BP the distances from the 880 in^3 seismic airgun array where sound levels 190, 180, 170, and 160 dB re 1 µPa (rms) would be received (Section 6.2 and Table 3). For these estimations, the results from transmission loss data obtained in the Liberty area in 1997 were used (Greene 1998). The calculations included distances for a reduced array of 440 in^3 and two different array depths (1 m and 4 m). These calculations form the basis for estimating the number of animals potentially affected.

Received sound levels will be measured as a function of distance from the array prior to the start of the survey. This will be done for: (a) two 440 in^3 arrays (880 in^3), (b) one 440 in^3 array, (c) one 70 in^3 airgun (smallest volume of array). BP will apply appropriate adjustments to the estimated safety zones (Table 3) based on measurements of the 880 in^3 (= two 440 in^3) array. Results from measurements of the 440 in^3 and 70 in^3 data will be used for the implementation of mitigation measures to power down the sound source and reduce the size of the safety zones when required (see section on power-down procedures below).

Marine mammal observers on board of the vessels play a key role in monitoring these safety zones and implementation of the mitigation measures. Their primary role is to monitor marine mammals near the seismic source vessel during all daylight airgun operations and during any nighttime start-up of the airguns. These observations will provide the real-time data needed to implement the key mitigation measures as described below. When marine mammals are observed within, or about to enter, designated safety zones airgun operations will be powered down (or shut down if necessary) immediately. These safety zones are defined as the distance from the source to a received level of 190 dB for pinnipeds and 180 dB for cetaceans. A specific dedicated vessel monitoring program to detect aggregations of baleen whales (12 or more) within the ≥160 dB zone or 4 or more bowhead whale cow-calf pairs within the ≥120 dB zone is not considered applicable here as none of these situations is expected for the proposed survey based on the estimated safety zones (Table 3). Monitoring options will be reconsidered if radii measured in the field are significantly larger than the estimated radii (and extend to areas where bowhead whales can be expected).

Speed and course alterations

If a marine mammal (in water) is detected outside the safety radius and, based on its position and the relative motion, is likely to enter the safety radius, the vessel's speed and/or direct course should be changed in a manner that does not compromise safety requirements. 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., either further course alterations or power-down or shut-down of the airgun(s).

Power-down, ramp-up and shut-down procedures

Power-down, ramp-up and shutdown procedures are implemented to prevent marine mammals from exposure to received levels of 190 dB (pinnipeds) and 180 dB (cetaceans). Dedicated marine mammal observers monitor these safety zones and have the authority to call for the implementation of these procedures when required by the situation. A summary of these situations is described below for each procedure. The criteria are consistent with guidelines listed for cetaceans and pinnipeds by NMFS (2000), and other guidance by NMFS.

Power-down procedure

A power-down involves decreasing the number of airguns in use such that the radii of the 190 dB and 180 dB zones are decreased to the extent that observed marine mammals are not in the applicable safety zone. Situations that would require a power down are listed below.

- When the vessel is changing from one source line to another, one airgun or a reduced number of airguns is operated. The continued operation of one airgun or a reduced airgun array is intended to (a) alert marine mammals to the presence of the seismic vessel in the area, and (b) retain the option of initiating a ramp up to full operations under poor visibility conditions.
- If a marine mammal is detected outside the safety radius but is likely to enter the safety radius, and if the vessel's speed and/or course cannot be changed to avoid the animal from entering the safety zone. As an alternative to a complete shut down, the airguns may be powered down before the animal is within the safety zone.
- If a marine mammal is already within the safety zone when first detected, the airguns may be powered down immediately if this is a reasonable alternative to a complete shut down. This decision will be made by the MMO and can be based on the results obtained from the acoustic measurements for the establishments of safety zones (see Section 11.2.1).

Following a power-down, operation of the full airgun array will not resume until the marine mammal has cleared the safety zone. The animal will be considered to have cleared the safety zone if it

- is visually observed to have left the safety zone, or
- has not been seen within the zone for 15 min in case of small odontocetes and pinnipeds, or
- has not been seen within the zone for 30 min in case of mysticetes (large odontocetes do not occur within the study area).

Shut-down Procedures

A shut-down procedure involves the complete turn off of all airguns. Ramp-up procedures will be followed during resumption of full seismic operations. The operating airgun(s) will be shut down completely during the following situations:

- If a marine mammal approaches or enters the applicable safety zone and a power down is not practical or adequate to reduce exposure to less than 190 or 180 dB (rms), as appropriate.
- If a marine mammal approaches or enters the estimated safety radius around the reduced source that will be used during a power down.

Airgun activity will not resume until the marine mammal has cleared the safety radius. The animal will be considered to have cleared the safety radius as described above under power-down procedures.

Ramp-up Procedures

A ramp-up procedure will be followed when the airgun array begins operating after a specified duration with no or reduced airgun operations. The specified duration depends on the speed of the source vessel, the size of the airgun array that is being used, and the size of the safety zone, but is often about 10 min.

NMFS normally requires that, once ramp-up commences, the rate of ramp-up be no more than 6 dB per 5 min period. Ramp up will likely begin with the smallest airgun, 70 in^3. The precise ramp-up procedure has yet to be determined, but BP intends to follow the ramp-up guideline of no more than 6 dB per 5 min period (unless otherwise required). A common procedure is to double the number of operating airguns at 5-min intervals. During the ramp-up, the safety zone for the full 8-gun array will be maintained. 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.

Poor visibility conditions

BP plans to conduct 24-hrs operations. Regarding night time observations, note that there will be no periods of total darkness until mid-August. Observers dedicated to marine mammal observations are proposed not to be on duty 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 following a full shut-down 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. The proposed provisions associated with operations at night or in periods of poor visibility include the following:

- During any nighttime operations, if the entire 180 dB safety radius is visible using vessel lights and/or night vision devices, then start of a ramp-up procedure after a complete shut-down of the airgun array may occur following a 30 min period of observation without sighting marine mammals in the safety zone.
- 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 can not 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.

BP has considered the use of passive acoustic monitoring in conjunction with visual monitoring to allow detection of marine mammals during poor visibility conditions, such as fog. The use of PAM for this specific survey might not be very effective because the species most commonly present (ringed seal) is not vocal during this time period.

12 PLAN OF COOPERATION

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

BP has begun negotiating a “Plan of Cooperation” in the form of a Conflict Avoidance Agreement (CAA) with representatives of the community of Nuiqsut, the AEWC and NSB for the proposed 2008 Liberty seismic survey in Foggy Island Bay, Beaufort Sea. BP is working with the people of these communities and organizations to identify and avoid areas of potential conflict. Meetings that have taken place prior to the survey include:

October 25, 2007: Meeting with AEWC and NSB representatives during the AEWC convention;

October 29, 2007: Meeting with NSB Wildlife Group to provide updates of the survey and to obtain information on their opinions and views on mitigation and monitoring requirements.

April 2008: As in previous years, BP plans to participate in the “open water peer/stakeholder review meeting” to be convened by NMFS in Anchorage in mid-April 2008, where representatives of the Alaska Eskimo Whaling Commission and North Slope Borough are also expected to participate.

Subsequent meetings with whaling captains, other community representatives, the AEWC, NSB, and any other stakeholders will be held as necessary to negotiate the terms of the plan and to coordinate the planned seismic survey operation with subsistence hunting activity.

The CAA will cover the phases of BP’s seismic survey planned to occur in July and August and if required after the whaling season or as agreed in the CAA with the respective communities. The purpose of this plan will be to identify measures that will be taken to minimize any adverse effects on the availability of marine mammals for subsistence uses and to ensure good communication between BP (including the seismic team leads), native communities along the coast, and subsistence hunters at sea.

The proposed Plan of Cooperation may address the following:

- Operational agreement and communications procedures
- Where/when agreement becomes effective
- General communications scheme
- On-board Inupiat observer
- Conflict avoidance
- Seasonally sensitive areas
- Vessel navigation
- Marine mammal monitoring activities
- Measures to avoid impacts to marine mammals
- Measures to avoid conflicts in areas of active whaling
- Emergency assistance
- Dispute resolution process

13 MONITORING AND REPORTING PLAN

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

BP proposes to sponsor marine mammal monitoring during the Liberty seismic survey, in order to implement the proposed mitigation measures that require real-time monitoring, to satisfy the anticipated monitoring requirements of the USFWS LOA and NMFS IHA, and to meet any monitoring requirements agreed to as part of the Plan of Cooperation/Conflict Avoidance Agreement.

BP's proposed Monitoring Plan is described below. BP understands that this Monitoring Plan will be subject to review by NMFS and others, and that refinements may be required.

The monitoring work described here has been planned as a self-contained project independent of any other related monitoring projects that may be occurring simultaneously in the same region. Provided that an acceptable methodology and business relationship can be worked out in advance, BP is prepared to work with other energy companies in its efforts to manage, understand, and fully communicate information about environmental impacts related to its activities.

13.1 Vessel-based visual monitoring by marine mammal observers (MMO)

There will be three MMOs on each source vessel during the entire survey. These vessel-based MMOs will monitor marine mammals near the seismic source vessels during all daylight hours and during any ramp-up of airguns at night. In case the source vessels are not shooting but are involved in the deployment or retrieval of receiver cables, the MMOs will remain on the vessels and will continue their observations. The main purpose of the MMOs is to monitor the established safety zones and to implement the mitigation measures as described in Section 11.

Objectives

The main objectives of the visual based marine mammal monitoring from the seismic source vessels are as follows:

1 To form the basis for implementation of mitigation measures during the seismic operation (e.g. course alteration, airgun power-down, shut-down and ramp-up);

2 To obtain information needed to estimate the number of marine mammals potentially affected, which must be reported to NMFS within 90 days after the survey;

3 To compare the distance and distribution of marine mammals relative to the source vessel at times with and without seismic activity;

4 To obtain data on the behavior and movement patterns of marine mammals observed and compare those at times with and without seismic activity.

Note that potential to successfully achieve objectives 3 and 4 is subject to the number of animals observed during the survey period.

Two MMOs will also be placed on the mothership the *M/V Arctic Wolf* during its transit from Homer or Anchorage, via the Chukchi Sea and around Barrow to the survey area. Presence of MMOs on this vessel is to prevent any potential impact on beluga whales during the spring hunt, in addition to other measures that will be taken in close communication with the whale hunters of Point Lay and Kotzebue. It will be important that at least one Alaska native resident who speaks Inupiat will be placed on this vessel.

Marine mammal observer protocol

BP intends to work with experienced MMOs that have had previous experience working on seismic survey vessels, which will be especially important for the lead MMO. At least one Alaska native resident who speaks Inupiat and is knowledgeable about the marine mammals of the area is expected to be included as one of the team members aboard both source vessels and the mother ship.

At least one observer will monitor for marine mammals at any time during daylight hours and nighttime ramp-ups after a full shut down (and if safety zone is visible). Note that there will be no periods of total darkness until mid-August. Two MMOs will be on duty whenever feasible and practical, as the use of two simultaneous observers will increase the detectability of animals present near the source vessels. MMOs will be on duty in shifts of maximum 4 hours, but the exact shift regime will be established by the lead MMO in consultation with each MMO team member.

Before the start of the seismic survey the lead MMO will explain the function of the MMOs, their monitoring protocol and mitigation measures to be implemented to the crew of the seismic source vessels *M/V Peregrine* and *M/V Maxime*. Additional information will be provided to the crew by the lead MMO that will allow the crew to assist in the detection of marine mammals and (where possible and practical) in the implementation of mitigation measures.

Both the *M/V Peregrine* and *M/V Maxime* are relatively small vessels but form suitable platforms for marine mammal observations. Observations will be made from the bridges, which are respectively ~15 ft (~4.5 m) and ~12 ft (~3.7 m) above sea level and where MMOs have the best view around the vessel. During daytime, the MMO(s) will scan the area around the vessel systematically with reticle binoculars (e.g., 7×50 Fujinon) and with the naked eye. During any periods of darkness, night vision devices will be available (ITT F500 Series Generation 3 binocular-image intensifier or equivalent), if and when required. Laser rangefinding binoculars (Leica LRF 1200 laser rangefinder or equivalent) will be available to assist with distance estimation; these are useful in training observers to estimate distances visually, but are generally not useful in measuring distances to animals directly.

Communication procedures

When marine mammals in the water are detected within or about to enter the designated safety zones, the airgun(s) power-down or shut-down procedures need to be implemented immediately. To assure prompt implementation of power-downs and shut-downs, multiple channels of communication between the MMOs and the airgun technicians will be established. During the power-down and shut-down, the MMO(s) will continue to maintain watch to determine when the animal(s) are outside the safety radius. Airgun operations can be resumed with a ramp-up procedure (depending on the extent of the power down) if the observers have visually confirmed that the animal(s) moved outside the safety zone, or if the animal(s) were not observed within the safety zone for 15 min (pinnipeds) or for 30 min (cetaceans). Direct communication with the airgun operator will be maintained throughout these procedures.

Data recording

All marine mammal observations and any airgun power-down, shut-down and ramp-up will be recorded in a standardized format. Data will be entered into a custom database using a notebook computer. The accuracy of the data entry will be verified by computerized validity data checks as the data are entered and by subsequent manual checking of the database. These procedures will allow initial summaries of data to be prepared during and shortly after the field program, and will facilitate transfer of the data to statistical, graphical, or other programs for further processing and archiving.

13.2 Acoustic measurements and monitoring

Acoustic measurements and monitoring will be conducted for three different purposes:

1 To establish the distances of the safety zones;

2 To measure source levels (i.e. received levels referenced to 1 m from the sound source) of each vessel of the seismic fleet, to obtain knowledge on the sounds generated by the vessels;

3 To measure received levels offshore of the barrier islands from the seismic sound source.

Verification and establishment of safety zones

Prior to, or at the beginning of the seismic survey, acoustic measurements will be conducted to calculate received sound levels as a function of distance from the airgun sound source. These measurements will be conducted for different discharge volumes.

The results of these acoustic measurements will be used to re-define the safety zone distances for received levels of 190 dB, 180 dB and 160 dB. The 160 dB received level is monitored to avoid any behavioral disturbances of whales that may be in the area. The distances of the received levels as a function of the different sound sources (varying discharge volumes) will be used to guide power-down and ramp-up procedures. A preliminary report describing the methodology and results of the measurement for at least the 190 dB and 180 dB (rms) safety zones will be submitted to NMFS within 72-hrs of completion of the measurements.

Measurements of vessel sounds

BP intends to measure vessel sounds of each representative vessel. The exact scope of the source level measurements (back-calculated as received levels at 1 m from the source) should follow a pre-defined protocol to eliminate the complex interplay of factors that underlie these measurements, such as bathymetry, vessel activity, location, season, etc. Where possible and practical the monitoring protocol will be developed in alignment with other existing vessel source level measurements. BP would welcome a discussion with NMFS or other stakeholders to define a mutual beneficial objective.

Received sound levels offshore the barrier islands

The proposed seismic survey will take place inside the barrier islands and as such the sounds from the seismic survey activities are not expected to propagate much beyond the shallow areas formed by these barrier islands. However, because the survey might extend partly into September/October, when bowheads migrate past the area, and there are some slightly deeper water channels in between the barrier islands, BP intends to develop a simple acoustic monitoring plan to measure received sound levels outside the barrier islands during the seismic survey.

13.3 Aerial Surveys

During the July and August timeframe no bowhead whales are expected to be present in or close to the survey area, so no aerial surveys are planned during this timeframe. If the survey continues into September or October, after the bowhead whale hunt and in compliance with the CAA, aerial surveys will be conducted bi-weekly, if conditions allow, until three days after the seismic survey and cover the area immediately offshore of the barrier islands. If other operators conduct surveys in the vicinity, cooperation regarding sharing data or flight time can be considered, provided that an acceptable methodology and business relationship can be worked out in advance.

13.4 Reporting

A report on the preliminary results of the acoustic verification measurements, including as a minimum the measured 190 and 180 dB (rms) radii of the airgun sources, will be submitted within 72-hrs after collection of those measurements at the start of the field season. This report will specify the distances of the safety zones that were adopted for the survey.

A report on BP's activities and on the relevant monitoring and mitigation results will be submitted to NMFS within 90 days after the end of the seismic survey. The report will describe the operations that were conducted, the measured sound levels, and the cetaceans and seals that were detected near the operations. The report will be submitted to NMFS, providing full documentation of methods, results, and interpretation pertaining to all acoustic and vessel-based marine mammal monitoring. The 90-day report will summarize the dates and locations of seismic operations, and all whale and seal sightings[2] (dates, times, locations, activities, associated seismic survey activities). Marine mammal sightings will be reported at species level, however, especially during unfavorable environmental conditions (e.g. low visibility, high sea states) this will not always be possible. The number and circumstances of ramp-up, power-down, shut-down, and other mitigation actions will be reported. The report will also include estimates of the amount and nature of potential impact to cetaceans and seals encountered during the survey.

14 COORDINATING RESEARCH TO REDUCE AND EVALUATE INCIDENTAL HARASSMENT

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

Provided that an acceptable methodology and business relationship can be worked out in advance, BP will work with any number of external entities, including other energy companies, agencies, universities, and NGOs, in its efforts to manage, understand, and fully communicate information about environmental impacts related to the seismic activities.

BP is also interested in better understanding cumulative effects. In the past, BP has been an active participant in the National Academy's cumulative effects study. In addition, BP sponsored workshops intended to design better approaches to cumulative effects studies. The challenge in this case is determining a responsible approach to considering cumulative effects from sound.

[2] Note that it will not always be possible to identify the observed marine mammal to species level.

We are open to ideas and discussion and welcome comments from stakeholders with regard to assessment of cumulative effects from sound.

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APPENDIX A

VESSEL SPECIFICATIONS

APPENDIX B

SEISMIC ARRAY DESCRIPTION

Two source vessels will tow along predetermined lines a 8-gun array with a total discharge volume of 880 in^3 at 8 to10 m from each vessel at depths varying between 1 and 4 m. Seismic pulses will be emitted by each vessel at intervals of ~8 s and recorded by the ocean bottom receivers. The figures below provide more detailed acoustic information about the source array.

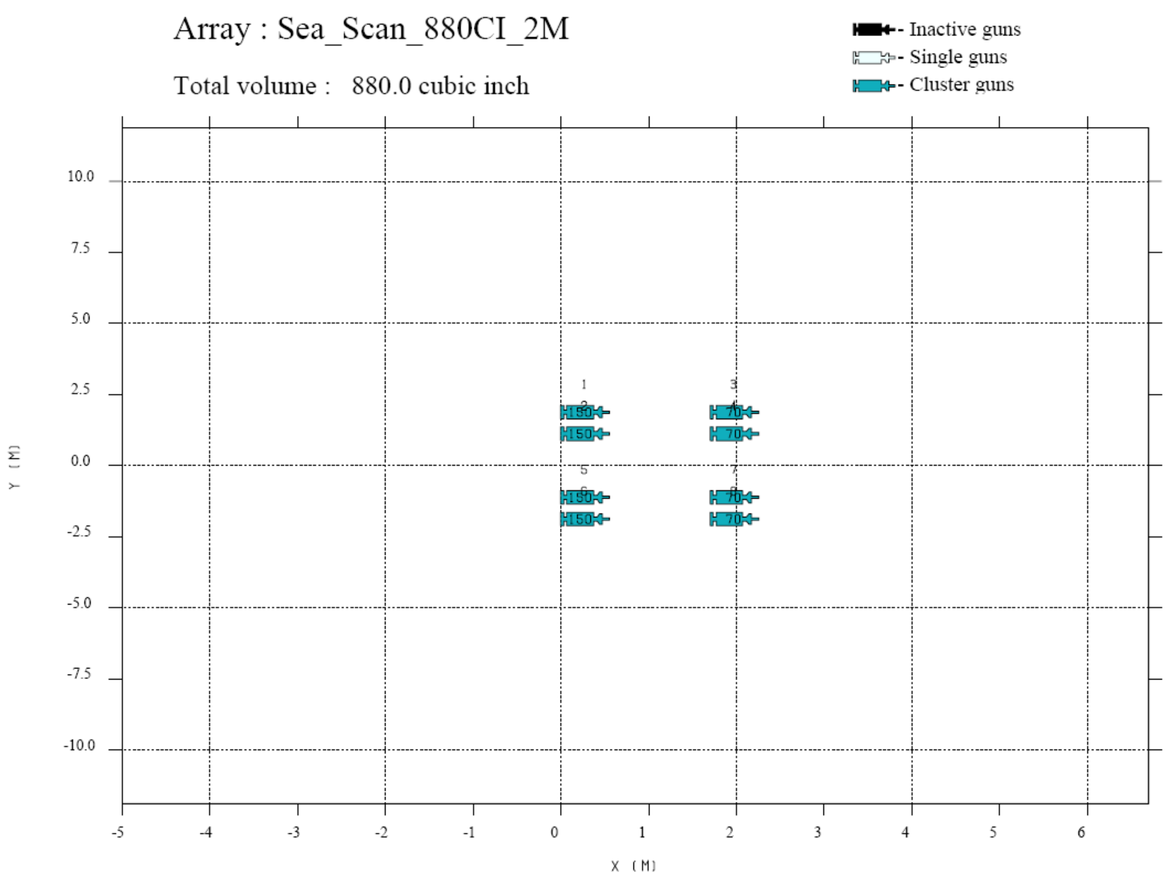

Figure B1. Spacing and configuration of the 880 in3 seismic airgun array to be towed behind the Peregrine and Maxim during the proposed survey. Four 150 in3 guns are on the left and four 70 in3 guns on the right. Measurements are in meters.

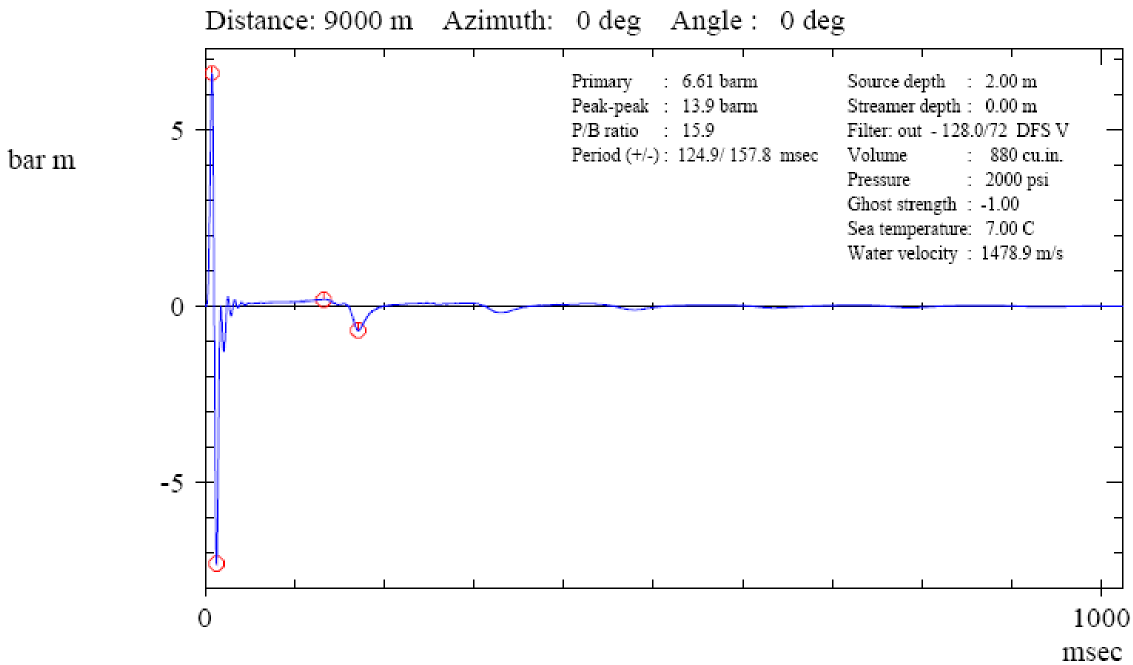

Figure B2. Far-field source signature for 8 sleeve gun 880 in3 array to be used by BPXA in the Liberty area, 2008.

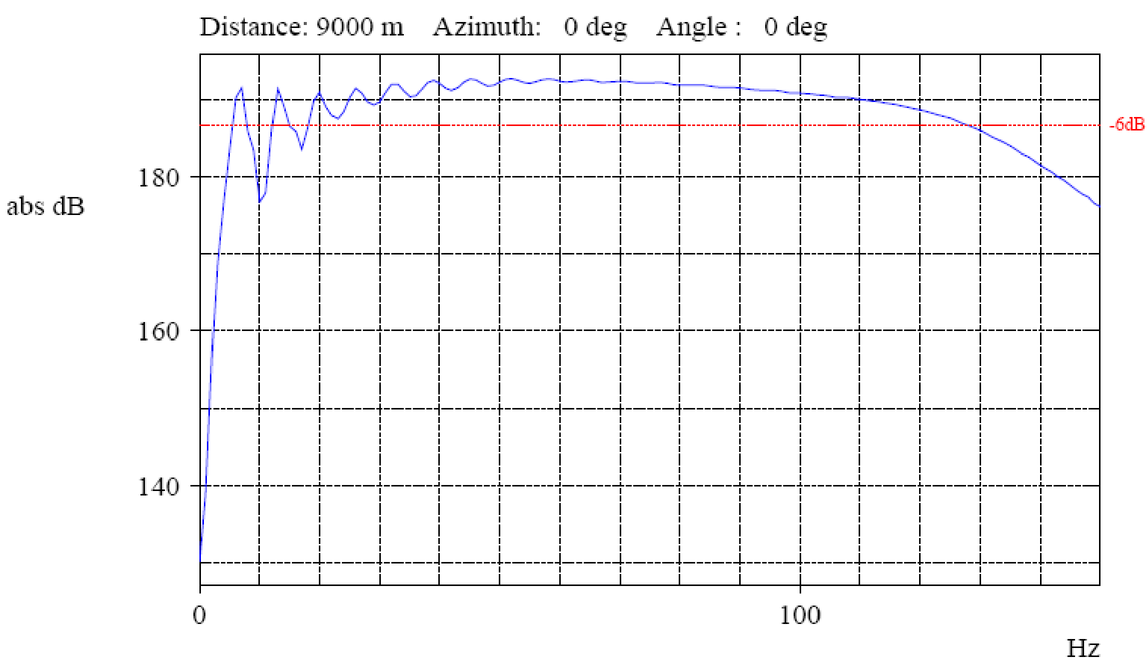

Figure B3. Far-field source amplitude spectrum for 8 sleeve gun 880 in3 array to be used by BPXA in the Liberty area, 2008.

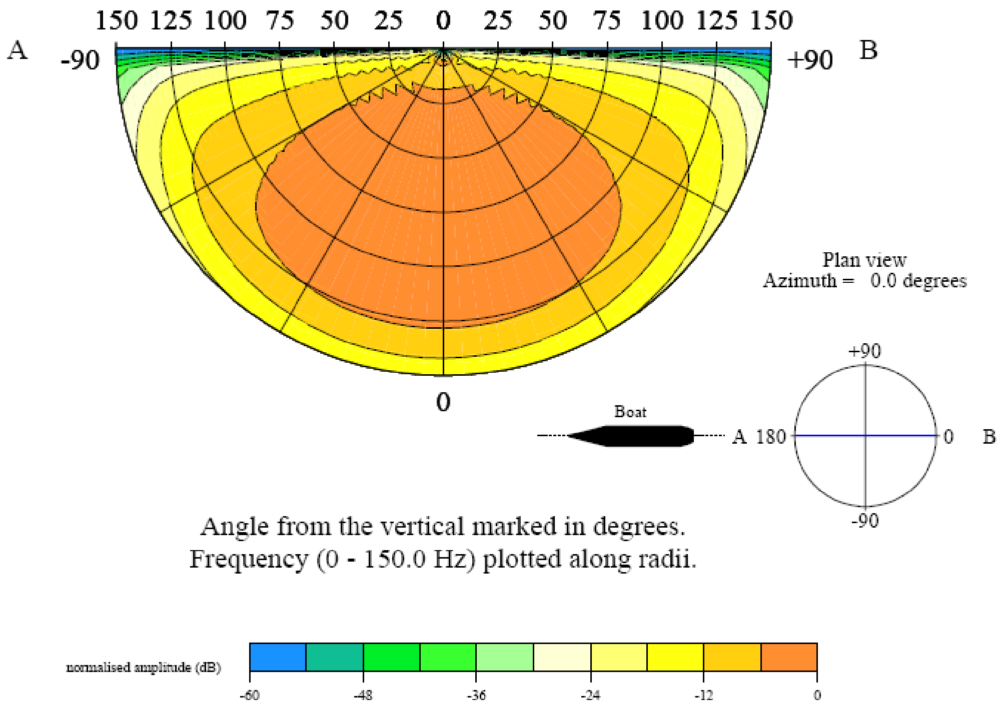

Figure B4. Source directivity plots for the 880 in3 gun array to be used by BPXA in the Liberty area, 2008 – azimuth: 0.0 degrees.

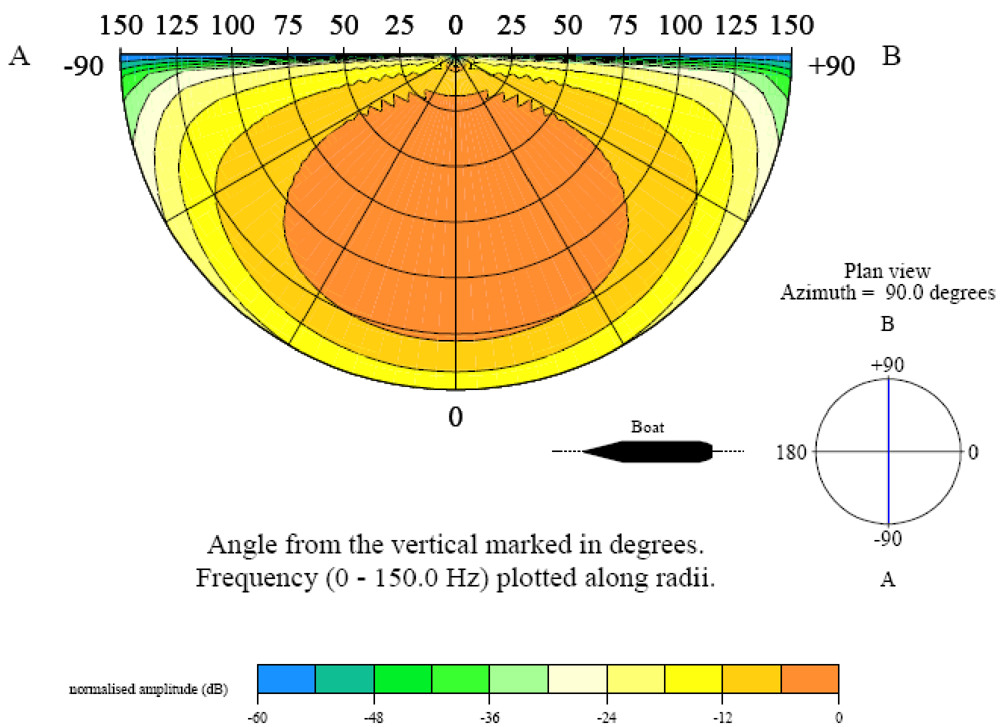

Figure B5. Source directivity plots for the 880 in3 gun array to be used by BPXA in the Liberty area, 2008 – azimuth: 90.0 degrees.

APPENDIX C

REVIEW OF POTENTIAL IMPACTS OF AIRGUN SOUNDS ON MARINE MAMMALS [3]

The following subsections review relevant information concerning the potential effects of airgun sounds on marine mammals. This information is included here as background for the briefer summary of this topic included in this IHA. This background material is little changed from corresponding subsections included in IHA applications and EAs submitted to NMFS for other seismic surveys from 2003 to date. Much of this information has also been included in varying formats in other reviews, assessments, and regulatory applications prepared by LGL Ltd., environmental research associates. Because this review is intended to be of general usefulness, it includes references to types of marine mammals that will not be found in some specific regions.

(a) Categories of Noise Effects

The effects of noise on marine mammals are highly variable, and can be categorized as follows (based on Richardson et al. 1995):

1. The noise may be too weak to be heard at the location of the animal, i.e., lower than the prevailing ambient noise level, the hearing threshold of the animal at relevant frequencies, or both;
2. The noise may be audible but not strong enough to elicit any overt behavioral response, i.e., the mammals may tolerate it;
3. The noise may elicit behavioral reactions of variable conspicuousness and variable relevance to the well being of the animal; these can range from subtle effects on respiration or other behaviors (detectable only by statistical analysis) to active avoidance reactions;
4. Upon repeated exposure, animals may exhibit diminishing responsiveness (habituation), or disturbance effects may persist; the latter is most likely with sounds that are highly variable in characteristics, unpredictable in occurrence, and associated with situations that the animal perceives as a threat;
5. Any man-made noise that is strong enough to be heard has the potential to reduce (mask) the ability of marine mammals to hear natural sounds at similar frequencies, including calls from conspecifics, echolocation sounds of odontocetes, and environmental sounds such as surf noise or (at high latitudes) ice noise. However, intermittent airgun or echosounder pulses could cause masking for only a small proportion of the time, given the short duration of these pulses relative to the inter-pulse intervals;
6. Very strong sounds have the potential to cause temporary or permanent reduction in hearing sensitivity, or other physical effects. Received sound levels must far exceed the animal's hearing threshold for any temporary threshold shift to occur. Received levels must be even higher for a risk of permanent hearing impairment.

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(b) Hearing Abilities of Marine Mammals

The hearing abilities of marine mammals are functions of the following (Richardson et al. 1995; Au et al. 2000):

1. Absolute hearing threshold at the frequency in question (the level of sound barely audible in the absence of ambient noise). The "best frequency" is the frequency with the lowest absolute threshold.
2. Critical ratio (the signal-to-noise ratio required to detect a sound at a specific frequency in the presence of background noise around that frequency).
3. The ability to localize sound direction at the frequencies under consideration.
4. The ability to discriminate among sounds of different frequencies and intensities.

Marine mammals rely heavily on the use of underwater sounds to communicate and to gain information about their surroundings. Experiments also show that they hear and may react to many man-made sounds including sounds made during seismic exploration.

Baleen Whales (Mysticetes)

The hearing abilities of baleen whales have not been studied directly. Behavioral and anatomical evidence indicates that they hear well at frequencies below 1 kHz (Richardson et al. 1995; Ketten 2000). Baleen whales also reacted to sonar sounds at 3.1 kHz and other sources centered at 4 kHz (see Richardson et al. 1995 for a review). Frankel (2005) noted that gray whales reacted to a 21–25 kHz whale-finding sonar. Some baleen whales react to pinger sounds up to 28 kHz, but not to pingers or sonars emitting sounds at 36 kHz or above (Watkins 1986). In addition, baleen whales produce sounds at frequencies up to 8 kHz and, for humpbacks, to >15 kHz (Au et al. 2001). The anatomy of the baleen whale inner ear seems to be well adapted for detection of low-frequency sounds (Ketten 1991, 1992, 1994, 2000). The absolute sound levels that they can detect below 1 kHz are probably limited by increasing levels of natural ambient noise at decreasing frequencies. Ambient noise energy is higher at low frequencies than at mid frequencies. At frequencies below 1 kHz, natural ambient levels tend to increase with decreasing frequency.

The hearing systems of baleen whales are undoubtedly more sensitive to low-frequency sounds than are the ears of the small toothed whales that have been studied directly. Thus, baleen whales are likely to hear airgun pulses farther away than can small toothed whales and, at closer distances, airgun sounds may seem more prominent to baleen than to toothed whales. However, baleen whales have commonly been seen well within the distances where seismic (or other source) sounds would be detectable and yet often show no overt reaction to those sounds. Behavioral responses by baleen whales to seismic pulses have been documented, but received levels of pulsed sounds necessary to elicit behavioral reactions are typically well above the minimum detectable levels (Malme et al. 1984, 1988; Richardson et al. 1986, 1995; McCauley et al. 2000a; Johnson 2002).

Toothed Whales (Odontocetes)

Hearing abilities of some toothed whales (odontocetes) have been studied in detail (reviewed in Chapter 8 of Richardson et al. [1995] and in Au et al. [2000]). Hearing sensitivity of several species has been determined as a function of frequency. The small to moderate-sized toothed whales whose hearing has been studied have relatively poor hearing sensitivity at frequencies below 1 kHz, but extremely good sensitivity at, and above, several kHz. There are very few data on the absolute hearing thresholds of most of the larger, deep-diving toothed whales, such as the sperm and beaked whales. However, Mann et al. (2005) and Cook et al.

(2006) reported that a Gervais' beaked whale showed evoked potentials from 5 to 80 kHz, with the best sensitivity at 40–80 kHz.

Despite the relatively poor sensitivity of small odontocetes at the low frequencies that contribute most of the energy in pulses of sound from airgun arrays, the sounds are sufficiently strong that their received levels sometimes remain above the hearing thresholds of odontocetes at distances out to several tens of kilometers (Richardson and Würsig 1997). However, there is no evidence that small odontocetes react to airgun pulses at such long distances, or even at intermediate distances where sound levels are well above the ambient noise level (see below).

The multibeam echosounders operated from oceanographic vessels to survey deep areas and sub-bottom profilers emit pulsed sounds at 12–15.5 kHz and 2.5–18 kHz, respectively. Those frequencies are within or near the range of best sensitivity of many odontocetes. Thus, sound pulses from the multibeam echosounder and sub-bottom profiler will be readily audible to these animals when they are within the narrow angular extent of the transmitted sound beam. Some vessels operate higher frequency (e.g., 24–455 kHz) multibeam echosounders designed to map shallower waters, and some of those will also be audible to odontocetes.

Seals and Sea Lions (Pinnipeds)

Underwater audiograms have been obtained using behavioral methods for three species of phocinid seals, two species of monachid seals, two species of otariids, and the walrus (reviewed in Richardson et al. 1995: 211*ff*; Kastak and Schusterman 1998, 1999; Kastelein et al. 2002). In comparison with odontocetes, pinnipeds tend to have lower best frequencies, lower high-frequency cutoffs, better auditory sensitivity at low frequencies, and poorer sensitivity at the best frequency.

At least some of the phocid (hair) seals have better sensitivity at low frequencies (≤1 kHz) than do odontocetes. Below 30–50 kHz, the hearing thresholds of most species tested are essentially flat down to about 1 kHz, and range between 60 and 85 dB re 1 µPa. Measurements for a harbor seal indicate that, below 1 kHz, its thresholds deteriorate gradually to ~97 dB re 1 µPa at 100 Hz (Kastak and Schusterman 1998). The northern elephant seal appears to have better underwater sensitivity than the harbor seal, at least at low frequencies (Kastak and Schusterman 1998, 1999).

For the otariid (eared) seals, the high frequency cutoff is lower than for phocinids, and sensitivity at low frequencies (e.g., 100 Hz) is poorer than for hair seals (harbor or elephant seal).

The underwater hearing of a walrus has been measured at frequencies from 125 Hz to 15 kHz (Kastelein et al. 2002). The range of best hearing was 1–12 kHz, with maximum sensitivity (67 dB re 1 µPa) occurring at 12 kHz (Kastelein et al. 2002).

Manatees and Dugong (Sirenians)

The West Indian manatee can apparently detect sounds from 15 Hz to 46 kHz, based on use of behavioral testing methods (Gerstein et al. 1999). Thus, manatees may hear, or at least detect, sounds in the low-frequency range where most seismic energy is released. It is possible that they are able to feel these low-frequency sounds using vibrotactile receptors or because of resonance in body cavities or bone conduction.

Based on measurements of evoked potentials, manatee hearing is apparently best around 1–1.5 kHz (Bullock et al. 1982). However, behavioral testing suggests their best sensitivity is at 6–20 kHz (Gerstein et al. 1999). The ability to detect high frequencies may be an adaptation to shallow water, where the propagation of low frequency sound is limited (Gerstein et al. 1999).

Sea Otter and Polar Bear (Fissipeds)

No data are available on the hearing abilities of sea otters (Ketten 1998), although the in-air vocalizations of sea otters have most of their energy concentrated at 3–5 kHz (McShane et al. 1995; Thomson and Richardson 1995; Richardson et al. 1995). Sea otter vocalizations are considered to be most suitable for short-range communication among individuals (McShane et al. 1995). Airborne sounds include screams, whines or whistles, hisses, deep-throated snarls or growls, soft cooing sounds, grunts, and barks (Kenyon 1975; McShane et al. 1995).

Data on the specific hearing capabilities of polar bears are also largely lacking. A recent study, and the only known testing of in-air hearing of polar bears, conducted measurements using auditory evoked potentials while tone pips were played to anesthetized bears (Nachtigall et al. 2007). Hearing was tested in ½ octave steps from 1 to 22.5 kHz, and best hearing sensitivity was found between 11.2 and 22.5 kHz. These data suggest that polar bears have sensitive hearing over a wide frequency range.

Data suggest that the frequencies of some medium- and high-frequency sounds may be audible to polar bears. However, polar bears' usual behavior (e.g., remaining on the ice, at the water surface, or on land) reduces or avoids their exposure to those sounds. Sea otters may be able to detect some low- and medium-frequency sounds, but as with polar bears, their largely water surface- and land-oriented behavior would reduce their exposure to those sounds.

(c) Characteristics of Airgun Pulses

Airguns function by venting high-pressure air into the water. The pressure signature of an individual airgun consists of a sharp rise and then fall in pressure, followed by several positive and negative pressure excursions caused by oscillation of the resulting air bubble. The sizes, arrangement, and firing times of the individual airguns in an array are designed and synchronized to suppress the pressure oscillations subsequent to the first cycle. The resulting downward-directed pulse has a duration of only 10–20 ms, with only one strong positive and one strong negative peak pressure (Caldwell and Dragoset 2000). Most energy emitted from airguns is at relatively low frequencies. For example, typical high-energy airgun arrays emit most energy at 10–120 Hz. However, the pulses contain some energy up to 500–1000 Hz and above (Goold and Fish 1998; Potter et al. 2006). Substantial high-frequency energy output of up to 150 kHz was found during tests of 60-in^3 and 250-in^3 airguns (Goold and Coates 2006). In fact, the output of those airguns covered the entire frequency range known to be used by marine mammals. The output included substantial energy levels that would be clearly audible to most, if not all, cetacean species (Goold and Coates 2006). Other recent studies—including controlled studies of sperm whales in the Gulf of Mexico (Tyack et al. 2006)—have also found that airguns exposed animals to significant sound energy above 500 Hz (Goold and Fish 1998; Sodal 1999). Those data increase concerns about the potential impacts of seismic sounds on odontocetes with poor low-frequency hearing but good higher-frequency hearing.

The pulsed sounds associated with seismic exploration have higher peak levels than other industrial sounds (except explosions) to which whales and other marine mammals are routinely exposed. The source levels of the 2- to 20-airgun arrays used by Lamont-Doherty Earth Observatory (L-DEO) from the R/V *Maurice Ewing* during previous projects ranged from 236 to 263 dB re 1 μPa_{p-p}, considering the frequency band up to about 250 Hz. The source level for the 36-airgun array used on the *Langseth* is 265 dB re 1 μPa_{p-p}. These are the nominal source levels applicable to downward propagation. The effective source levels for horizontal propagation are lower than those for downward propagation when numerous airguns spaced apart from one another are used. The only man-made sources with effective source levels as high as (or higher than) a large array of airguns are explosions and high-power sonars operating near maximum power.

Levels of anthropogenic underwater sounds, including those produced by seismic surveys, have been increasing worldwide. Concurrently, there is growing concern by the general public, researchers, government entities, and others regarding exposure of marine mammals to these sounds (e.g., Hildebrand 2004; Marine Technological Society 2004; Simmonds et al. 2006). In a comparison of anthropogenic underwater sound sources, airgun arrays worldwide were estimated to introduce 3.9 x 10^{13} Joules of energy into the ocean, second only to underwater nuclear explosions and ranking above military sonars (Moore and Angliss 2006). As a result, there has been increasing interest and studies on methods to estimate the numbers of animals exposed to various sound levels and to mitigate exposure to these sounds (e.g., Hollingshead and Harrison 2005).

Recent attention has focused on developing sound exposure criteria appropriate to the acoustic sensitivities of various marine mammal groups and species (e.g., Hollingshead and Harrison 2005; Miller et al. 2005a). These exposure criteria have important implications for identifying appropriate "safety radii" and sound exposure limits, including balancing mitigation with goals of geophysical seismic studies (e.g., Barton et al. 2006). Various empirical data are being collected, and modeling and predictions of the propagation and received levels of airgun sounds are being developed and applied (e.g., Breitzke 2006; Diebold et al. 2006; Frankel et al. 2006; Miller et al. 2006; Racca et al. 2006; Turner et al. 2006; Tyack et al. 2006). These recent studies are affecting the way underwater sound is modeled. For example, DeRuiter et al. (2005) reported that on-axis source levels and spherical spreading assumptions alone insufficiently describe airgun pulse propagation and the extent of exposure zones.

Several important mitigating factors need to be kept in mind. *(1)* Airgun arrays produce intermittent sounds, involving emission of a strong sound pulse for a small fraction of a second followed by several seconds of near silence. In contrast, some other sources produce sounds with lower peak levels, but their sounds are continuous or discontinuous but continuing for much longer durations than seismic pulses. *(2)* Airgun arrays are designed to transmit strong sounds downward through the seafloor, and the amount of sound transmitted in near-horizontal directions is considerably reduced. Nonetheless, they also emit sounds that travel horizontally toward non-target areas. *(3)* An airgun array is a distributed source, not a point source. The nominal source level is an estimate of the sound that would be measured from a theoretical point source emitting the same total energy as the airgun array. That figure is useful in calculating the expected received levels in the far field, i.e., at moderate and long distances. Because the airgun array is not a single point source, there is no one location within the near field (or anywhere else) where the received level is as high as the nominal source level.

The strengths of airgun pulses can be measured in different ways, and it is important to know which method is being used when interpreting quoted source or received levels. Geophysicists usually quote pk–pk levels, in bar-meters or (less often) dB re 1 µPa•m. The peak (= 0–pk) level for the same pulse is typically ~6 dB less. In the biological literature, levels of received airgun pulses are often described based on the "average" or "root-mean-square" (rms) level, where the average is calculated over the duration of the pulse. The rms value for a given airgun pulse is typically ~10 dB lower than the peak level, and 16 dB lower than the pk–pk value (Greene 1997; McCauley et al. 1998, 2000a). A fourth measure that is sometimes used is the energy, or Sound Exposure Level (SEL), in dB re 1 μPa^2•s. Because the pulses are <1 s in duration, the numerical value of the energy is lower than the rms pressure level, but the units are different. Because the level of a given pulse will differ substantially depending on which of these measures is being applied, it is important to be aware which measure is in use when interpreting any quoted pulse level. In the past, NMFS has commonly referred to rms levels when discussing levels of pulsed sounds that might "harass" marine mammals.

Seismic sound received at any given point will arrive via a direct path, indirect paths that include reflection from the sea surface and bottom, and often indirect paths including segments through the bottom sediments. Sounds propagating via indirect paths travel longer distances and often arrive later than sounds arriving via a direct path. (However, sound traveling in the bottom may travel faster than that in the water, and thus may, in some situations, arrive slightly earlier than the direct arrival despite traveling a greater distance.) These variations in travel time have the effect of lengthening the duration of the received pulse, or may cause two or more received pulses from a single emitted pulse. Near the source, the predominant part of a seismic pulse is ~10–20 ms in duration. In comparison, the pulse duration received at long horizontal distances can be much greater. For example, for one airgun array operating in the Beaufort Sea, pulse durations were ~300 ms at a distance of 8 km, 500 ms at 20 km, and 850 ms at 73 km (Greene and Richardson 1988).

Another important aspect of sound propagation is that received levels of low-frequency underwater sounds diminish close to the surface because of pressure-release and interference phenomena that occur at and near the surface (Urick 1983; Richardson et al. 1995). Paired measurements of received airgun sounds at depths of 3 vs. 9 or 18 m have shown that received levels are typically several decibels lower at 3 m (Greene and Richardson 1988). For a mammal whose auditory organs are within 0.5 or 1 m of the surface, the received level of the predominant low-frequency components of the airgun pulses would be further reduced. In deep water, the received levels at deep depths can be considerably higher than those at relatively shallow (e.g., 18 m) depths at the same horizontal distance from the airguns (Tolstoy et al. 2004a,b).

Pulses of underwater sound from open-water seismic exploration are often detected 50–100 km from the source location, even during operations in nearshore waters (Greene and Richardson 1988; Burgess and Greene 1999). At those distances, the received levels are low, <120 dB re 1 μPa on an approximate rms basis. However, faint seismic pulses are sometimes detectable at even greater ranges (e.g., Bowles et al. 1994; Fox et al. 2002). Considerably higher levels can occur at distances out to several kilometers from an operating airgun array. In fact, recent data show that low-frequency airgun signals can be detected thousands of kilometers from their source. For example, sound from seismic surveys conducted offshore of Nova Scotia, the coast of western Africa, and northeast of Brazil were reported as a dominant feature of the underwater noise field recorded along the mid-Atlantic ridge (Nieukirk et al. 2004).

(d) Masking Effects of Seismic Surveys

Masking effects of pulsed sounds on marine mammal calls and other natural sounds are expected to be limited, although there are few specific data on this. Some whales are known to continue calling in the presence of seismic pulses. Their calls can be heard between the seismic pulses (e.g., Richardson et al. 1986; McDonald et al. 1995; Greene et al. 1999; Nieukirk et al. 2004). Although there has been one report that sperm whales ceased calling when exposed to pulses from a very distant seismic ship (Bowles et al. 1994), more recent studies reported that sperm whales continued calling in the presence of seismic pulses (Madsen et al. 2002; Tyack et al. 2003; Smultea et al. 2004; Holst et al. 2006). Masking effects of seismic pulses are expected to be negligible in the case of the smaller odontocetes, given the intermittent nature of seismic pulses plus the fact that sounds important to them are predominantly at much higher frequencies than are airgun sounds.

Most of the energy in the sound pulses emitted by airgun arrays is at low frequencies, with strongest spectrum levels below 200 Hz, considerably lower spectrum levels above 1000 Hz, and smaller amounts of energy emitted up to ~150 kHz. These low frequencies are mainly used by mysticetes, but generally not by odontocetes, pinnipeds, or sirenians. An industrial sound source will reduce the effective communication or echolocation distance only if its frequency is close to that of the marine mammal signal. If little or no overlap occurs between the industrial noise and the frequencies used, as in the case of many marine mammals vs. airgun sounds, communication and echolocation are not expected to be disrupted. Furthermore, the discontinuous nature of seismic pulses makes significant masking effects unlikely even for mysticetes.

A few cetaceans are known to increase the source levels of their calls in the presence of elevated sound levels, or to shift their peak frequencies in response to strong sound signals (Dahlheim 1987; Au 1993; review in Richardson et al. 1995:233ff., 364ff.; Lesage et al. 1999; Terhune 1999; Nieukirk et al. 2005; Parks et al. 2005). These studies involved exposure to other types of anthropogenic sounds, not seismic pulses, and it is not known whether these types of responses ever occur upon exposure to seismic sounds. If so, these adaptations, along with directional hearing and preadaptation to tolerate some masking by natural sounds (Richardson et al. 1995), would all reduce the importance of masking.

(e) Disturbance by Seismic Surveys

Disturbance includes a variety of effects, including subtle changes in behavior, more conspicuous changes in activities, and displacement. In the terminology of the 1994 amendments to the MMPA, seismic noise could cause "Level B" harassment of certain marine mammals. Level B harassment is defined as "...disruption of behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering."

There has been debate regarding how substantial a change in behavior or mammal activity is required before the animal should be deemed to be "taken by Level B harassment". NMFS has stated that

> "…a simple change in a marine mammal's actions does not always rise to the level of disruption of its behavioral patterns. … If the only reaction to the [human] activity on the part of the marine mammal is within the normal repertoire of actions that are required to carry out that behavioral pattern, NMFS considers [the human] activity not to have caused a disruption of the behavioral pattern, provided the animal's reaction is not otherwise significant enough to be considered disruptive due to length or severity. Therefore, for example, a short-term change in breathing rates or a somewhat shortened or lengthened dive sequence that are within the animal's normal range and that do not have any biological significance (i.e., do no disrupt the animal's overall behavioral pattern of breathing under the circumstances), do not rise to a level requiring a small take authorization." (NMFS 2001, p. 9293).

Based on this guidance from NMFS (2001) and the National Research Council (NRC 2005), we assume that simple exposure to sound, or brief reactions that do not disrupt behavioral patterns in a potentially significant manner, do not constitute harassment or "taking". By potentially significant, we mean "in a manner that might have deleterious effects to the well-being of individual marine mammals or their populations".

Even with this guidance, there are difficulties in defining what marine mammals should be counted as "taken by harassment". For many species and situations, we do not have detailed information about their reactions to noise, including reactions to seismic and other sound pulses. Behavioral reactions of marine mammals to sound are difficult to predict. Reactions to sound, if any, depend on species, state of maturity, experience, current activity, reproductive state, time of day, and many other factors. If a marine mammal does react to an underwater sound by changing its behavior or moving a small distance, the impacts of the change may not be significant to the individual, let alone the stock or the species as a whole. However, if a sound source displaces marine mammals from an important feeding or breeding area for a prolonged period, impacts on individuals and populations could be significant. Given the many uncertainties in predicting the quantity and types of impacts of noise on marine mammals, it is common practice to estimate how many mammals were present within a particular distance of industrial activities, or exposed to a particular level of industrial sound. This likely overestimates the numbers of marine mammals that are affected in some biologically important manner.

The definitions of "taking" in the U.S. MMPA, and its applicability to various activities, were altered slightly in November 2003 for military and federal scientific research activities. Also, NMFS is proposing to replace current Level A and B harassment criteria with guidelines based on exposure characteristics that are specific to species and sound types (NMFS 2005). In 2005, public meetings were conducted across the nation to consider the impact of implementing new criteria for what constitutes a "take" of marine mammals. Currently, a committee of specialists on noise impact issues is drafting recommendations for new impact criteria (Gentry et al. 2004; Hollingshead and Harrison 2005; Miller et al. 2005a); those recommendations are expected to be made public soon. Thus, for projects subject to U.S. jurisdiction, changes in procedures may be required in the near future.

The sound criteria used to estimate how many marine mammals might be disturbed to some biologically-important degree by a seismic program are based on behavioral observations during studies of several species. However, information is lacking for many species. Detailed studies have been done on humpback, gray, and bowhead whales, and on ringed seals. Less detailed data are available for some other species of baleen whales, sperm whales, and small toothed whales.

Baleen 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 airgun pulses 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. Some studies and reviews on this topic are Malme et al. (1984, 1985, 1988); Richardson et al. (1986, 1995, 1999); Ljungblad et al. (1988); Richardson and Malme (1993); McCauley et al. (1998, 2000a); Miller et al. (1999; 2005b); Gordon et al. (2004); Nowacek et al. (2007); and Moulton and Miller (in press). There is also evidence that baleen whales will often show avoidance of a small airgun source or upon onset of a ramp up when just one airgun is firing. Experiments with a single airgun showed that bowhead, humpback and gray whales all showed localized avoidance to a single airgun of 20–100 in^3 (Malme et al. 1984, 1985, 1986, 1987, 1988; Richardson et al. 1986; McCauley et al. 1998, 2000a,b). During a 2004 Caribbean seismic survey with a large airgun array, mean closest point of approach (CPA) of large whales during seismic was 1722 m compared to 1539 m during non-seismic, but sample sizes were small (Smultea et al. 2004; Holst et al. 2006).

Prior to the late 1990s, it was thought that bowhead, gray, and humpback whales all begin to show strong avoidance reactions to seismic pulses at received levels of ~160 to 170 dB re 1 μPa_{rms}, but that subtle behavioral changes sometimes become evident at somewhat lower received levels (Richardson et al. 1995). More recent studies have shown that some species of baleen whales (bowheads and humpbacks in particular) may show strong avoidance at received levels lower than 160–170 dB re 1 μPa_{rms}. The observed avoidance reactions involved movement away from feeding locations or statistically significant deviations in the whales' direction of swimming and/or migration corridor as they approached or passed the sound sources (e.g., Miller et al. 1999; McCauley et al. 2000a). In the case of the migrating whales, the observed changes in behavior appeared to be of little or no biological consequence to the animals—they simply avoided the sound source by displacing their migration route to varying degrees, but within the natural boundaries of the migration corridors (Malme et al. 1984; Malme and Miles 1985; Richardson et al. 1995).

Humpback Whales.—McCauley et al. (1998, 2000a) studied the responses of humpback whales off Western Australia to a full-scale seismic survey with a 16-airgun, 2678-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 airgun. Observations were made from the seismic vessel, from which the maximum viewing distance was listed as 14 km. Avoidance reactions began at 5–8 km from the array, and those reactions kept most groups about 3–4 km from the operating seismic boat. McCauley et al. (2000a) noted localized displacement during migration of 4–5 km by traveling groups and 7–12 km by cow-calve pairs. 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 (CPA) of the airgun to the whales, corresponded to a received level of 143 dB re 1 μPa$_{rms}$. One startle response was reported at 112 dB re 1 μPa$_{rms}$. The initial avoidance response generally occurred at distances of 5–8 km from the airgun array and 2 km from the single airgun. However, some individual humpback whales, especially males, approached within distances 100–400 m, where the maximum received level was 179 dB re 1 μPa$_{rms}$.

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 et al. 1985). Some humpbacks seemed "startled" at received levels of 150–169 dB re 1 μPa. Malme et al. (1985) concluded that there was no clear evidence of avoidance, despite the possibility of subtle effects, at received levels up to 172 re 1 μPa on an approximate rms basis.

It has been suggested that South Atlantic humpback whales wintering off Brazil may be displaced or even strand upon exposure to seismic surveys (Engel et al. 2004). The evidence for this was circumstantial, subject to alternative explanations (IAGC 2004), and not consistent with results from direct studies of humpbacks exposed to seismic surveys in other areas and seasons. After allowance for data from subsequent years, there was "no observable direct correlation" between strandings and seismic surveys (IWC 2007:9).

Bowhead Whales.—Bowhead whales on their summering grounds in the Canadian Beaufort Sea showed no obvious reactions to pulses from seismic vessels at distances of 6–99 km and received sound levels of 107–158 dB on an approximate rms basis (Richardson et al. 1986); their general activities were indistinguishable from those of a control group. However, subtle but statistically significant changes in surfacing–respiration–dive cycles were evident upon statistical analysis. Bowheads usually did show strong avoidance responses when seismic vessels approached within a few kilometers (~3–7 km) and when received levels of airgun sounds were 152–178 dB (Richardson et al. 1986, 1995; Ljungblad et al. 1988). In one case, bowheads engaged in near-bottom feeding began to turn away from a 30-airgun array with a source level of 248 dB re 1 μPa·m at a distance of 7.5 km, and swam away when it came within ~2 km. Some whales continued feeding until the vessel was 3 km away. This work and a more recent study by Miller et al. (2005b) show that feeding bowhead whales tend to tolerate higher sound levels than migrating bowhead whales before showing an overt change in behavior. The feeding whales may be affected by the sounds, but the need to feed may reduce the tendency to move away.

Migrating bowhead whales in the Alaskan Beaufort Sea seem more responsive to noise pulses from a distant seismic vessel than are summering bowheads. In 1996–1998, a partially-controlled study of the effect of Ocean Bottom Cable (OBC) seismic surveys on westward-migrating bowheads was conducted in late summer and autumn in the Alaskan Beaufort Sea (Miller et al. 1999; Richardson et al. 1999). Aerial surveys showed that some westward-migrating whales avoided an active seismic survey boat by 20–30 km, and that few bowheads approached within 20 km. Received sound levels at those distances were only 116–135 dB re 1 μPa_{rms}. At times when the airguns were not active, many bowheads moved into the area close to the inactive seismic vessel. Avoidance of the area of seismic operations did not persist beyond 12–24 h after seismic shooting stopped.

Gray Whales.—Malme et al. (1986, 1988) studied the responses of feeding eastern gray whales to pulses from a single 100-in^3 airgun off St. Lawrence Island in the northern Bering Sea. They estimated, based on small sample sizes, that 50% of feeding gray whales ceased feeding at an average received pressure level of 173 dB re 1 μPa on an (approximate) rms basis, and that 10% of feeding whales interrupted feeding at received levels of 163 dB. Malme at al. (1986) estimated that an average pressure level of 173 dB occurred at a range of 2.6–2.8 km from an airgun array with a source level of 250 dB re 1 μPa_p in the northern Bering Sea. These findings were generally consistent with the results of experiments conducted on larger numbers of gray whales that were migrating along the California coast. Malme and Miles (1985) concluded that, during migration, changes in swimming pattern occurred for received levels of about 160 dB re 1 μPa and higher, on an approximate rms basis. The 50% probability of avoidance was estimated to occur at a CPA distance of 2.5 km from a 4000-in^3 array operating off central California. This would occur at an average received sound level of ~170 dB re 1 μPa_{rms}. Some slight behavioral changes were noted at received sound levels of 140 to 160 dB re 1 μPa_{rms}.

There was no indication that western gray whales exposed to seismic noise were displaced from their overall feeding grounds near Sakhalin Island during seismic programs in 1997 (Würsig et al. 1999) or in 2001. However, there were indications of subtle behavioral effects and (in 2001) localized avoidance by some individuals (Johnson 2002; Weller et al. 2002, 2006a,b).

- re 1 μPa_{rms}Gray whales in British Columbia exposed to seismic survey sound levels up to about 170 dB re 1 μPa did not appear to be disturbed (Bain and Williams 2006). The whales were moving away from the airguns but toward higher exposure levels (into deeper water where sound propagated more efficiently, so it was unclear whether their movements reflected a response to sounds associated with seismic surveys (Bain and Williams 2006).

Rorquals.—Blue, sei, fin, and minke whales have occasionally been reported in areas ensonified by airgun pulses. Sightings by observers on seismic vessels off the U.K. from 1997 to 2000 suggest that, at times of good sightability, numbers of rorquals seen are similar when airguns are shooting and not shooting (Stone 2003). Although individual species did not show any significant displacement in relation to seismic activity, all baleen whales combined were found to remain significantly further from the airguns during shooting compared with periods without shooting (Stone 2003; Stone and Tasker 2006). Baleen whale groups sighted from the ship were at a median distance of ~1.6 km from the array during shooting and 1.0 km during periods without shooting (Stone 2003). Baleen whales, as a group, made more frequent alterations of course (usually away from the vessel) during shooting compared with periods of no shooting. In addition, fin/sei whales were less likely to remain submerged during periods of seismic shooting (Stone 2003).

In a study off Nova Scotia, Moulton and Miller (in press) found little or no difference in sighting rates and initial sighting distances of balaenopterid whales when airguns were operating *vs*. silent, but there were indications that they were more likely to be moving away when seen during airgun operations.

Discussion and Conclusions.—Baleen whales generally tend to avoid operating airguns, but avoidance radii are quite variable. Whales are often reported to show no overt reactions to airgun pulses at distances beyond a few kilometers, even though the airgun pulses remain well above ambient noise levels out to much longer distances. However, studies done since the late 1990s of humpback and especially migrating bowhead whales, show that reactions, including avoidance, sometimes extend to greater distances than documented earlier. Avoidance distances often exceed the distances at which boat-based observers can see whales, so observations from the source vessel are biased. Studies indicate monitoring over broader areas may be needed to determine the range of potential effects of some larger seismic surveys (Richardson et al. 1999; Bain and Williams 2006; Moore and Angliss 2006).

Some baleen whales show considerable tolerance of seismic pulses. However, when the pulses are strong enough, avoidance or other behavioral changes become evident. Because the responses become less obvious with diminishing received sound level, it has been difficult to determine the maximum distance (or minimum received sound level) at which reactions to seismic become evident and, hence, how many whales are affected.

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; however, lower levels have also been shown to elicit avoidance responses by some individuals. In many areas, seismic pulses diminish to these levels at distances ranging from 4.5 to 14.5 km from the source. A substantial proportion of the baleen whales within this distance range may show avoidance or other strong disturbance reactions to the seismic array. In the case of migrating bowhead whales, avoidance extends to larger distances and lower received sound levels.

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. 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 (Appendix A in Malme et al. 1984; Richardson et al. 1995; Angliss and Outlaw 2005). Bowhead whales continued to travel to the eastern Beaufort Sea each summer despite seismic exploration in their summer and autumn range for many years. Bowheads were often seen in summering areas where seismic exploration occurred in preceding summers (Richardson et al. 1987). They also have been observed over periods of days or weeks in areas repeatedly ensonified by seismic pulses. However, it is not known whether the same individual bowheads were involved in these repeated observations (within and between years) in strongly ensonified areas.

Toothed Whales

Little systematic information is available about reactions of toothed whales to noise pulses. Few studies similar to the more extensive baleen whale/seismic pulse work summarized above have been reported for toothed whales, and none similar in size and scope to the studies of humpback, bowhead, and gray whales mentioned above. However, a systematic study on sperm whales is underway (Jochens and Biggs 2003; Tyack et al. 2003; Miller et al. 2006), and there is an increasing amount of information about responses of various odontocetes to seismic surveys based on monitoring studies (e.g., Stone 2003; Smultea et al. 2004; Bain and Williams 2006; Holst et al. 2006; Stone and Tasker 2006; Moulton and Miller in press).

Delphinids (Dolphins) and Monodontids (Beluga).—Seismic operators sometimes see dolphins and other small toothed whales near operating airgun arrays, but in general there seems to be a tendency for most delphinids to show some limited avoidance of operating seismic vessels (e.g., Stone 2003; Holst et al. 2006; Stone and Tasker 2006; Moulton and Miller in press). Studies that have reported cases of small toothed whales close to the operating airguns include Duncan (1985), Arnold (1996), Stone (2003), and Holst et al. (2006). When a 3959-in^3, 18-airgun array was firing off California, toothed whales behaved in a manner similar to that observed when the airguns were silent (Arnold 1996). Most, but not all, dolphins often seemed to be attracted to the seismic vessel and floats, and some rode the bow wave of the seismic vessel regardless of whether the airguns were firing.

Goold (1996a,b,c) studied the effects on common dolphins of 2D seismic surveys in the Irish Sea. Passive acoustic surveys were conducted from the "guard ship" that towed a hydrophone 180-m aft. The results indicated that there was a local displacement of dolphins around the seismic operation. However, observations indicated that the animals were tolerant of the sounds at distances outside a 1-km radius from the airguns (Goold 1996a). Initial reports of larger-scale displacement were later shown to represent a normal autumn migration of dolphins through the area, and were not attributable to seismic surveys (Goold 1996a,b,c).

A monitoring study of summering belugas exposed to a seismic survey found that sighting rates, as determined by aerial surveys, were significantly lower at distances of 10–20 km compared with 20–30 km from the operating airgun array (Miller et al. 2005b). The low number of sightings from the vessel seemed to confirm a large avoidance response to the 2250-in^3 airgun array. The apparent displacement effect on belugas extended farther than has been shown for other small odontocetes exposed to airgun pulses.

Observers stationed on seismic vessels operating off the United Kingdom from 1997 to 2000 have provided data on the occurrence and behavior of various toothed whales exposed to seismic pulses (Stone 2003; Gordon et al. 2004; Stone and Tasker 2006). Dolphins of various species often showed more evidence of avoidance of operating airgun arrays than has been reported previously for small odontocetes. Sighting rates of white-sided dolphins, white-beaked dolphins, *Lagenorhynchus* spp., and all small odontocetes combined were significantly lower during periods of shooting. Except for pilot whales, all of the small odontocete species tested, including killer whales, were found to be significantly farther from large airgun arrays during periods of shooting compared with periods of no shooting. Pilot whales showed few reactions to seismic activity. The displacement of the median distance from the array was ~0.5 km or more for most species groups. Killer whales appeared to be more tolerant of seismic shooting in deeper waters.

For all small odontocete species, except pilot whales, that were sighted during seismic surveys off the U.K. in 1997–2000, the numbers of positive interactions with the survey vessel (e.g., bow-riding, approaching the vessel) were significantly fewer during periods of shooting. All small odontocetes combined showed more negative interactions (e.g., avoidance) during periods of shooting. Small odontocetes, including white-beaked dolphins, *Lagenorhynchus* spp., and other dolphin species, showed a tendency to swim faster during periods with seismic shooting; *Lagenorhynchus* spp. were also observed to swim more slowly during periods without shooting. Significantly fewer white-beaked dolphins, *Lagenorhynchus* spp., and pilot whales traveled towards the vessel and/or more were traveling away from the vessel during periods of shooting.

During two NSF-funded L-DEO seismic surveys using a large, 20-airgun array (~7000-in^3), sighting rates of delphinids were lower and initial sighting distances were farther away from the vessel during seismic than non-seismic periods (Smultea et al. 2004; Holst et al. 2005a, 2006). Monitoring results during a seismic survey in the Southeast Caribbean showed that the mean CPA of delphinids during seismic operations was 991 m compared with 172 m when the airguns were not operational (Smultea et al. 2004). Surprisingly, nearly all acoustic encounters (including delphinids and sperm whales) were made when the airguns were operating (Smultea et al. 2004). Although the number of sightings during monitoring of a seismic survey off the Yucatán Peninsula, Mexico, was small (n = 19), the results showed that the mean CPA of delphinids during seismic operations was 472 m compared with 178 m when the airguns were not operational (Holst et al. 2005b). The acoustic detection rates were nearly 5 times higher during non-seismic compared with seismic operations (Holst et al. 2005b).

Reactions of toothed whales to a single airgun or other small airgun source are not well documented, but do not seem to be very substantial (e.g., Stone 2003). Results from three NSF-funded L-DEO seismic surveys using small arrays (up to 3 GI guns and 315 in^3) were inconclusive. During a survey in the Eastern Tropical Pacific (Holst et al. 2005a) and in the Northwest Atlantic (Haley and Koski 2004), detection rates were slightly lower during seismic compared to non-seismic periods. However, mean CPAs were closer during seismic operations during one cruise (Holst et al. 2005a), and greater during the other cruise (Haley and Koski 2004). Interpretation of the data was confounded by the fact that survey effort and/or number of sightings during non-seismic periods during both surveys was small. Results from another small-array survey in southeast Alaska were even more variable (MacLean and Koski 2005).

Captive bottlenose dolphins and beluga whales exhibited changes in behavior when exposed to strong pulsed sounds similar in duration to those typically used in seismic surveys (Finneran et al. 2000, 2002, 2005). Finneran et al. (2002) exposed a captive bottlenose dolphin and beluga to single impulses from a water gun (80 in^3). As compared with airgun pulses, water gun impulses were expected to contain proportionally more energy at higher frequencies because there is no significant gas-filled bubble, and thus little low-frequency bubble-pulse energy (Hutchinson and Detrick 1984). The captive animals sometimes vocalized after exposure and exhibited reluctance to station at the test site where subsequent exposure to impulses would be implemented (Finneran et al. 2002). Similar behaviors were exhibited by captive bottlenose dolphins and a beluga exposed to single underwater pulses designed to simulate those produced by distant underwater explosions (Finneran et al. 2000). It is uncertain what relevance these observed behaviors in captive, trained marine mammals exposed to single sound pulses may have to free-ranging animals exposed to multiple pulses. In any event, the animals tolerated rather high received levels of sound before exhibiting the aversive behaviors mentioned above; for pooled data at 3, 10, and 20 kHz sound exposure levels during sessions with 25, 50, and 75% altered behavior were 180, 190, and 199 dB re 1 $\mu Pa^2 \cdot s$, respectively (Finneran and Schlundt 2004).

Observations of odontocete responses (or lack of responses) to noise pulses from underwater explosions (as opposed to airgun pulses) may be relevant as an indicator of odontocete responses to very strong noise pulses. During the 1950s, small explosive charges were dropped into an Alaskan river in attempts to scare belugas away from salmon. Success was limited (Fish and Vania 1971; Frost et al. 1984). Small explosive charges were "not always effective" in moving bottlenose dolphins away from sites in the Gulf of Mexico where larger demolition blasts were about to occur (Klima et al. 1988). Odontocetes may be attracted to fish killed by explosions, and thus attracted rather than repelled by "scare" charges. Captive false killer whales showed no obvious reaction to single noise pulses from small (10 g) charges; the received level was ~185 dB re 1 μPa (Akamatsu et al. 1993). Jefferson and Curry (1994) reviewed several additional studies that found limited or no effects of noise pulses from small explosive charges on killer whales and other odontocetes. Aside from the potential for temporary threshold shift (TTS), the tolerance to these charges may indicate a lack of effect or the failure to move away may simply indicate a stronger desire to eat, regardless of circumstances.

Phocinids (Porpoises).—Porpoises, like delphinids, show variable reactions to seismic operations. Calambokidis and Osmek (1998) noted that Dall's porpoises observed during a survey with a 6000-in^3, 12–16-airgun array tended to head away from the boat. Similarly, during seismic surveys off the U.K. in 1997–2000, significantly fewer harbor porpoises traveled towards the vessel and/or more were traveling away from the vessel during periods of shooting (Stone 2003). During both an experimental and a commercial seismic survey, Gordon et al. (1998 *in* Gordon et al. 2004) noted that acoustic contact rates for harbor porpoises were similar during seismic and non-seismic periods.

The limited available data suggest that harbor porpoises show stronger avoidance of seismic operations than Dall's porpoises (Stone 2003; Bain and Williams 2006). In Washington State waters, the harbor porpoise, a high-frequency specialist, appeared to be the species affected by the lowest level of sound (<145 dB re 1 μPa_{rms} at a distance >70 km) (Bain and Williams 2006). In contrast, Dall's porpoises seem relatively tolerant of airgun operations (MacLean and Koski 2005; Bain and Williams 2006). This apparent difference in responsiveness of the two species is consistent with their relative responsiveness to boat traffic in general (Richardson et al. 1995).

Beaked Whales.—There are no specific data on the behavioral reactions of beaked whales to seismic surveys. Most beaked whales tend to avoid approaching vessels of other types (e.g., Würsig et al. 1998). They may also dive for an extended period when approached by a vessel (e.g., Kasuya 1986). It is likely that these beaked whales would normally show strong avoidance of an approaching seismic vessel, but this has not been documented explicitly. Northern bottle-nose whales sometimes are quite tolerant of slow-moving vessels (Reeves et al. 1993; Hooker et al. 2001). However, those vessels were not emitting airgun pulses.

There are increasing indications that some beaked whales tend to strand when naval exercises, including sonar operation, are ongoing nearby (e.g., Simmonds and Lopez-Jurado 1991; Frantzis 1998; NOAA and USN 2001; Jepson et al. 2003; Barlow and Gisiner 2006; see also the "Strandings and Mortality" subsection, later). These strandings are apparently at least in part a disturbance response, although auditory or other injuries may also be a factor. Whether beaked whales would ever react similarly to seismic surveys is unknown. Seismic survey sounds are quite different from those of the sonars in operation during the above-cited incidents. There was a stranding of Cuvier's beaked whales in the Gulf of California (Mexico) in September 2002 when the R/V *Maurice Ewing* was conducting a seismic survey in the general area (e.g., Malakoff 2002). Another stranding of Cuvier's beaked whales in the Galapagos occurred during a seismic survey in April 2000; however "There is no obvious mechanism that bridges the distance between this source and the stranding site" (Gentry [ed.] 2002). The evidence with respect to seismic surveys and beaked whale strandings is inconclusive, and NMFS has not established a link between the Gulf of California stranding and the seismic activities (Hogarth 2002).

Sperm Whales.—All three species of sperm whales have been reported to show avoidance reactions to standard vessels not emitting airgun sounds (e.g., Richardson et al. 1995; Würsig et al. 1998; McAlpine 2002; Baird 2005). Thus, it is expected that they would tend to avoid an operating seismic survey vessel. There are some limited observations suggesting that sperm whales in the Southern Ocean ceased calling during some (but not all) times when exposed to weak noise pulses from extremely distant (>300 km) seismic exploration (Bowles et al. 1994). This "quieting" was suspected to represent a disturbance effect, in part because sperm whales exposed to pulsed man-made sounds at higher frequencies often cease calling (Watkins and Schevill 1975; Watkins et al. 1985). Also, there are several accounts of possible avoidance or other adverse effects of seismic vessels on sperm whales in the Gulf of Mexico (Mate et al. 1994; Johnson et al. 2004; Miller et al. 2006).

On the other hand, recent (and more extensive) data from vessel-based monitoring programs in U.K. waters suggest that sperm whales in that area show little evidence of avoidance or behavioral disruption in the presence of operating seismic vessels (Stone 2003; Stone and Tasker 2006). These types of observations are difficult to interpret because the observers are stationed on or near the seismic vessel, and may underestimate reactions by some of the more responsive species or individuals, which may be beyond visual range. However, the U.K. results do seem to show considerable tolerance of seismic surveys by at least some sperm whales. Also, a recent study off northern Norway indicated that sperm whales continued to call when exposed to pulses from a distant seismic vessel. Received levels of the seismic pulses were up to 146 dB re 1 μPa_{p-p} (Madsen et al. 2002). Similarly, a study conducted off Nova Scotia that analyzed recordings of sperm whale vocalizations at various distances from an active seismic program did not detect any obvious changes in the distribution or behavior of sperm whales (McCall Howard 1999).

An experimental study of sperm whale reactions to seismic surveys in the Gulf of Mexico is presently underway (Caldwell 2002; Jochens and Biggs 2003), along with a study of the movements of sperm whales with satellite-linked tags in relation to seismic surveys (Mate 2003). During two controlled exposure experiments where sperm whales were exposed to seismic pulses at received levels 143–148 dB re 1 µPa, there was no indication of avoidance of the vessel or changes in feeding efficiency (Jochens and Biggs 2003). The received sounds were measured on an “rms over octave band with most energy” basis (P. Tyack, pers. comm.); the broadband rms value would be somewhat higher. Neither gross diving behavior nor direction of movement changed for any of eight tagged sperm whales exposed to seismic airgun sounds at the onset of gradual ramp-up at ranges of 7 to 13 km or during full-power exposures ranging from 1.5 to 12.8 km (Jochens et al. 2006). However, some changes in foraging behavior were observed that suggested avoidance of deep dives near operating airguns. Based on a small sample size, foraging behavior was disrupted by airguns at exposure levels ranging from <130 to 162 dB re 1 μPa_{p-p} at distances of ~1–12 km from the sound source.

Conclusions.—Dolphins and porpoises are often seen by observers on active seismic vessels, occasionally at close distances (e.g., bow riding). However, some studies, especially near the U.K., show localized avoidance. Belugas summering in the Beaufort Sea tended to avoid waters out to 10–20 km from an operating seismic vessel. In contrast, recent studies show little evidence of reactions by sperm whales to airgun pulses, contrary to earlier indications.

There are no specific data on responses of beaked whales to seismic surveys, but it is likely that most if not all species show strong avoidance. There is increasing evidence that some beaked whales may strand after exposure to strong noise from sonars. Whether they ever do so in response to seismic survey noise is unknown.

Pinnipeds

Few studies of the reactions of pinnipeds to noise from open-water seismic exploration have been published (for review, see Richardson et al. 1995). However, pinnipeds have been observed during a number of seismic monitoring studies. Monitoring in the Beaufort Sea during 1996–2002 provided a substantial amount of information on avoidance responses (or lack thereof) and associated behavior. Pinnipeds exposed to seismic surveys have also been observed during seismic surveys along the U.S. west coast. Some limited data are available on physiological responses of pinnipeds exposed to seismic sound, as studied with the aid of radio telemetry. Also, there are data on the reactions of pinnipeds to various other related types of impulsive sounds.

Early observations provided considerable evidence that pinnipeds are often quite tolerant of strong pulsed sounds. During seismic exploration off Nova Scotia, grey seals exposed to noise from airguns and linear explosive charges reportedly did not react strongly (J. Parsons *in* Greene et al. 1985). An airgun caused an initial startle reaction among South African fur seals but was ineffective in scaring them away from fishing gear (Anonymous 1975). Pinnipeds in both water and air sometimes tolerate strong noise pulses from non-explosive and explosive scaring devices, especially if attracted to the area for feeding or reproduction (Mate and Harvey 1987; Reeves et al. 1996). Thus, pinnipeds are expected to be rather tolerant of, or habituate to, repeated underwater sounds from distant seismic sources, at least when the animals are strongly attracted to the area.

In the U.K., a radio-telemetry study has demonstrated short-term changes in the behavior of harbor (=common) seals and grey seals exposed to airgun pulses (Thompson et al. 1998). In this study, harbor seals were exposed to seismic pulses from a 90-in^3 array (three 30-in^3 airguns), and behavioral responses differed among individuals. One harbor seal avoided the array at distances up to 2.5 km from the source and only resumed foraging dives after seismic stopped. Another harbor seal exposed to the same small airgun array showed no detectable behavioral response, even when the array was within 500 m. All grey seals exposed to a single 10-in^3 airgun showed an avoidance reaction: they moved away from the source, increased swim speed and/or dive duration, and switched from foraging dives to predominantly transit dives. These effects appeared to be short-term as all grey seals either remained in, or returned at least once to, the foraging area where they had been exposed to seismic pulses. These results suggest that there are interspecific as well as individual differences in seal responses to seismic sounds.

Off California, visual observations from a seismic vessel showed that California sea lions "typically ignored the vessel and array. When [they] displayed behavior modifications, they often appeared to be reacting visually to the sight of the towed array. At times, California sea lions were attracted to the array, even when it was on. At other times, these animals would appear to be actively avoiding the vessel and array" (Arnold 1996). In Puget Sound, sighting distances for harbor seals and California sea lions tended to be larger when airguns were operating; both species tended to orient away whether or not the airguns were firing (Calambokidis and Osmek 1998).

Monitoring work in the Alaskan Beaufort Sea during 1996–2001 provided considerable information regarding the behavior of seals exposed to seismic pulses (Harris et al. 2001; Moulton and Lawson 2002). Those seismic projects usually involved arrays of 6–16 airguns with total volumes 560–1500 in^3. The combined results suggest that some seals avoid the immediate area around seismic vessels. In most survey years, ringed seal sightings tended to be farther away from the seismic vessel when the airguns were operating then when they were not (Moulton and Lawson 2002). However, these avoidance movements were relatively small, on the order of 100 m to (at most) a few hundreds of meters, and many seals remained within 100–200 m of the trackline as the operating airgun array passed by. Seal sighting rates at the water surface were lower during airgun array operations than during no-airgun periods in each survey year except 1997.

The operation of the airgun array had minor and variable effects on the behavior of seals visible at the surface within a few hundred meters of the array (Moulton and Lawson 2002). The behavioral data indicated that some seals were more likely to swim away from the source vessel during periods of airgun operations and more likely to swim towards or parallel to the vessel during non-seismic periods. No consistent relationship was observed between exposure to airgun noise and proportions of seals engaged in other recognizable behaviors, e.g., “looked” and “dove”. Such a relationship might have occurred if seals seek to reduce exposure to strong seismic pulses, given the reduced airgun noise levels close to the surface where “looking” occurs (Moulton and Lawson 2002).

Monitoring results from the Canadian Beaufort Sea during 2001–2002 were more variable (Miller et al. 2005b). During 2001, sighting rates of seals (mostly ringed seals) were similar during all seismic states, including periods without airgun operations. However, seals were seen closer to the vessel during non-seismic than seismic periods. In contrast, during 2002, sighting rates of seals were higher during non-seismic periods than seismic operations, and seals were seen farther from the vessel during non-seismic compared to seismic activity (a marginally significant result). The combined data for both years showed that sighting rates were higher during non-seismic periods compared to seismic periods, and that sighting distances were similar during both seismic states. Miller et al. (2005b) concluded that seals showed very limited avoidance to the operating airgun array.

In summary, visual monitoring from seismic vessels has shown only slight (if any) avoidance of airguns by pinnipeds, and only slight (if any) changes in behavior. These studies show that pinnipeds frequently do not avoid the area within a few hundred meters of an operating airgun array. However, initial telemetry work suggests that avoidance and other behavioral reactions may be stronger than evident to date from visual studies.

Fissipeds.—Behavior of sea otters along the California coast was monitored by Riedman (1983, 1984) while they were exposed to a single 100-in^3 airgun and a 4089-in^3 array. No disturbance reactions were evident when the airgun array was as close as 0.9 km. Otters also did not respond noticeably to the single airgun. The results suggest that sea otters may be less responsive to marine seismic pulses than other marine mammals. Also, sea otters spend a great deal of time at the surface feeding and grooming. While at the surface, the potential noise exposure of sea otters would be much reduced by the pressure release effect at the surface.

(f) Hearing Impairment and Other Physical Effects

Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds, but there has been no specific documentation of this in the case of exposure to sounds from seismic surveys. Current NMFS policy regarding exposure of marine mammals to high-level sounds is that cetaceans and pinnipeds should not be exposed to impulsive sounds exceeding 180 and 190 dB re 1 μPa_{rms}, respectively (NMFS 2000). Those criteria have been used in establishing the safety (=shut-down) radii planned for numerous seismic surveys. However, those criteria were established before there was any information about the minimum received levels of sounds necessary to cause auditory impairment in marine mammals. As discussed below,

- the 180 dB criterion for cetaceans is probably quite precautionary, i.e., lower than necessary to avoid temporary auditory impairment let alone permanent auditory injury, at least for delphinids.
- temporary threshold shift (TTS) is not injury and does not constitute “Level A harassment” in MMPA terminology.
- the minimum sound level necessary to cause permanent hearing impairment (“Level A harassment”) is higher, by a variable and generally unknown amount, than the level that induces barely-detectable TTS.

- the level associated with the onset of TTS is often considered to be a level below which there is no danger of permanent damage.

NMFS is presently developing new noise exposure criteria for marine mammals that account for the now-available scientific data on TTS, the expected offset between TTS and permanent threshold shift (PTS), differences in the acoustic frequencies to which different marine mammal groups are sensitive, and other relevant factors. For preliminary information about this process, and about the structure of the new criteria in marine and terrestrial mammals see Wieting (2004), Miller et al. (2005a), and NMFS (2005).

Several aspects of the monitoring and mitigation measures that are now often implemented during seismic survey projects are designed to detect marine mammals occurring near the airgun array, and to avoid exposing them to sound pulses that might, at least in theory, cause hearing impairment. In addition, many cetaceans show some avoidance of the area with ongoing seismic operations (see above). In these cases, the avoidance responses of the animals themselves will reduce or (most likely) avoid the possibility of hearing impairment.

Non-auditory physical effects may also occur in marine mammals exposed to strong underwater pulsed sound. Possible types of non-auditory physiological effects or injuries that might (in theory) occur include stress, neurological effects, bubble formation, and other types of organ or tissue damage. It is possible that some marine mammal species (i.e., beaked whales) may be especially susceptible to injury and/or stranding when exposed to strong pulsed sounds.

Temporary Threshold Shift (TTS)

TTS is the mildest form of hearing impairment that can occur during exposure to a strong sound (Kryter 1985). While experiencing TTS, the hearing threshold rises and a sound must be stronger in order to be heard. TTS can last from minutes or hours to (in cases of strong TTS) days. However, it is a temporary phenomenon, and (especially when mild) is not considered to represent physical damage or “injury”. Rather, the onset of TTS is an indicator that, if the animals is exposed to higher levels of that sound, physical damage is ultimately a possibility.

The magnitude of TTS depends on the level and duration of noise exposure, among other considerations (Richardson et al. 1995). For sound exposures at or somewhat above the TTS threshold, hearing sensitivity recovers rapidly after exposure to the noise ends. Only a few data have been obtained on sound levels and durations necessary to elicit mild TTS in marine mammals, and none of the published data concern TTS elicited by exposure to multiple pulses of sound.

Baleen Whales.—There are no data, direct or indirect, on levels or properties of sound that are required to induce TTS in any baleen whale. The frequencies to which mysticetes are most sensitive are lower than those to which odontocetes are most sensitive, and natural background noise levels at those low frequencies tend to be higher. As a result, auditory thresholds of baleen whales within their frequency band of best hearing are believed to be higher (less sensitive) than are those of odontocetes at their best frequencies (Clark and Ellison 2004). From this, it is suspected that received levels causing TTS onset may also be higher in mysticetes.

In practice during seismic surveys, no cases of TTS are expected given the strong likelihood that baleen whales would avoid the approaching airguns (or vessel) before being exposed to levels high enough for there to be any possibility of TTS. (See above for evidence concerning avoidance responses by baleen whales.) This assumes that the ramp up (soft start) procedure is used when commencing airgun operations, to give whales near the vessel the opportunity to move away before they are exposed to sound levels that might be strong enough to elicit TTS. As discussed above, single-airgun experiments with bowhead, gray, and humpback whales show that those species do tend to move away when a single airgun starts firing nearby, which simulates the onset of a ramp up.

Toothed Whales.—Ridgway et al. (1997) and Schlundt et al. (2000) exposed bottlenose dolphins and beluga whales to single 1-s pulses of underwater sound. TTS generally became evident at received levels of 192–201 dB re 1 μPa_{rms} at 3, 10, 20, and 75 kHz, with no strong relationship between frequency and onset of TTS across this range of frequencies. At 75 kHz, one dolphin exhibited TTS at 182 dB re 1 μPa_{rms}, and at 0.4 kHz, no dolphin or beluga exhibited TTS after exposure to levels up to 193 dB re 1 μPa_{rms} (Schlundt et al. 2000). There was no evidence of permanent hearing loss; all hearing thresholds returned to baseline values at the end of the study.

Finneran et al. (2000) exposed bottlenose dolphins and a beluga whale to single underwater pulses designed to generate sounds with pressure waveforms similar to those produced by distant underwater explosions. Pulses were 5.1–13 ms in duration, and the measured frequency spectra showed a lack of energy below 1 kHz. Exposure to those impulses at a peak received SPL (sound pressure level) of up to 221 dB re 1 µPa did not produce temporary threshold shift, although disruption of the animals' trained behaviors occurred.

A similar study was conducted by Finneran et al. (2002) using an 80-in^3 water gun, which generated impulses with higher peak pressures and total energy fluxes than used in the aforementioned study. Water gun impulses were expected to contain proportionally more energy at higher frequencies than airgun pulses (Hutchinson and Detrick 1984). "Masked TTS" (MTTS refers to the fact that measurements were obtained under conditions with substantial, but controlled, background noise) was observed in a beluga after exposure to a single impulse with a SPL of 226 dB re 1 μPa_{p-p}, 160 kPa re 1 μPa_p, and total energy flux of 186 dB re 1 $\mu Pa^2 \cdot s$. Thresholds returned to within 2 dB of pre-exposure value ~4 min after exposure. No MTTS was observed in a bottlenose dolphin exposed to one pulse with pressure of 228 dB re 1 μPa_{p-p}, equivalent to 207 kPa re 1 μPa_p and total energy flux of 188 dB re 1 $\mu Pa^2 \cdot s$ (Finneran et al. 2002). In this study, TTS was defined as occurring when there was a 6 dB or larger increase in post-exposure thresholds. Pulse duration at the highest exposure levels, where MTTS became evident in the beluga, was typically 10–13 ms.

The data quoted above all concern exposure of small odontocetes to single pulses of duration 1 s or shorter, generally at frequencies higher than the predominant frequencies in airgun pulses. With single short pulses, the TTS threshold appears to be (to a first approximation) a function of the energy content of the pulse (Finneran et al. 2002). The degree to which this generalization holds for other types of signals is unclear (Nachtigall et al. 2003).

Finneran et al. (2005) examined the effects of tone duration on TTS in bottlenose dolphins. Bottlenose dolphins were exposed to 3 kHz tones for periods of 1, 2, 4, or 8 s, with hearing tested at 4.5 kHz. For 1-s exposures, TTS occurred with SELs of 197 dB, and for exposures >1 s, SEL $\geq$195 dB resulted in TTS. (SEL is equivalent to energy flux, in dB re 1 $\mu Pa^2 \cdot s$.) At SEL of 195 dB, the mean TTS (4 min after exposure) was 2.8 dB. Finneran et al. (2005) suggested that an SEL of 195 dB is the likely threshold for the onset of TTS in dolphins and white whales exposed to mid-frequency tones of durations 1-8 s, i.e., TTS onset occurs at a near-constant SEL, independent of exposure duration. That implies that a doubling of exposure time results in a 3 dB lower TTS threshold.

Mooney et al. (2005) exposed a bottlenose dolphin to octave-band noise ranging from 4 to 8 kHz at SPLs of 160–172 dB re 1 µPa for periods of 1.8–30 min. Recovery time depended on the shift and frequency, but full recovery always occurred within 40 min (Mooney et al. 2005). They reported that to induce TTS in a bottlenose dolphin, there is an inverse relationship of exposure time and SPL; as a first approximation, as exposure time was halved, an increase in noise SPL of 3 dB was required to induce the same amount of TTS.

Additional data are needed in order to determine the received sound levels at which small odontocetes would start to incur TTS upon exposure to repeated, low-frequency pulses of airgun sound with variable received levels. Given the results of the aforementioned studies and a seismic pulse duration (as received at close range) of ~20 ms, the received level of a single seismic pulse might need to be on the order of 210 dB re 1 μPa_{rms} (~221–226 dB re 1 $\mu Pa \cdot m_{p-p}$) in order to produce brief, mild TTS. Exposure to several seismic pulses at received levels near 200–205 dB re 1 μPa_{rms} might result in slight TTS in a small odontocete, assuming the TTS threshold is (to a first approximation) a function of the total received pulse energy. Seismic pulses with received levels of 200–205 dB or more are usually restricted to a radius of no more than 100 m around a seismic vessel.

To better characterize this radius, it would be necessary to determine the total energy that a mammal would receive as an airgun array approached, passed at various CPA distances, and moved away. At the present state of knowledge, it would also be necessary to assume that the effect is directly related to total energy even though that energy is received in multiple pulses separated by gaps. The lack of data on the exposure levels necessary to cause TTS in toothed whales when the signal is a series of pulsed sounds, separated by silent periods, is a data gap.

Pinnipeds.—TTS thresholds for pinnipeds exposed to brief pulses (either single or multiple) of underwater sound have not been measured. Two California sea lions did not incur TTS when exposed to single brief pulses with received levels of ~178 and 183 dB re 1 μPa_{rms} and total energy fluxes of 161 and 163 dB re 1 $\mu Pa^2 \cdot s$ (Finneran et al. 2003). However, initial evidence from prolonged exposures suggested that some pinnipeds may incur TTS at somewhat lower received levels than do small odontocetes exposed for similar durations. For sounds of relatively long duration (20–22 min), Kastak et al. (1999) reported that they could induce mild TTS in California sea lions, harbor seals, and northern elephant seals by exposing them to underwater octave-band noise at frequencies in the 100–2000 Hz range. Mild TTS became evident when the received levels were 60–75 dB above the respective hearing thresholds, i.e., at received levels of about 135–150 dB. Three of the five subjects showed shifts of ~4.6–4.9 dB and all recovered to baseline hearing sensitivity within 24 hours of exposure.

Schusterman et al. (2000) showed that TTS thresholds of these pinnipeds were somewhat lower when the animals were exposed to the sound for 40 min than for 20–22 min, confirming that there is a duration effect in pinnipeds. Similarly, Kastak et al. (2005) reported that threshold shift magnitude increased with increasing SEL in a California sea lion and harbor seal. They noted that doubling the exposure duration from 25 to 50 min i.e., +3 dB change in SEL, had a greater effect on TTS than an increase of 15 dB (95 *vs*. 80 dB) in exposure level. Mean threshold shifts ranged from 2.9 to 12.2 dB, with full recovery within 24 h (Kastak et al. 2005). Kastak et al. (2005) suggested that sound exposure levels resulting in TTS onset in pinnipeds may range from 183 to 206 dB re 1 $\mu Pa^2 \cdot s$, depending on the absolute hearing sensitivity.

There are some indications that, for corresponding durations of sound, some pinnipeds may incur TTS at somewhat lower received levels than do small odontocetes (Kastak et al. 1999, 2005; Ketten et al. 2001; *cf*. Au et al. 2000). However, TTS onset in the California sea lion and northern elephant seal may occur at a similar sound exposure level as in odontocetes (Kastak et al. 2005).

Likelihood of Incurring TTS.—A marine mammal within a radius of ≤100 m around a typical array of operating airguns might be exposed to a few seismic pulses with levels of ≥205 dB, and possibly more pulses if the mammal moved with the seismic vessel.

As shown above, most cetaceans show some degree of avoidance of seismic vessels operating an airgun array. It is unlikely that these cetaceans would be exposed to airgun pulses at a sufficiently high level for a sufficiently long period to cause more than mild TTS, given the relative movement of the vessel and the marine mammal. TTS would be more likely in any odontocetes that bow- or wake-ride or otherwise linger near the airguns. However, while bow- or wake-riding, odontocetes would be at or above the surface and thus not exposed to strong sound pulses given the pressure-release effect at the surface. But if bow-or wake-riding animals were to dive intermittently near airguns, they would be exposed to strong sound pulses, possibly repeatedly. If some cetaceans did incur mild or moderate TTS through exposure to airgun sounds in this manner, this would very likely be a temporary and reversible phenomenon.

Some pinnipeds show avoidance reactions to airguns, but their avoidance reactions are not as strong or consistent as those of cetaceans (see above). Pinnipeds occasionally seem to be attracted to operating seismic vessels. As previously noted, there are no specific data on TTS thresholds of pinnipeds exposed to single or multiple low-frequency pulses. It is not known whether pinnipeds near operating seismic vessels, and especially those individuals that linger nearby, would incur significant TTS.

NMFS (1995, 2000) concluded that cetaceans should not be exposed to pulsed underwater noise at received levels exceeding 180 dB re 1 μPa_{rms}. The corresponding limit for pinnipeds has been set at 190 dB, although the HESS Team (1999) recommended 180-dB limit for pinnipeds in California. The 180 and 190 dB re 1 μPa_{rms} levels are not considered to be the levels above which TTS might occur. Rather, they are the received levels above which, in the view of a panel of bioacoustics specialists convened by NMFS before any TTS measurements for marine mammals were available, one could not be certain that there would be no injurious effects, auditory or otherwise, to marine mammals. As discussed above, TTS data that have subsequently become available imply that, at least for dolphins, TTS is unlikely to occur unless the dolphins are exposed to airgun pulses stronger than 180 dB re 1 μPa_{rms}. Furthermore, it should be noted that mild TTS is not injury, and in fact is a natural phenomenon experienced by marine and terrestrial mammals (including humans).

It has been shown that most large whales tend to avoid ships and associated seismic operations. In addition, ramping up airgun arrays, which is standard operational protocol for many seismic operators, should allow cetaceans to move away from the seismic source and to avoid being exposed to the full acoustic output of the airgun array. [Three species of baleen whales that have been exposed to pulses from single airguns showed avoidance (Malme et al. 1984–1988; Richardson et al. 1986; McCauley et al. 1998, 2000a,b). This strongly suggests that baleen whales will begin to move away during the initial stages of a ramp up, when a single airgun is fired.] Thus, whales will likely not be exposed to high levels of airgun sounds. Likewise, any whales close to the trackline could move away before the sounds from the approaching seismic vessel become sufficiently strong for there to be any potential for TTS or other hearing impairment. Therefore, there is little potential for whales to be close enough to an airgun array to experience TTS. Furthermore, in the event that a few individual cetaceans did incur TTS through exposure to airgun sounds, this is a temporary and reversible phenomenon.

Permanent Threshold Shift (PTS)

When PTS occurs, there is physical damage to the sound receptors in the ear. In some cases, there can be total or partial deafness, whereas in other cases, the animal has an impaired ability to hear sounds in specific frequency ranges. Physical damage to a mammal's hearing apparatus can occur if it is exposed to sound impulses that have very high peak pressures, especially if they have very short rise times (time required for sound pulse to reach peak pressure from the baseline pressure). Such damage can result in a permanent decrease in functional sensitivity of the hearing system at some or all frequencies.

There is no specific evidence that exposure to pulses of airgun sound can cause PTS in any marine mammal, even with large arrays of airguns. However, given the likelihood that some mammals close to an airgun array might incur at least mild TTS (see Finneran et al. 2002), there has been speculation about the possibility that some individuals occurring very close to airguns might incur TTS (Richardson et al. 1995, p. 372*ff*).

Single or occasional occurrences of mild TTS are not indicative of permanent auditory damage in terrestrial mammals. Relationships between TTS and PTS thresholds have not been studied in marine mammals but are assumed to be similar to those in humans and other terrestrial mammals. The low-to-moderate levels of TTS that have been induced in captive odontocetes and pinnipeds during recent controlled studies of TTS have been confirmed to be temporary, with no measurable residual PTS (Kastak et al. 1999; Schlundt et al. 2000; Finneran et al. 2002; Nachtigall et al. 2003, 2004). However, very prolonged exposure to sound strong enough to elicit TTS, or shorter-term exposure to sound levels well above the TTS threshold, can cause PTS, at least in terrestrial mammals (Kryter 1985). In terrestrial mammals, the received sound level from a single non-impulsive sound exposure must be far above the TTS threshold for any risk of permanent hearing damage (Kryter 1994; Richardson et al. 1995). However, there is special concern about strong sounds whose pulses have very rapid rise times. In terrestrial mammals, there are situations when pulses with rapid rise times can result in PTS even though their levels are only a few dB higher than the level causing slight TTS. The rise time of airgun pulses is fast, but not nearly as fast as that of explosions, which are the main concern in this regard.

Some factors that contribute to onset of PTS, at least in terrestrial mammals, are as follows:

- exposure to single very intense sound,
- repetitive exposure to intense sounds that individually cause TTS but not PTS, and
- recurrent ear infections or (in captive animals) exposure to certain drugs.

Cavanagh (2000) has reviewed the thresholds used to define TTS and PTS. Based on this review and SACLANT (1998), it is reasonable to assume that PTS might occur at a received sound level 20 dB or more above that inducing mild TTS. However, for PTS to occur at a received level only 20 dB above the TTS threshold, the animal probably would have to be exposed to a strong sound for an extended period, or to a strong sound with rather rapid rise time.

Sound impulse duration, peak amplitude, rise time, and number of pulses are the main factors thought to determine the onset and extent of PTS. Based on existing data, Ketten (1994) has noted that the criteria for differentiating the sound pressure levels that result in PTS (or TTS) are location and species-specific. PTS effects may also be influenced strongly by the health of the receiver's ear.

Given that marine mammals are unlikely to be exposed to received levels of seismic pulses that could cause TTS, it is highly unlikely that they would sustain permanent hearing impairment. If we assume that the TTS threshold for exposure to a series of seismic pulses may be on the order of 220 dB re 1 $\mu Pa_{p\text{–}p}$ in odontocetes, then the PTS threshold might be as high as 240 dB re 1 $\mu Pa_{p\text{–}p}$ or 10 bar-m. Such levels are found only in the immediate vicinity of the largest airguns (Richardson et al. 1995:137; Caldwell and Dragoset 2000). It is very unlikely that an odontocete would remain within a few meters of a large airgun for sufficiently long to incur PTS. The TTS (and thus PTS) thresholds of baleen whales and/or pinnipeds (e.g. harbor seal) may be lower, and thus may extend to a somewhat greater distance. However, baleen whales generally avoid the immediate area around operating seismic vessels, so it is unlikely that a baleen whale could incur

PTS from exposure to airgun pulses. Pinnipeds, on the other hand, often do not show strong avoidance of operating airguns.

Although it is unlikely that airgun operations during most seismic surveys would cause PTS in marine mammals, caution is warranted given the limited knowledge about noise-induced hearing damage in marine mammals, particularly baleen whales. Commonly-applied monitoring and mitigation measures, including visual and passive acoustic monitoring, course alteration, ramp ups, and power downs or shut downs of the airguns when mammals are seen within the "safety radii", would minimize the already-low probability of exposure of marine mammals to sounds strong enough to induce PTS.

(g) Strandings and Mortality

Marine mammals close to underwater detonations of high explosive can be killed or severely injured, and the auditory organs are especially susceptible to injury (Ketten et al. 1993; Ketten 1995). Airgun pulses are less energetic and have slower rise times, and there is no proof that they can cause serious injury, death, or stranding. However, the spatiotemporal association of mass strandings of beaked whales with naval exercises and possibly an L-DEO seismic survey in 2002 has raised the possibility that beaked whales may be especially susceptible to injury and/or behavioral reactions that can lead to stranding when exposed to strong pulsed sounds.

In March 2000, several beaked whales that had been exposed to repeated pulses from high intensity, mid-frequency military sonars stranded and died in the Providence Channels of the Bahamas Islands, and were subsequently found to have incurred cranial and ear damage (NOAA and USN 2001). Based on post-mortem analyses, it was concluded that an acoustic event caused hemorrhages in and near the auditory region of some beaked whales. These hemorrhages occurred before death. They would not necessarily have caused death or permanent hearing damage, but could have compromised hearing and navigational ability (NOAA and USN 2001). The researchers concluded that acoustic exposure caused this damage and triggered stranding, which resulted in overheating, cardiovascular collapse, and physiological shock that ultimately led to the death of the stranded beaked whales. During the event, five naval vessels used their AN/SQS-53C or -56 hull-mounted active sonars for a period of 16 h. The sonars produced narrow (<100 Hz) bandwidth signals at center frequencies of 2.6 and 3.3 kHz (-53C), and 6.8–8.2 kHz (-56). The respective source levels were usually 235 and 223 dB re 1 μPa, but the -53C briefly operated at an unstated but substantially higher source level. The unusual bathymetry and constricted channel where the strandings occurred were conducive to channeling sound. That and the extended operations by multiple sonars apparently prevented escape of the animals to the open sea. In addition to the strandings, there are reports that beaked whales were no longer present in the Providence Channel region after the event, suggesting that other beaked whales either abandoned the area or perhaps died at sea (Balcomb and Claridge 2001).

Other strandings of beaked whales associated with operation of military sonars have also been reported (e.g., Simmonds and Lopez-Jurado 1991; Frantzis 1998; Hohn et al. 2006; Southall et al. 2006), although in most cases, the connection between the stranding and naval sonar activity was not conclusively established (Cox et al. 2006). In these cases, it was not determined whether there were noise-induced injuries to the ears or other organs. Another stranding of beaked whales (15 whales) happened on 24–25 September 2002 in the Canary Islands, where naval maneuvers were taking place, although the specifics of the naval activities are not readily available (D'Spain et al. 2006), and the sound levels received by the cetaceans prior to stranding are unknown.

Based on the strandings in the Canary Islands, Jepson et al. (2003) proposed that cetaceans might be subject to decompression injury in some situations. Fernández et al. (2005a) showed that those beaked whales did indeed have gas bubble-associated lesions and fat embolisms.

Fernández et al. (2005b) also found evidence of fat embolism in three beaked whales that stranded 100 km north of the Canaries in 2004 during naval exercises. Examinations of several other stranded species have also revealed evidence of gas and fat embolisms (e.g., Arbelo et al. 2005; Jepson et al. 2005a; Méndez et al 2005; Dalton 2006). These effects were suspected to be induced by exposure to sonar sounds, but the mechanism of injury was not auditory. Most of the afflicted species were deep divers. Gas and fat embolisms could occur if cetaceans ascend unusually quickly when exposed to aversive sounds, or if sound in the environment causes the destabilization of existing bubble nuclei (Potter 2004; Moore and Early 2004; Arbelo et al. 2005; Fernández et al. 2005a; Jepson et al. 2005b). Rommel et al. (2006) suggested that the evolution of gas bubbles is driven by behaviorally altered dive profiles, e.g., extended surface intervals. Previously it was widely assumed that diving marine mammals are not subject to the bends or air embolism.

It is important to note that seismic pulses and mid-frequency sonar pulses are quite different. Sounds produced by the types of airgun arrays used to profile sub-sea geological structures are broadband with most of the energy below 1 kHz. Typical military mid-frequency sonars operate at frequencies of 2–10 kHz, generally with a relatively narrow bandwidth at any one time (though the center frequency may change over time). Because seismic and sonar sounds have considerably different characteristics and duty cycles, it is not appropriate to assume that there is a direct connection between the effects of military sonar and seismic surveys on marine mammals. However, evidence that sonar pulses can, in special circumstances, lead to hearing damage and, indirectly, mortality suggests that caution is warranted when dealing with exposure of marine mammals to any high-intensity pulsed sound.

As noted earlier, in September 2002, there was a stranding of two Cuvier's beaked whales in the Gulf of California (Mexico) when a seismic survey by the R/V *Maurice Ewing* was underway in the general area. (Malakoff 2002). The airgun array in use during that project was the *Ewing*'s 20-airgun 8490-in^3 array. This might be a first indication that seismic surveys can have effects, at least on beaked whales, similar to the suspected effects of naval sonars. However, the evidence linking the Gulf of California strandings to the seismic surveys was inconclusive, and not based on any physical evidence (Hogarth 2002; Yoder 2002). The ship was also operating its multibeam echosounder at the same time but, as discussed elsewhere, this source had much less potential than the aforementioned naval sonars to affect beaked whales. Although the link between the Gulf of California strandings and the seismic (plus multibeam echosounder) survey is inconclusive, this plus the various incidents involving beaked whale strandings "associated with" naval exercises suggests a need for caution in conducting seismic surveys in areas occupied by beaked whales.

(h) Non-auditory Physiological Effects

Possible types of non-auditory physiological effects or injuries that might theoretically occur in marine mammals exposed to strong underwater sound might include stress, neurological effects, bubble formation, and other types of organ or tissue damage. However, studies examining such effects are limited. If any such effects do occur, they would probably be limited to unusual situations. Those could include cases when animals are exposed at close range for unusually long periods, when the sound is strongly channeled with less-than-normal propagation loss, or when dispersal of the animals is constrained by shorelines, shallows, etc.

Long-term exposure to anthropogenic noise may have the potential of causing physiological stress that could affect the health of individual animals or their reproductive potential, which in turn could (theoretically) cause effects at the population level (Gisiner [ed.] 1999). Romano et al. (2004) examined the effects of single underwater impulse sounds from a seismic water gun (up to 228 dB re 1 $\mu Pa \cdot m_{p-p}$) and single pure tones (sound pressure level up to

201 dB re 1 μPa) on the nervous and immune systems of a beluga and a bottlenose dolphin. They found that neural-immune changes to noise exposure were minimal. Although levels of some stress-released substances (e.g., catecholamines) changed significantly with exposure to sound, levels returned to baseline after 24 hr. Further information about the occurrence of noise-induced stress in marine mammals is not available at this time. However, it is doubtful that any single marine mammal would be exposed to strong seismic sounds for sufficiently long that significant physiological stress would develop. This is particularly so in the case of seismic surveys where the tracklines are long and/or not closely spaced.

High sound levels could potentially cause bubble formation of diving mammals that in turn could cause an air or fat embolism, tissue separation, and high, localized pressure in nervous tissue (Gisiner [ed.] 1999; Houser et al. 2001). Moore and Early (2004) suggested that sperm whales are subjected to natural bone damage caused by repeated decompression events during their lifetimes. Those authors hypothesized that sperm whales are neither anatomically nor physiologically immune to the effects of deep diving. The possibility that marine mammals may be subject to decompression sickness was first explored at a workshop (Gentry [ed.] 2002) held to discuss whether the stranding of beaked whales in the Bahamas in 2000 (Balcomb and Claridge 2001; NOAA and USN 2001) might have been related to air cavity resonance or bubble formation in tissues caused by exposure to noise from naval sonar. A panel of experts concluded that resonance in air-filled structures was not likely to have caused this stranding. Among other reasons, the air spaces in marine mammals are too large to be susceptible to resonant frequencies emitted by mid- or low-frequency sonar; lung tissue damage has not been observed in any mass, multi-species stranding of beaked whales; and the duration of sonar pings is likely too short to induce vibrations that could damage tissues (Gentry [ed.] 2002). Opinions were less conclusive about the possible role of gas (nitrogen) bubble formation/growth in the Bahamas stranding of beaked whales. Workshop participants did not rule out the possibility that bubble formation/growth played a role in the stranding, and participants acknowledged that more research is needed in this area.

Jepson et al. (2003) first suggested a possible link between mid-frequency sonar activity and acute and chronic tissue damage that results from the formation *in vivo* of gas bubbles, based on 14 beaked whales that stranded in the Canary Islands close to the site of an international naval exercise in September 2002. The interpretation that the effect was related to decompression injury was initially unproven (Piantadosi and Thalmann 2004; Fernández et al. 2004). However, there is increasing evidence and suspicion that decompression illness can occur in beaked whales and perhaps some other odontocetes, and that there may, at times, be a connection to noise exposure (see preceding section).

Gas and fat embolisms may occur if cetaceans ascend unusually quickly when exposed to aversive sounds, or if sound in the environment causes the destabilization of existing bubble nuclei (Potter 2004; Moore and Early 2004; Arbelo et al. 2005; Fernández et al. 2005a; Jepson et al. 2005b). Thus, air and fat embolisms could be a mechanism by which exposure to strong sounds could, indirectly, result in non-auditory injuries and perhaps death. However, even if those effects can occur during exposure to mid-frequency sonar, there is no evidence that those types of effects could occur in response to airgun sounds.

The only available information on acoustically-mediated bubble growth in marine mammals is modeling assuming prolonged exposure to sound. Crum et al. (2005) tested *ex vivo* bovine liver, kidney, and blood to determine the potential role of short pulses of sound to induce bubble nucleation or decompression sickness. In their experiments, supersaturated bovine tissues and blood showed extensive bubble production when exposed to low-frequency sound. Exposure to 37 kHz at ~50 kPa caused bubble formation in blood and liver tissue, and exposure to three acoustic pulses of 10,000 cycles, each 1 min, also produced bubbles in kidney tissue. Crum et al.

(2005) speculated that marine mammal tissue may be affected in similar ways under such conditions. However, these results may not be directly applicable to free-ranging marine mammals exposed to sonar.

Recent controlled exposure of head tissue from a neonate Cuvier's beaked whale to high-intensity sonar-like sounds (3.5 kHz at 180 dB re 1 µPa received level) and related computational modeling indicated no evidence of any significant injurious effects to the tissue at this sound level (Krysl et al. 2006). The authors concluded that within the range of parameters tested, such tissues are not likely to suffer direct mechanical or thermal damage. However, more animal tissues and parameters will need to be tested to extrapolate the results of this study and model to other situations.

In summary, very little is known about the potential for seismic survey sounds to cause either auditory impairment or other non-auditory physical effects in marine mammals. Available data suggest that such effects, if they occur at all, would be limited to short distances. However, the available data do not allow for meaningful quantitative predictions of the numbers (if any) of marine mammals that might be affected in these ways. Marine mammals that show behavioral avoidance of seismic vessels, including most baleen whales, some odontocetes, and some pinnipeds, are unlikely to incur auditory impairment or other physical effects.

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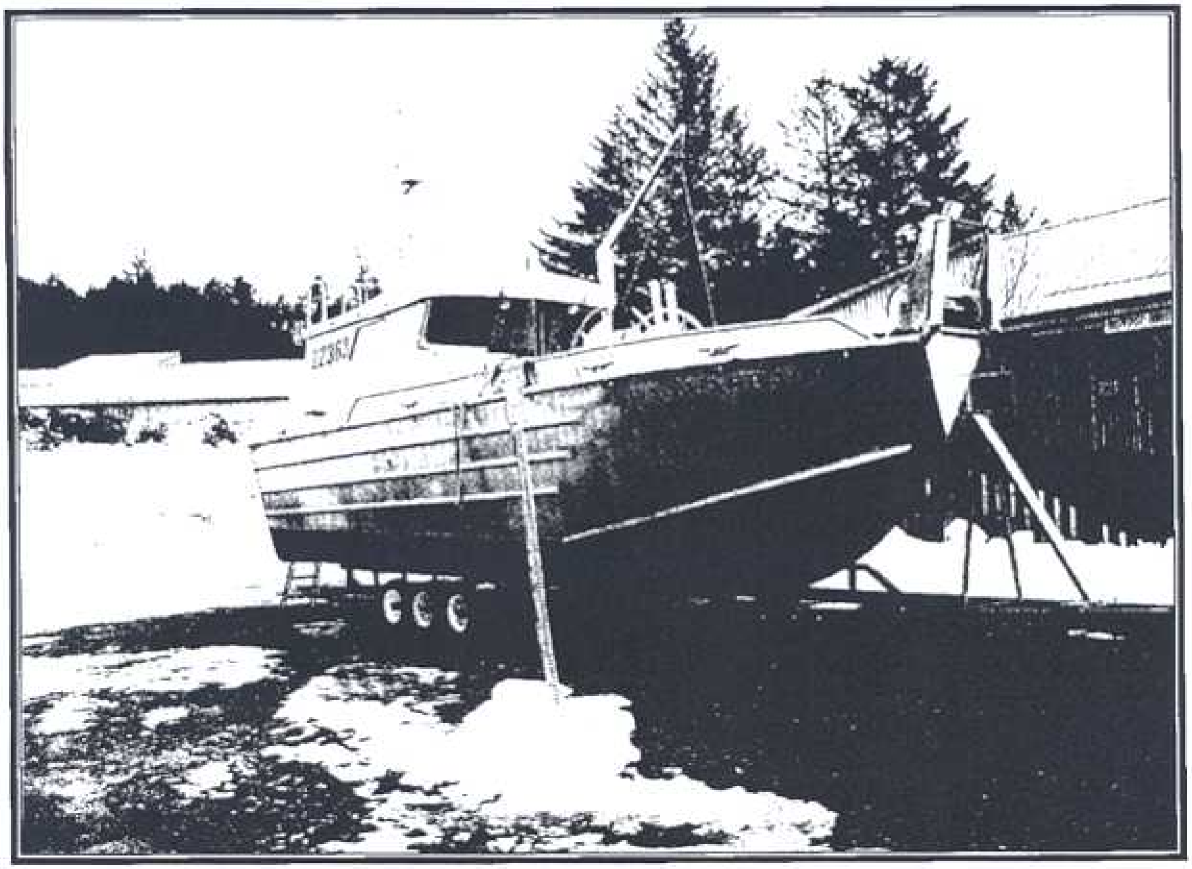


Survey Report of Fishing Vessel

"*Canvasback*"

Documentation Nº: 696778

Surveyed in Cordova, Alaska

Report Date: February 19, 2007

Acting at the request of John Bocci, the undersigned did attend February 16, 2007, onboard the fishing vessel **Canvasback** while the vessel was out of the water on a trailer, Cordova Harbor, Cordova, Alaska. Attending the survey were John Bocci, owner/operator and Troy Tirrell AMS, undersigned.

The purpose of this inspection was to ascertain the condition of the vessel and provide an evaluation for insurance.

The vessel was carefully examined and tested in accessible places in a nondestructive way without any penetration of structural members. Except for removal of panels, floorboards and other loose items, no probing of inaccessible areas was carried out except visually with a flashlight, pick awl, hammer, scraper, and mirrors where possible.

The engines were inspected on the basis of exterior surface inspection and not observed operating. The hull, engines, fuel system, and related equipment were inspected for leaks, condition, and with regard to USCG, ABYC, and NFPA rules and standards.

Note: Numbers within parenthesis ( ) are quantities.

Vessel: *F/V Canvasback*

Doc. №: 1093742 **Gross Ton:** 18 **Net Ton:** 14

HIN: PD0032140074

ADFG №: 22363

Radio call sign: WDC-9169

Type of Vessel: 32-foot aluminum twin diesel waterjet bowpicker

Service: Commercial salmon gillnet fishing

Waters Navigated: Prince William Sound, Copper River delta, Alaska

Owner: John Bocci, P.O. Box 1312, Cordova, AK 99574

Vessel Location for Survey: Out of the water on a trailer, Cordova Harbor, Cordova, Alaska

Survey Requested by: Owner

Builder: All-American Marine **Year Built**: 2000

Builder Location: Ferndale, Washington

Type of Survey: Condition & Value for Insurance

Hull Details

Dimensions: **LOA**: 32' **Beam**: 14' **Draft**: 20"
Hull Construction: Welded aluminum with 1/4" bottom & 3/16" sides
Hull Description: Planing bottom with slight vee, square stern, hard chine & raked bow (port sheer cut out for longlining roller)
Framing:
(6) 2 1/2" external hull stringers/keel coolers
(4) 3/8" x 6" flat bar engine bed stringers
3/16" x 2" x 4" angle frames on 18" centers on bottom
3/16" x 2" x 2" T frames on 18" centers on sides
Bulkheads: (4) bent aluminum
Decks: 3/16" plate with 2" x 2" box beams

Propulsion

Engines: (2) Cummins 6BTA 5.9
Horsepower: 315 each @ 2800 RPM
Type: Turbocharged & aftercooled 6-cylinder diesel
Year: Both 2007
Tach Gauge Hours: Port: 3500 Starboard: 3515
(both engines are new rebuilds with 0 hours at time of inspection)
Serial Nº:
Port: 60237888 Starboard: 60239426
Cooling: (6) 2 1/2" external hull stringers/keel coolers
Exhaust: Wet exhaust w/fiberglass silencers
Transmissions: (2) Borg Warner Velvet Drive 10-18-002
Ratio: 1:1
Drive Units: (2) Hamilton 273 waterjets

Serial Nº: Port: 091 Starboard: 090
Propellers/Impellers: (2) five blade
Transmission: (2) Borg Warner Velvet Drive 10-18-002
Ratio: 1:1
Serial Nº: Port: 26874 Starboard: 26862
Remarks: Engine room is very clean

Hydraulics:
(2) Spencer load-sensing variable volume 0-2.77 cubic inch pump direct driven off portside of both main engines
(2) 6 gpm Vickers pump with steel 1 gal. tanks run off of jet units for shift
(1) aluminum 25 gal. reservoir tank, keel cooled, portside

Trim Tabs: (4) stainless steel rams on welded aluminum trim tabs & powered off of jet hydraulics

Batteries: (3) 8d in aluminum frame box located center & starboard in engine room

Sea Cocks: (2) Mylar **Type:** Ball
Remarks: In working order

Steering: (2) Seastar hydraulic steering helms with hydraulic rams

Engine Controls: (2) station Hynatic throttle & shift controls
Morris cable for transmission hydraulic assist off of jet

Tanking Sytem:
Fuel Tank: 400 gal. welded aluminum located forward & center under deck
Fuel Filters: (2) Racor 900FG fuel filters & secondary on engines
Fuel Lines: USCG type A-1 neoprene hoses with Parker push-lock hose & fittings
Water Tank: (1) est. 60 gal., aluminum, located in forepeak

Bilge Pumps:
(1) Rule 3500 located in fish hold
(1) Rule 2000 located in engine room

Other Pumps:
(1) 1 ¼" Jabsco hydraulic washdown
Flo-Jet freshwater pump
Flo-Jet ¾" 12v deck hose

Stoves & Heaters:
Dickinson "Alaska" oil stove/oven
Seaward 3-burner propane stove/oven with 5 gal. steel propane tank mounted outside of cabin in forward steering console
(2) Heatercraft engine heat cabin heaters with ducting
Seaward engine heat hot water heater

Anchor Gear: 20 KG Bruce anchor with 30' x 3/8" lead chain & 100' x ¾" Samson line

Head: Marine flushing toilet w/ holding tank & shower head

Deck Machinery & Equipment:
Net reel: 46" x 42" aluminum drum, sliding rail & swivel w/Twister drive
Levelwind: aluminum
Bow roller: Kinematics hydraulic power roller
Herring shaker: yes
Mooring cleats: (6) 10"
Watertight hatch: (1) Freeman, on foredeck
Handrails: 1" pipe handrail around top of cabin
Other: Live bleeding tank, raingear locker starboard side cabin forward

Electronics:
VHF radio: Standard Omni
CB radio: Radioshack TRC-503
Other radios: Midland Lowband, Kenwood TM-701A
Radar: JRC Raster Scan 2000 Model NCD3845 SN: LE5581
Fathometers: Furuno 667 color video fishfinder, Vexilar
Map plotter: Simrad Shipmate CP32
Laptop: Toshiba laptop w/Nobletec software
Stereo: Jensen AM/FM cassette
Cell phone: American bag phone

Navigation Equipment:
Running & anchor lights for class
Compass: Ritchie 3", magnetic
Deck lights: (9) halogen

Horn: manual Air

Electrical:

Insulated stranded marine copper wire, secured w/tie backs
DC panel with breakers
(4) cabin lights: bunk, helm
(2) marine alternators, 110 amp. each, mounted on engines
Xantrex 2000 watt inverter/charger
Norcold Tek II 12vDC refrigerator

Lifesaving Equipment:

(2) immersion suit, adult
Oil pressure & water temperature alarm
Marine first aid kit
Life ring with 60' throw line
Orion day/night offshore signal flares (dated: 2008)
USCG Fishing Vessel Safety Exam (dated Feb. 2007)

Portable Fire Extinguishers:

(2) 2.5 lb. dry chemical (A,B,C) at helm stations; gauge in the green

Fish Hold:

Est. 26,000 lb. capacity
(9) watertight aluminum hatch covers

General Description and Arrangement:

The F/V ***Canvasback*** is a modern Alaska aluminum bowpicker fishing vessel. Vessel's 11' x 11' cabin is offset 22" to port for a lead line shoot/walkway, and has a ladder on the stern to the flying bridge. A helm station with bucket seat is located on the flying bridge. Forward of cabin is a self-bailing open deck containing net reel, bow anchor, steering station, and rain gear locker. Flush deck fish holds are amidships, and wheelhouse containing helm and accommodations is aft. Access to cabin is through a watertight aluminum companionway forward.

Forward to port in cabin is helm station with bench seat and navigation equipment; next aft is galley containing oil stove, sink, counter, and storage. To starboard is settee with bench seating and storage. Next aft is a marine head. Three stacking bunks are located at back of cabin.

The cabin is finished with teak cabinets and trim, vinyl sole, Scandia white headliner, and Formica counter tops. Forward windows are rubber mounted with metal frames. Sliding windows are located on port and starboard sides of cabin.

Recommendations:

Found
Life ring cracked
Recommend
Replace life ring

Comments:

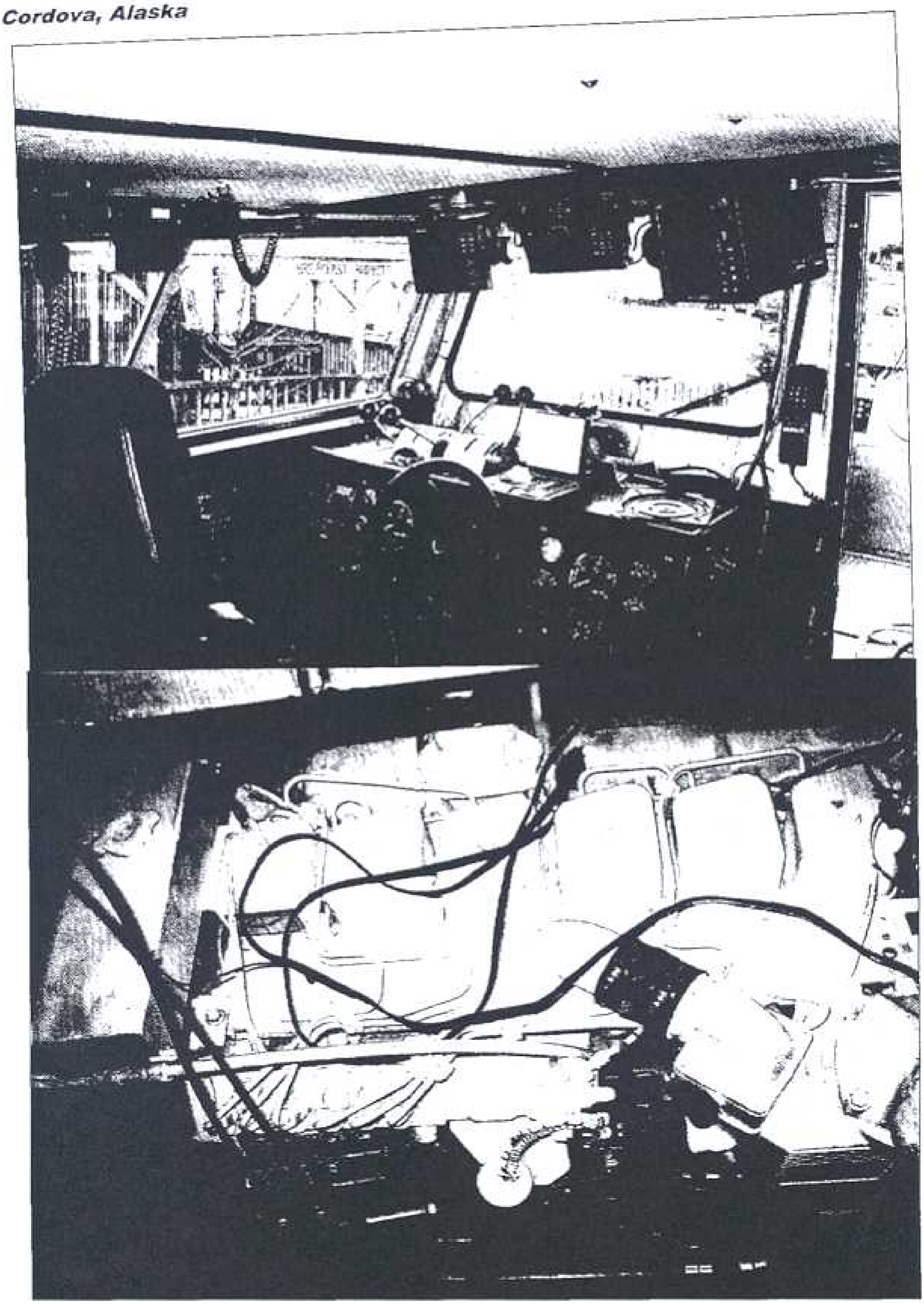
The F/V **Canvasback** is state of the art design and exceptionally well maintained. The overall condition of the vessel is excellent for a vessel its age, and the vessel appears well suited for commercial fishing in Alaskan waters.

Value:

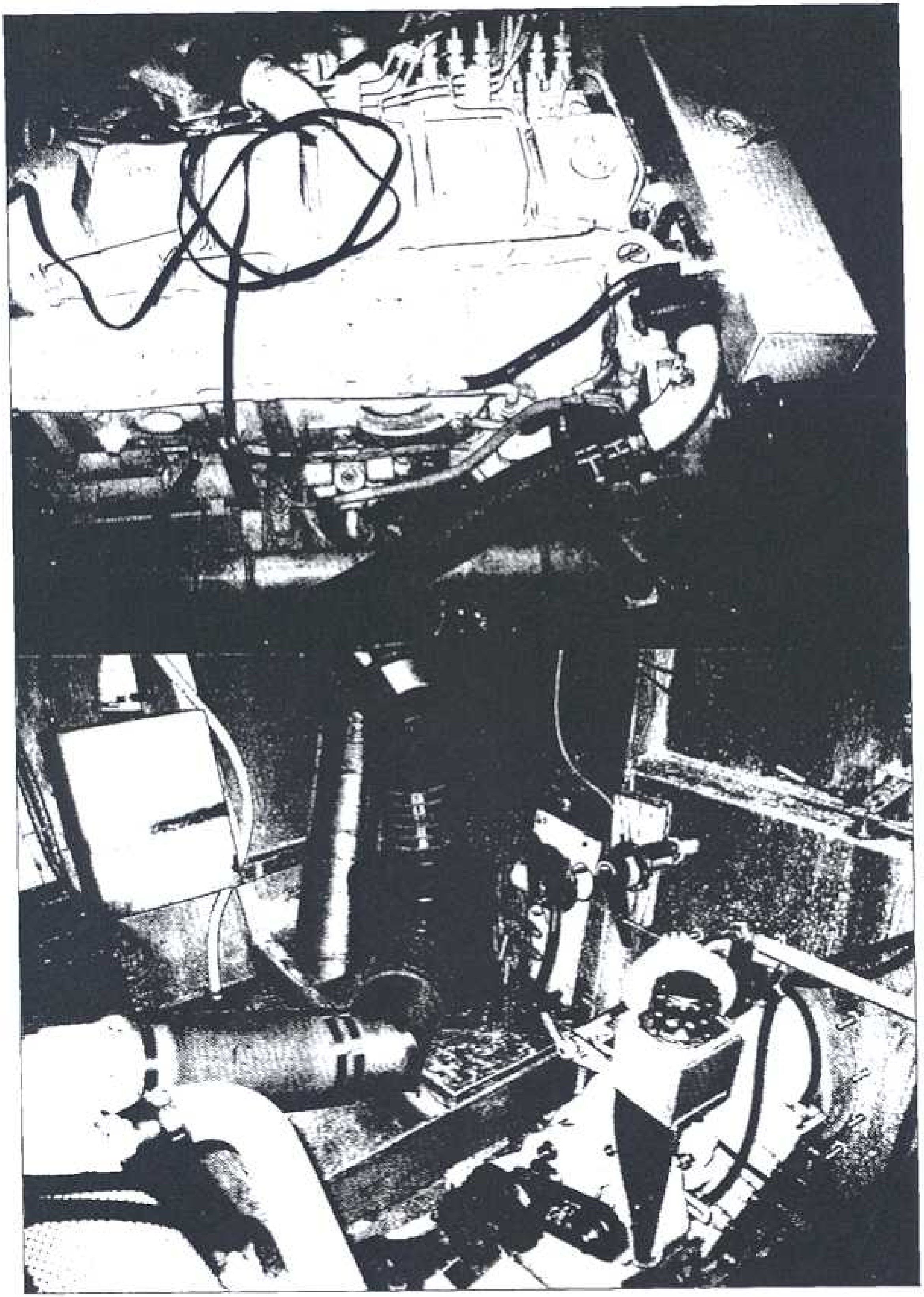
Estimated market value.............$ 170,000
Estimated replacement cost (new)...$ 290,000

The above reported conditions are based on a careful examination of all parts available for inspection without removal of structural members, joinerwork or ceiling, unless specifically noted. The engines and electrical systems were not functionally tested. All metallic parts are reported on the basis of exterior surface inspection only. The entire report is based on the best use of the knowledge and experience of the surveyor without prejudice, but does not constitute a guarantee of the vessel or its parts.

Troy L. Tirrell AMS
Accredited Marine Surveyor
Member of SAMS, ASA, IAMI, & ABYC



F/V Canvasback



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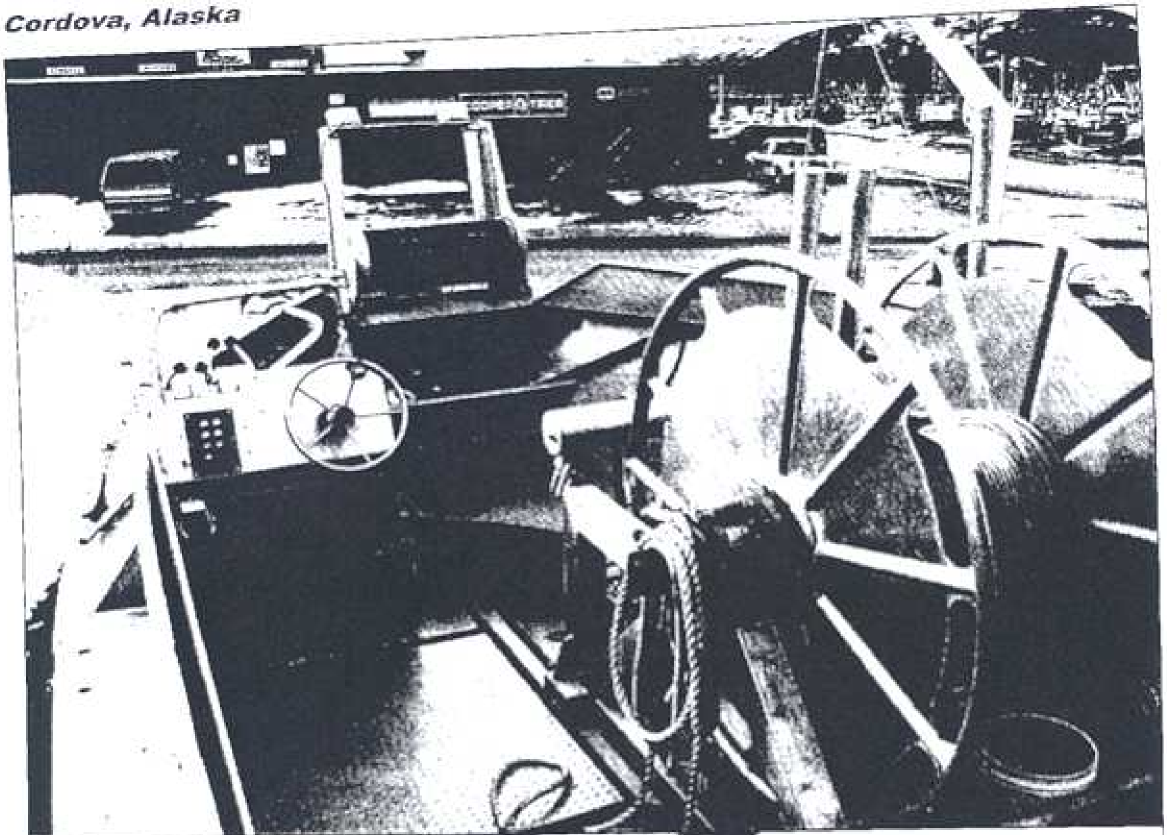

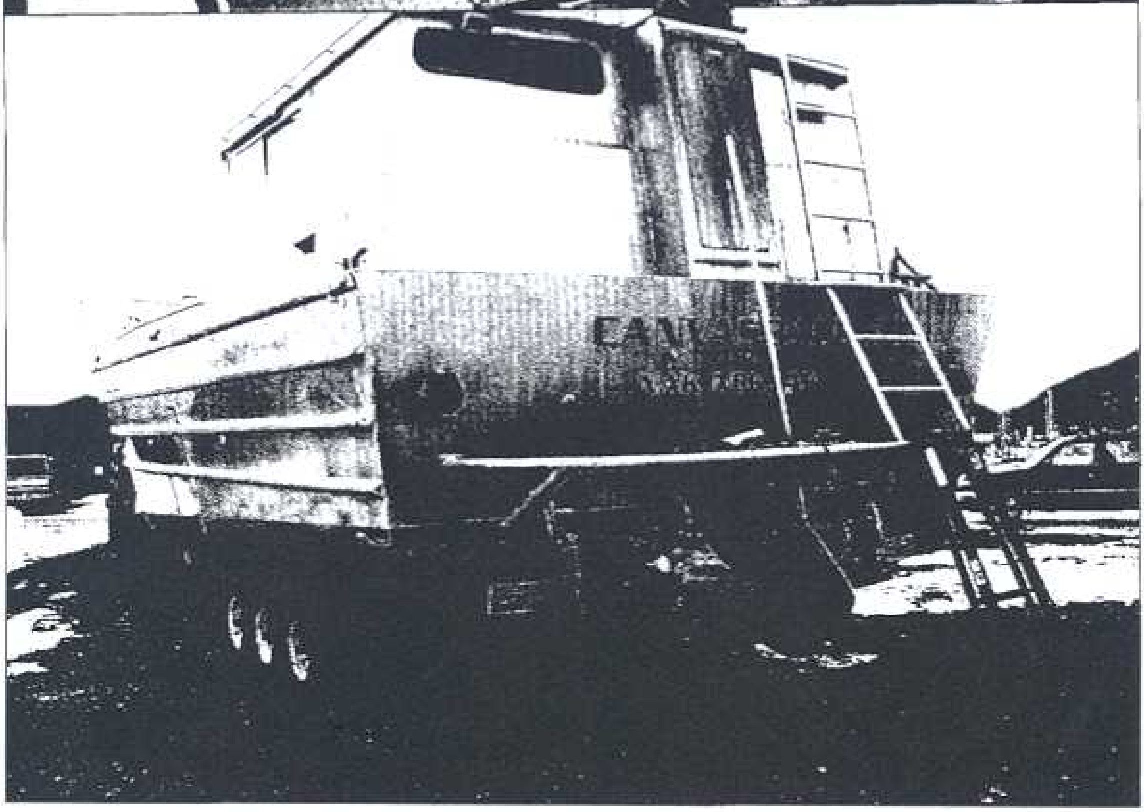

F/V Canvasback

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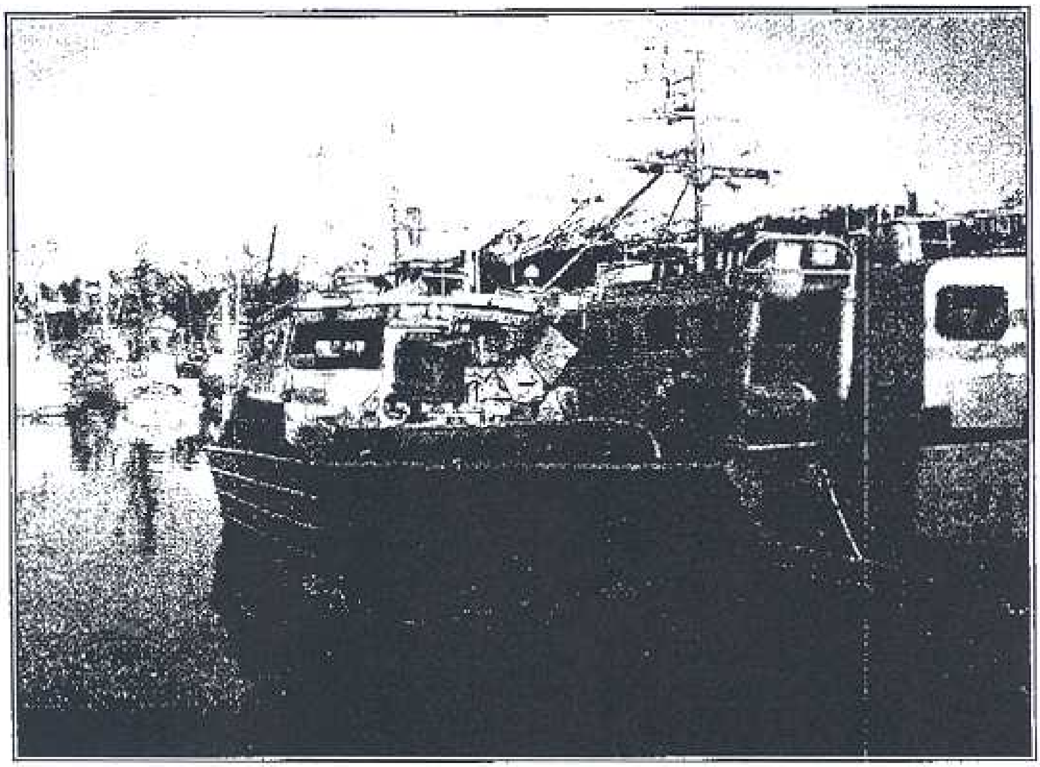


Survey Report of Fishing Vessel
"*Cape Fear*"
Documentation Nº: 1063695
Surveyed in Cordova, Alaska
Report Date: April 13, 2004

Acting at the request of Rob Eckley the undersigned did attend March 29, 2004, on board the fishing vessel ***Cape Fear*** while the vessel was in the owner's warehouse Mile 1.5 Whitshed Road, Cordova, Alaska. Attending the survey were Rob Eckley the owner/operator and Troy Tirrell, AMS the undersigned.

The purpose of this inspection was to ascertain the condition and supply an evaluation of the vessel for Insurance.

The vessel was carefully examined and tested in accessible places in a nondestructive way without any penetration of structural members. Except for removal of panels, floor boards and other loose items, no probing of inaccessible areas was carried out except visually with a flashlight, pick awl, hammer, scraper and mirrors as best possible.

The engines were inspected on the basis of exterior surface inspection only. The hull, engines, fuel system and related equipment were inspected for leaks, condition, and with regard to USCG, ABYC, and NFPA rules and standards.

Note: Numbers within parenthesis ( ) are quantities.

Vessel: F/V *Cape Fear*

Doc. Nº: 1063695 **Gross Tons:** 15 **Net Tons:** 12

ADFG No.: 70393 **HIN:** PP-98-32126-055

Radio Call Sign: WCY-6755

Vessel Weight: 14,383 lbs. with 100 gal. of fuel onboard

Type of Vessel: 32-foot aluminum twin diesel waterjet bowpicker

Service: Commercial salmon gillnet & longline fishing

Waters Navigated: Prince William Sound, Copper River delta, Alaska

Owner: Robert Eckley, Box 1274, Cordova, AK 99574

Vessel Location for Survey: Dry docked on a trailer in owner's warehouse Mile 1.5 Whitshed Road, Cordova, Alaska.

Survey Requested by: Owner

Builder: All-American Marine **Year Built:** 1998

Builder Location: Ferndale, Washington

Type of Survey: Condition & Value for Owner

Hull Details

Dimensions:
LOA: 32' **Beam:** 12' 6" **Draft:** 20"
Hull Construction: Welded aluminum with 1/4" bottom & 3/16" sides
Hull Description: Planing bottom with slight vee, square stern, 9" reverse chine & raked bow
Framing: (6) 2 1/2" external hull stringers/keel coolers
(4) 3/8" x 6" flat bar engine bed stringers
3/16" x 2" x 4" angle frames on 18" centers on bottom
3/16" x 2" x 2" T frames on 18" centers on sides
Bulkheads: (4) bent aluminum
Decks: 3/16" plate with 2" x 2" box beams

Propulsion

Engines: (2) Cummins 6BTA 5.9-M2 **Horsepower:** 315 each
Type: Turbocharged & aftercooled, 6-cylinder diesel
Year: 1998
Tach Gauge Hours: Port: 4489 Starboard: 4251
new starboard engine installed @ 3681, Sept. 2003
Serial Nos.: Port: 45629907 Starboard: 46293198
Rebuilt spare engine: Serial No.: 45629947
Cooling: (6) 2 1/2" external hull stringers/keel coolers
Exhaust: Wet with fiberglass Naoualift silencers high temperature silicone hose and double clamped

Transmission: (2) Borg Warner Velvet Drive 10-18-002 with high performance clutch plates
Ratio: 1:1
Drive Units: (2) Hamilton 273 waterjets
Serial Nos.: Port: 9733 Starboard: 9734
Ventilation: Engine is natural air ventilated to outside
Remarks: The starboard engine in like new condition. New exhaust 2004
Impellers: (2) five-blade

Hydraulics:
Spencer load-sensing variable volume 0-2.77 cubic inch pump direct driven off portside of port engine
(2) 6 gpm Vickers pumps with steel 1 gal. tanks run off of jet units
(1) aluminum 17 gal. reservoir tank, keel cooled, portside
(1) 7 gpm. pump direct driven off 10 hp. Yanmar single cylinder diesel engine, located in engine room SN: 05805 (new 2004)

Trim Tabs:
(2) cavitation/trim tabs under jets units with Bennett dual plastic rams

Batteries:
(2) 4d in aluminum frame box located center in engine room (new in 2001)

Sea Cocks: (2) ball **Type:** Mylar **Remarks:** In working order

Steering: (2) Seastar hydraulic steering helms with draulic rams

Engine Controls:
(2) station Morse cable throttle & shift controls with hydraulic assist off of jet

Fuel Tankage:
386 gal. welded aluminum located center under forward deck
Removable 187 gal. welded aluminum mounted on transom
Total fuel capacity: 574 gal.
Fuel Filters: (2) Racor 900FG fuel filters & secondary on engines
Fuel Lines: USCG type A-1 neoprene hoses with pushlock

fittings

Water Tank: (1) est. 160 gal., aluminum, located in forepeak

Bilge Pumps:
(1) Rule 2000 located in fish hold
(1) Rule 2000 located in engine room

Other Pumps:
1 ½" Jabsco hydraulic washdown (REV. TO ENGINE ROOM EVACUATE) RRE.
2" Pacer hydraulic driven net wash/washdown & suction with plastic housing
Jabsco oil change pump
SurFlo freshwater pump

Stoves & Heaters:
Dickinson "Pacific" oil stove/oven
1-burner propane stove/oven with 2 gal. aluminum tank mounted outside of cabin in forward steering counsel
Heatercraft engine heat cabin heater
Seaward engine heat 6 gal. hot water heater
Little microwave oven

Anchor Gear: 20 kg. Bruce anchor with 60' x 3/8" lead chain & 150' x ½" Samson line

Head: Marine flushing toilet w/ holding tank & showerhead

Deck Machinery & Equipment:
Net reel: 45" x 43" Howard Fabrication aluminum drum with Twister drive, mounted on sliding track
Levelwind: Kolstrand automatic
Bow roller: Kinematics, hydraulic power roller
Long line roller: Kolstrand
Long line hauler: Kabelvng
Herring shaker: Howard Fabrication with aluminum ramp
Raingear locker starboard side cabin forward
Mooring cleats: (6) 10"
Watertight hatch: (1) Freeman, on foredeck
Handrails: 1" pipe handrail around top of cabin
Other: Removable aluminum 1" pipe boarding ladder

Electronics:
VHF radios: Standard Omni, Uniden MC535
VHF hand held: Apelco, Raytheon

SSB radio: Stevens SEA 222
CB radio: Uniden Pro-510
Other radio: Kenwood Dual Band TM-733
Radar: Furuno 1721
Fathometers: Si-Tex CVS-210 1000 watt fish finder
GPS: Furuno Navigator
Map plotter: Echotec CTM 900 with PWS chip
Computer: Dell Inspiron 4100 with Maptec software
Cell phone: Motorola 3 watt bag phone
Stereo: Pioneer with 10 CD changer and Bose speakers
Other stereo: Legacy DVD/VCD/MP3 player
TV: Westinghouse 15" flat screen
VCR: Sylvania
- CARBON MONOXIDE DETECTOR (RRE)

Navigation Equipment:

Running & anchor lights for class
Compass: Ritchie 3", magnetic
Deck lights: (9) halogen
Horn: Falcon Air
(2) pyrometers

Electrical:

Insulated stranded marine copper wire, secured w/tie backs
DC panel with breakers
Xantrex Freedom Marine 20 inverter
DCv amp and volt meters
(3) cabin lights: bunk, helm
(2) marine alternators, 110 amp. each, mounted on main engines
Norcold Tek II 12vDC refrigerator
(2) SMOKE DETECTORS - (RRE)

Lifesaving Equipment:

(3) Imperial immersion suits, Mustang, adult size
Healer first aid kit
Oil pressure & water temperature alarm
Life ring with 60' throw line
Orion day/night signal flares outside waters pack of 6, 3 & 3

Other:

Eckley Welding three-axle steel trailer (new 2003)

Portable Fire Extinguishers:

RRE, (2) - ~~(1)~~ 2.5 lb. dry chemical (A,B,C) at helm station; full charge
(1) 10 lb. dry chemical (A,B,C) at on deck in rain

gear locker; full charge

Fish Hold:

Est. 23,000 lb. capacity
(9) watertight aluminum hatch covers
(6) aft fish holds are spray foam insulated

General Description & Arrangement:

The F/V **Cape Fear** is a modern Alaska aluminum bowpicker fishing vessel with a house aft and self-bailing open deck forward containing net reel, steering station and rain gear locker. Flush deck fish holds are amidships and wheelhouse containing helm and accommodations aft. Access to cabin is through a watertight aluminum companionway forward.

Forward to port in cabin is helm station with bucket seat and navigation equipment; next aft is galley containing stoves, sink, counter and storage. To starboard is settee with bench seating and storage. Next aft is a marine head. Two stacking bunks are located at back of cabin.

The cabin is finished with teak cabinets and trim, carpet sole, fabric hull liner and Formica counter tops. Forward windows are rubber mounted with all other windows mounted with metal frames. Sliding windows are located on port and starboard sides of cabin.

Recommendations:

No deficiencies found at this time

Comments:

The F/V ***Cape Fear*** is very well designed and exceptionally well maintained. Some of the improvements done in 2003-2004 are: extended cabin, rebuilt bunks with new upholstery, galley shelving and survival suit storage, new Yanmar axillary, new starboard main engine, rebuilt spare engine, 9" reverse chine, 187 gal. portable fuel tank, all new wet exhaust systems, aft window, trailer, SSB radio, custom boarding ladder, water filter, TV & stereo and many other aluminum fabrication details.

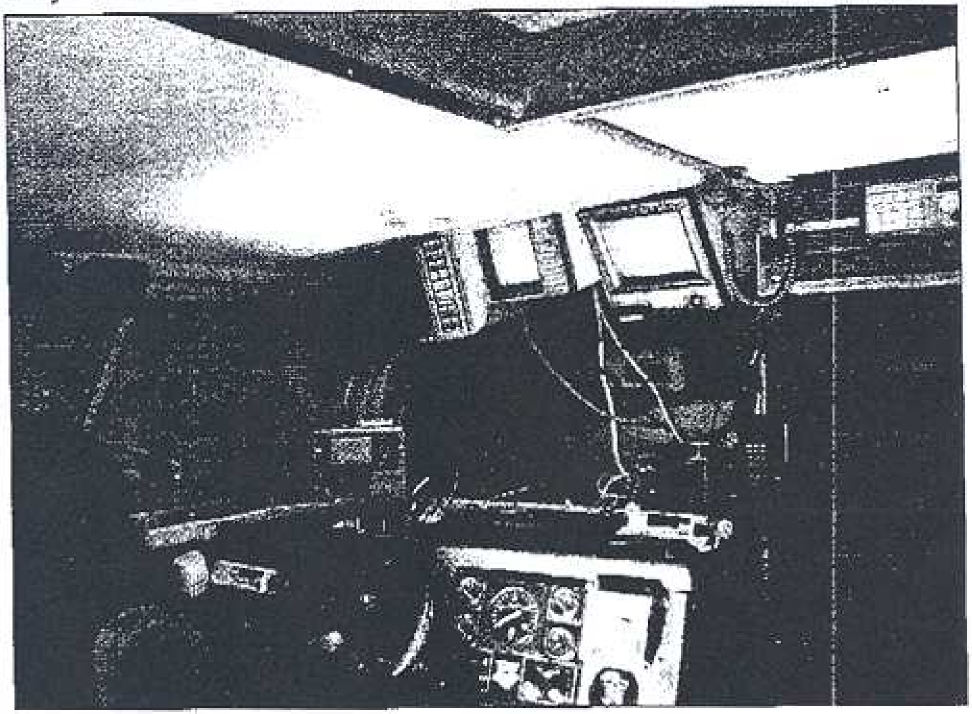
The overall condition of the vessel is excellent and the vessel appears well suited for commercial fishing in Alaskan waters.

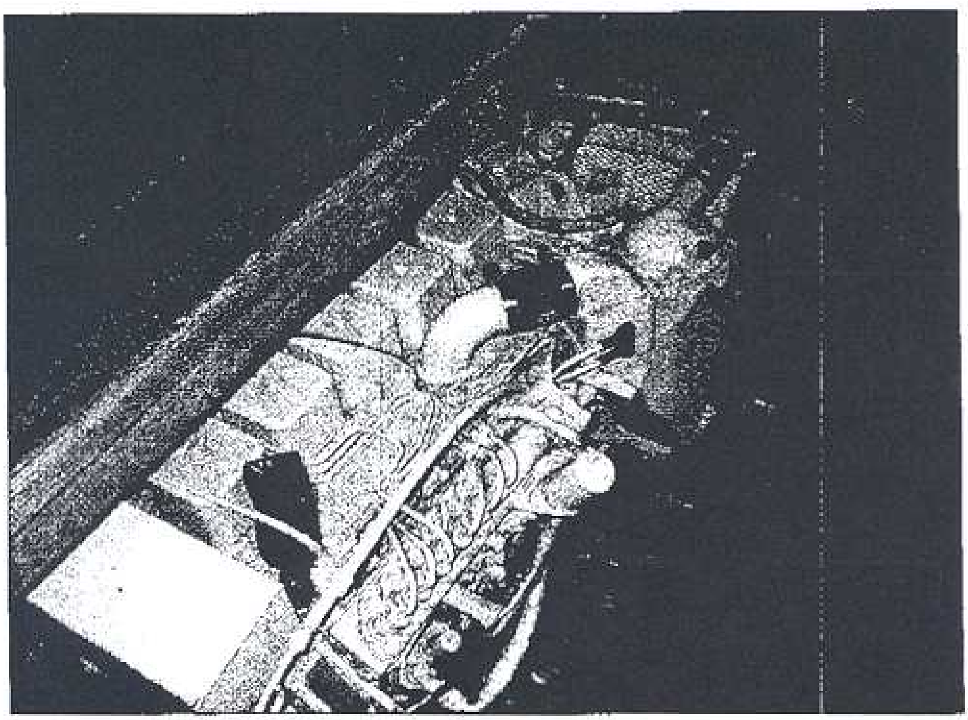
Value:

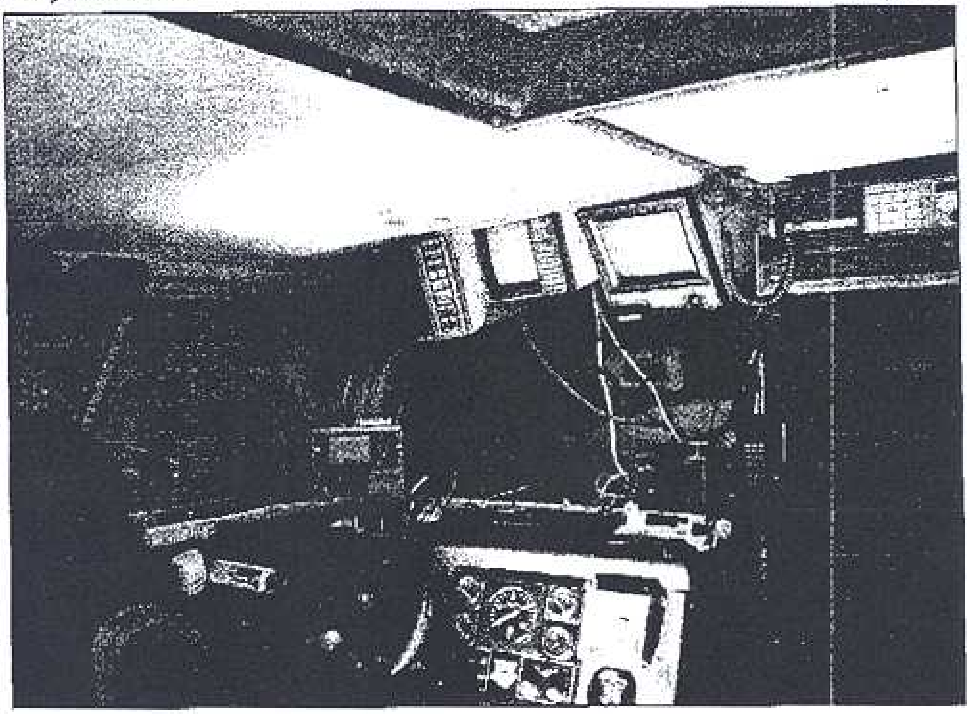
Estimated market value-------------------------- $135,000
Estimated replacement cost (new)---------------- $230,000

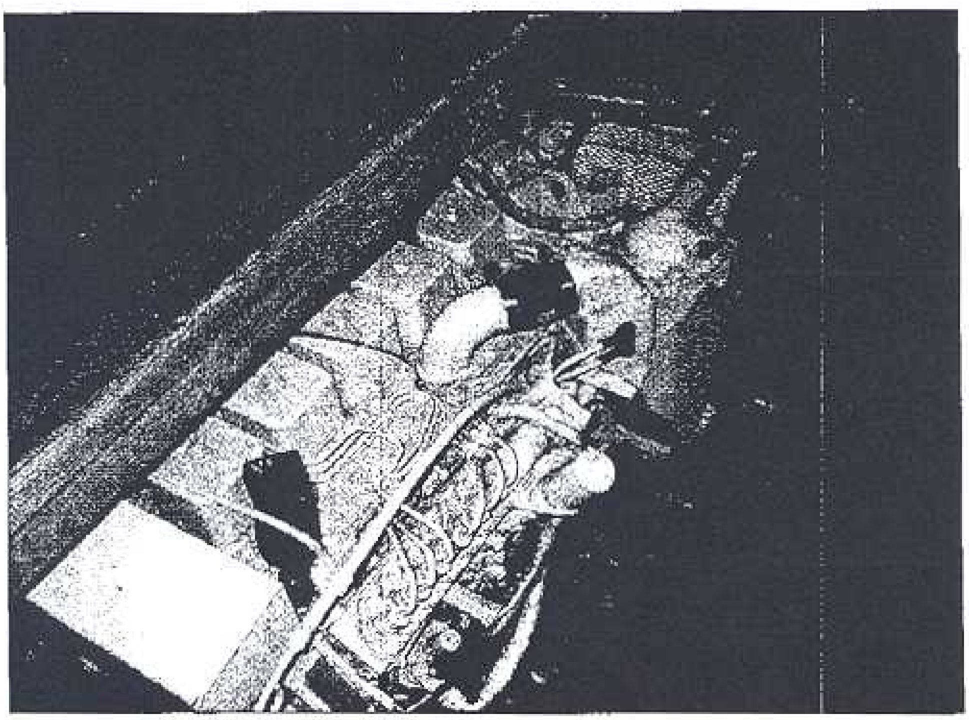
The above reported conditions are based on a careful examination of all parts available for inspection without removal of structural members, joinerwork or ceiling, unless specifically noted. The engines and electrical systems were not functionally tested. All metallic parts are reported on the basis of exterior surface inspection only. The entire report is based on the best use of the knowledge and experience of the surveyor without prejudice, but does not constitute a guarantee of the vessel or its parts.

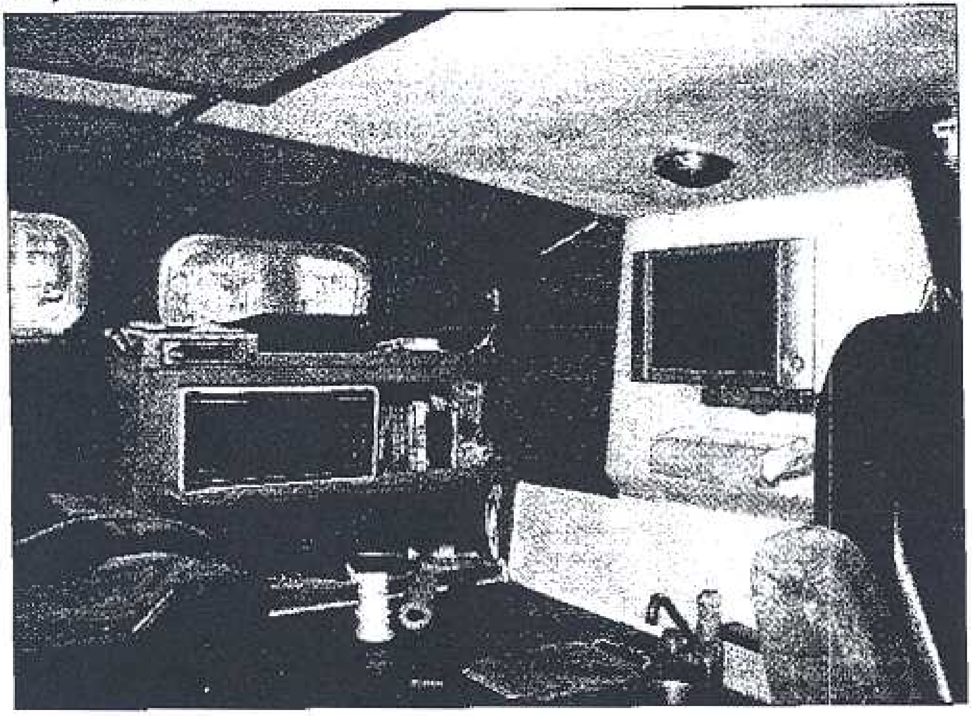
Troy L. Tirrell, AMS
Accredited Marine Surveyor
Member of SAMS, MIAS, IAMI & ABYC

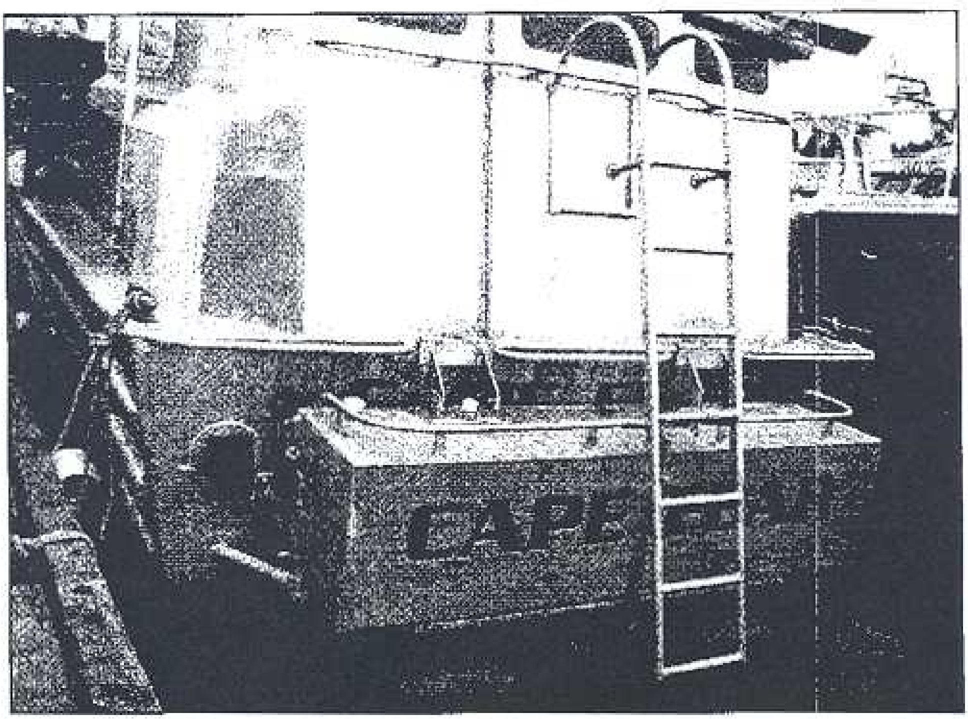




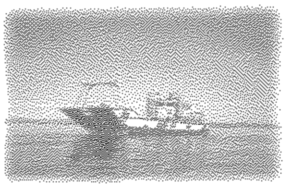








F/V Cape Fear



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F/V Rumpleminz Bowpicker

New construction 2007-2008
32x14 Draft 24"

Twin C9 500 hp cat engines
Twin 13" Ultra jet Jet drives
1 power bow roller
Keel coolers for engines
Fish hold/deck space 14'x15'
Fuel capacity 350 gallons
Water 20 gallons
1 3000 watt inverter for AC with 4-4D batteries
VHF, plotter, radar, depth finder
2" wash down / fine pump
Duel hydraulics
High water alarm
(Cabin) Sleeps 2, small galley with head, shower, table for 4 people, stove, sink.
(Safety gear) 1 six man life raft, two 30" life rings.
2 swing stations for boat transfer. One 406 epirb
4 fire extinguishers, 4 survival suits, 4 life jackets type 1
USCG approved Nav lights
Davit with pot puller
Fuel consumption 30 gallons per hour 32kt
Working speed 3-5kt 10 gallons per hour

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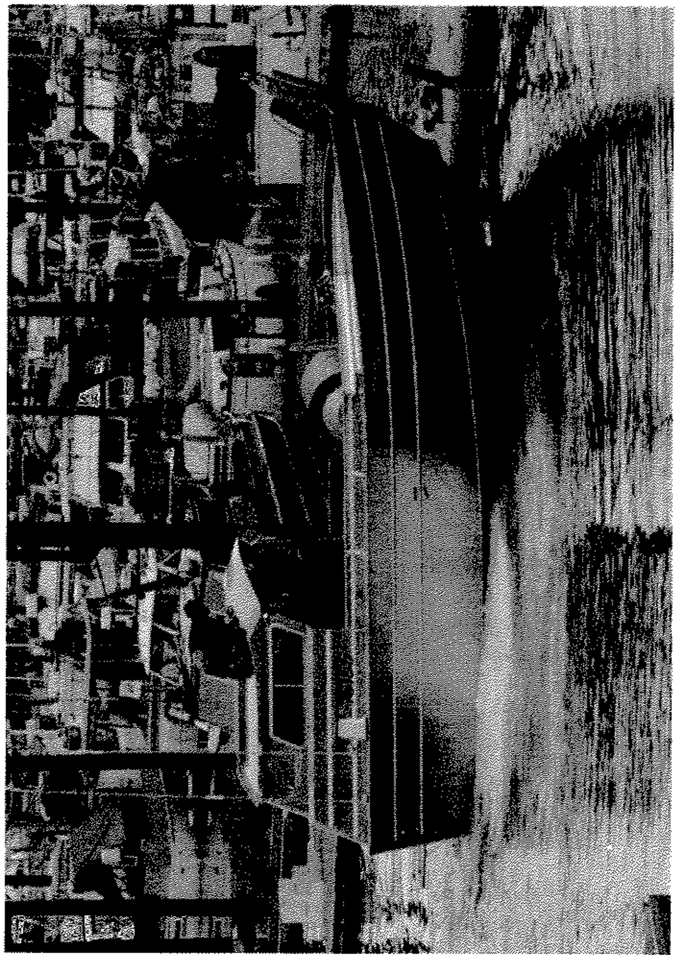
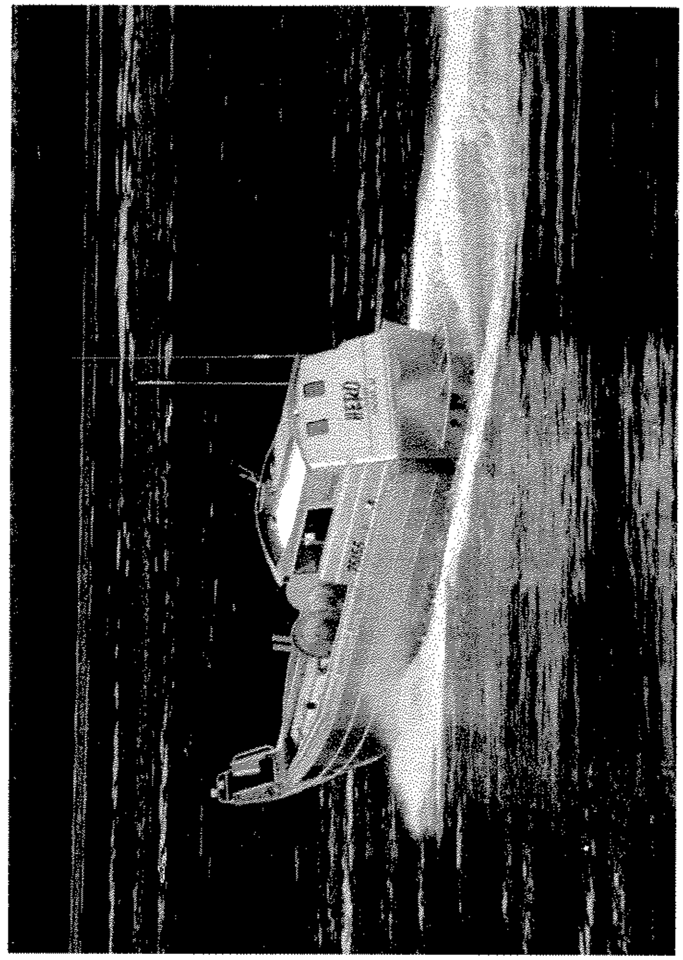
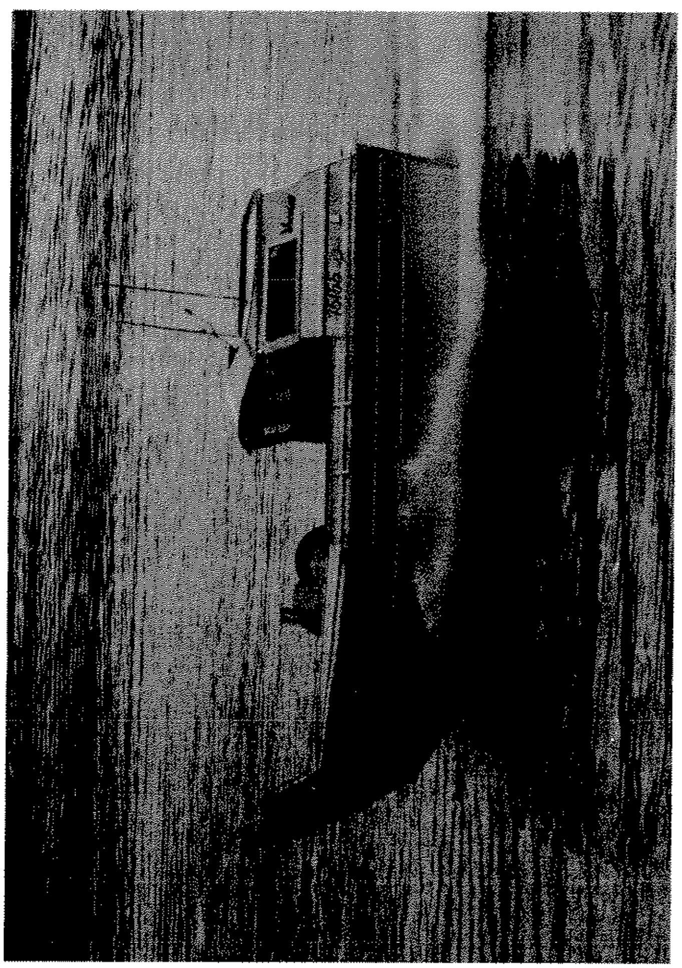
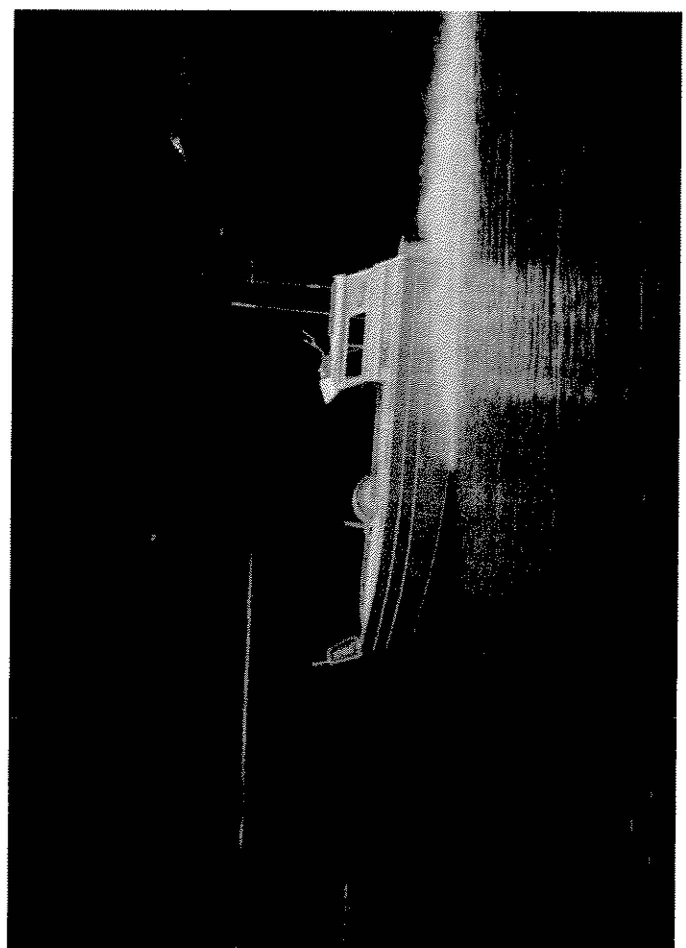
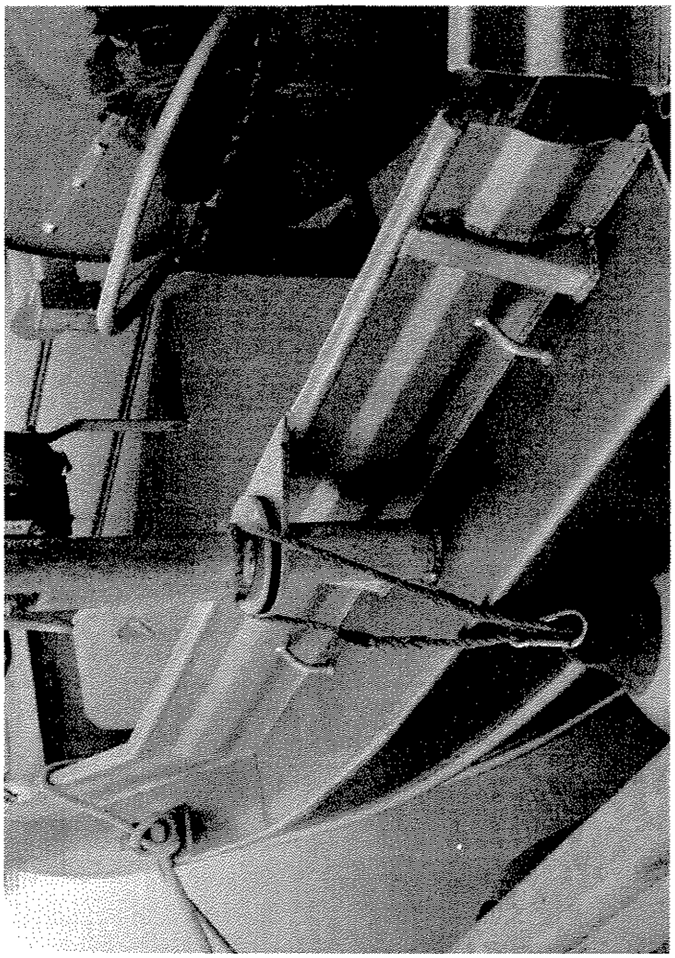
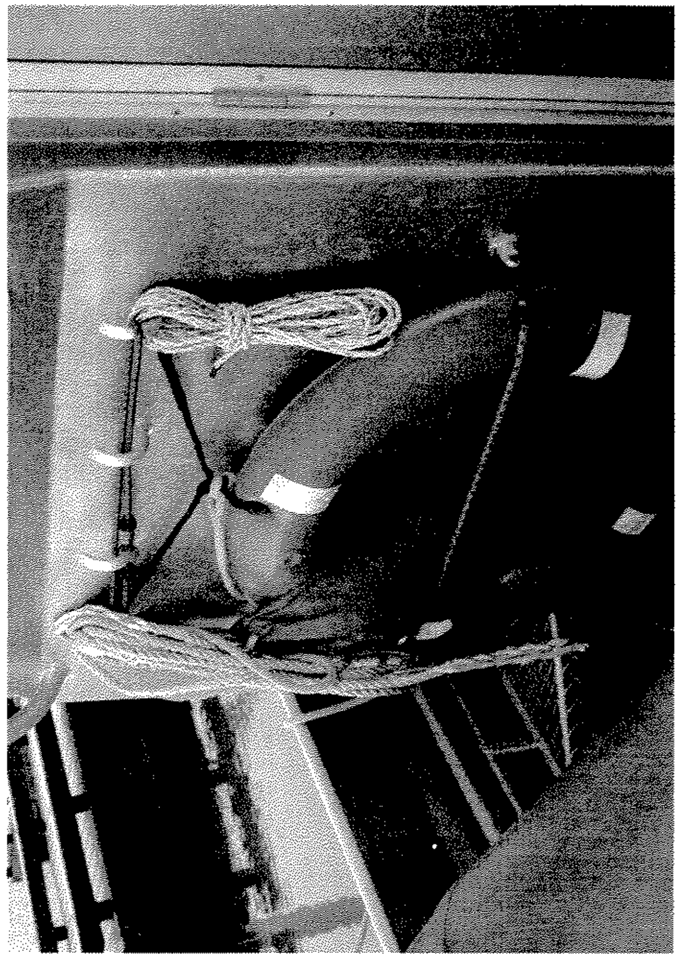
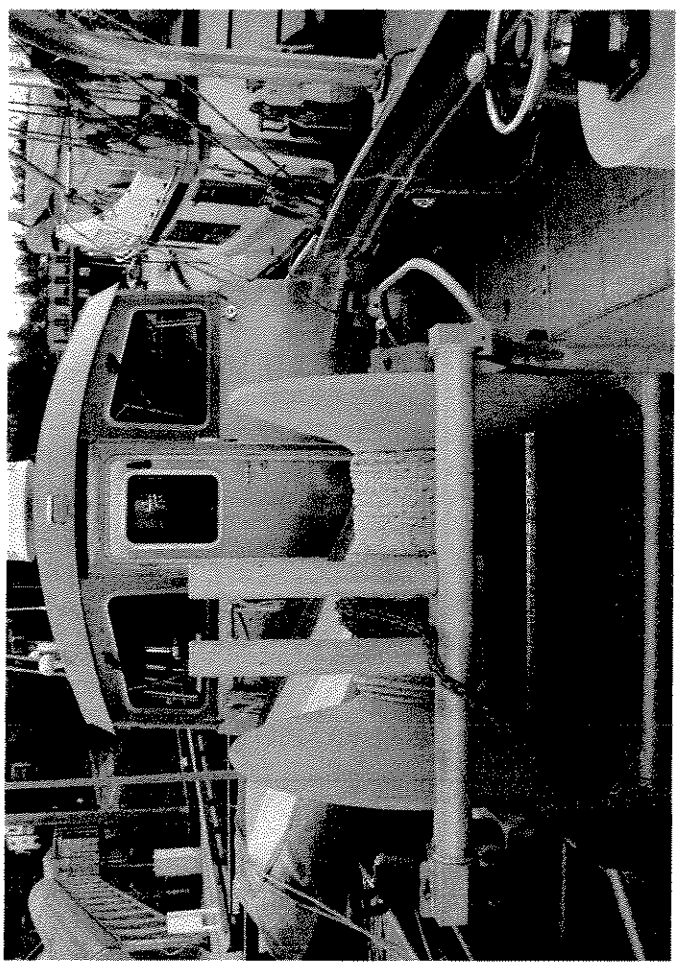
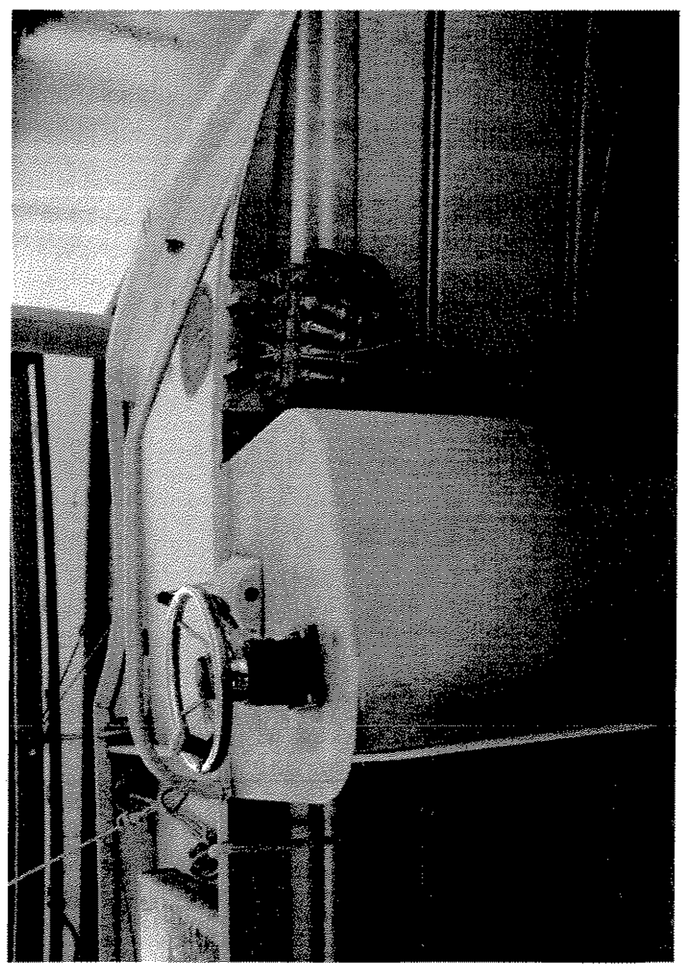
Jeff Johnson, Owner • (907) 258-6448 • Fax (907) 258-4654

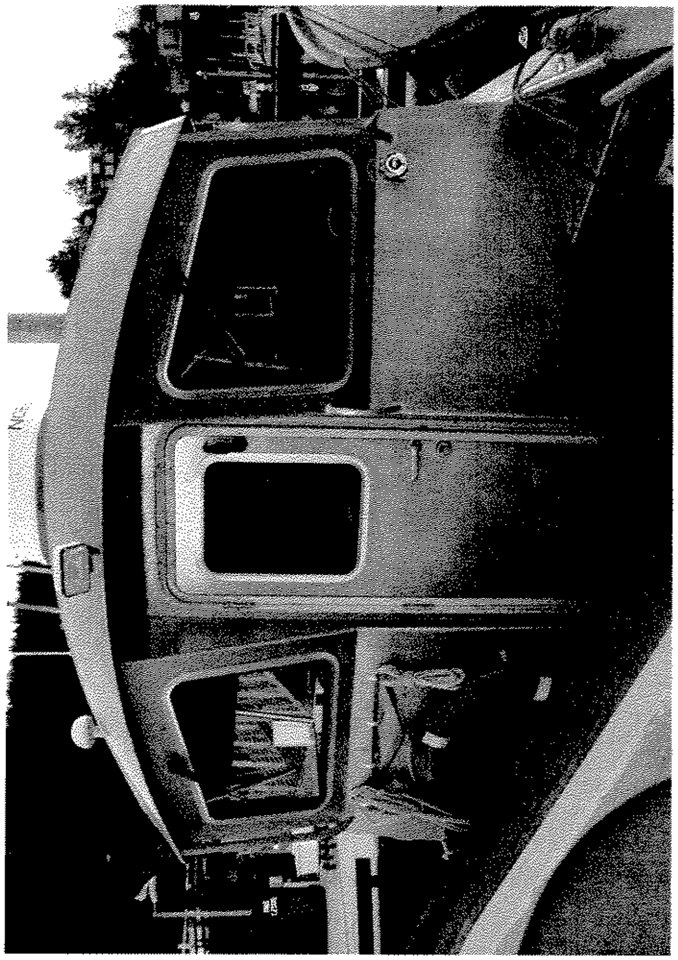
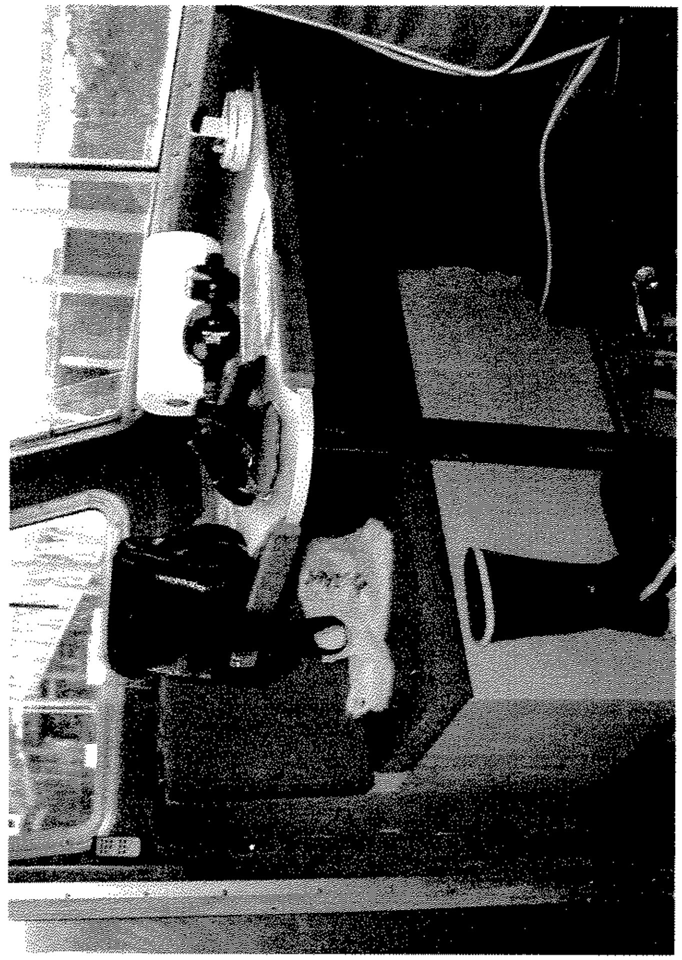
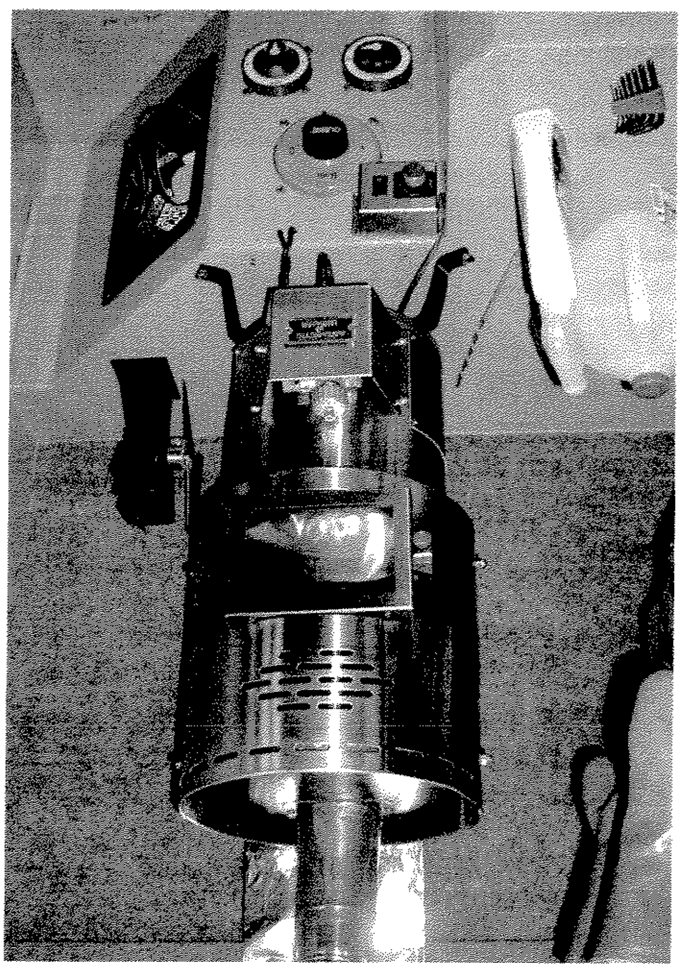
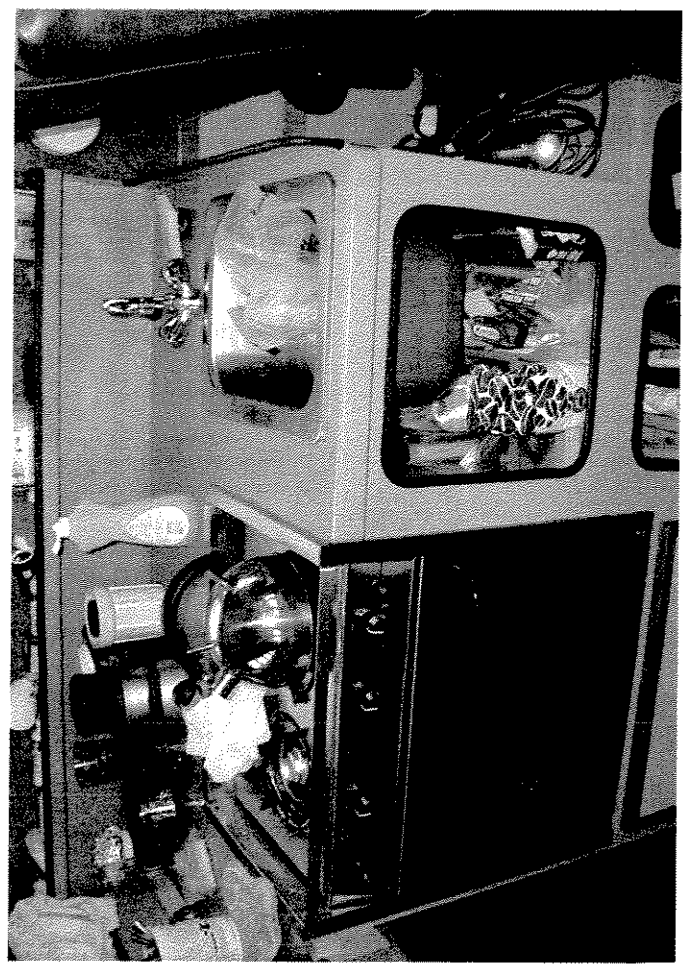













Rocky Point Enterprises, Inc.
P.O. Box 1047
Homer, Alaska 99603

MARINE SURVEYOR

Commercial • Fishing • Pleasure
Condition • Value • Insurance

Capt. Dale W. Johnson
(907) 235-8967
Fax (907) 235-2108

MARINE SURVEY REPORT

F/V SLEEP ROBBER

June 15, 2007

This is to certify that the attending surveyor, upon the request of Mr. Jeff Jenson, did attend the F/V Sleep Robber while it lay afloat at Homer, Alaska on June 13, 2007 for the purpose of conducting a condition and value survey to be used for the purpose of obtaining financing and/or insurance. The closing paragraph of this survey is incorporated wholly by reference herein and will not be duplicated here.

GENERAL VESSEL PARTICULARS

VESSEL NAME: Sleep Robber

VESSEL OWNER: Jeff Jenson
Box 770955
Eagle River, AK 99577

VESSEL TYPE: gillnet

HAILING PORT: Juneau, Alaska

OFFICIAL NUMBER: 1047324

HULL CONSTRUCTION: welded aluminum

GROSS TONS: 14 NET TONS: 18

REGISTERED LENGTH: 32.0' BREADTH: 14.0' DEPTH: 6.0'

YEAR BUILT: 1996 BUILT BY: Bennett Marine at Bellingham, WA

PROPULSION: Twin Volvo Penta TAMD-63-L diesel engines with
Borg Warner marine gears/Hamilton jet drives

ENGINE ALARMS: high temperature, low lube oil

FIRE EXTINGUISHERS: (2) 2 1/2 lb. dry chemical, (1) 5 lb. dry chemical

HEAT/SMOKE/VAPOR SENSORS: YES, (1) Xintex #S-2A propane vapor sensor

BILGE ALARMS: NONE

BILGE PUMPS: (1) 12 volt Rule #2000, (1) 12 volt Rule #3500

LAST DRYDOCKED: June 8, 2007 REASON: storage and engine overhaul

LIFESAVING EQUIPMENT: (1) life ring, (4) survival suits, (1) marine flare kit

RECOMMENDATIONS OUTSTANDING ON THIS SURVEY: YES **NUMBERS: 1 - 2**

GENERAL AND ARRANGEMENT:

This is a welded aluminum hull constructed of apparent good and adequate scantlings by Bennett Marine at Bellingham, Washington in 1996. The vessel has one deck, hinged navigation mast, raked stem, transom stern, hard chined planing hull, self bailing open work deck forward, net reel and fish holds midships, cabin aft.

The foredeck is surrounded by 28" to 32" bulwarks and contains a bow mounted Maritime Fabricators power roller, next aft a Freeman flush deck hatch to the forward void/storage compartment, to starboard forward a helm with full engine controls, next aft a hydraulic driven net reel with levelwind on slide rails and ten individual fish holds with single section aluminum covers (six 36" x 38" and four 30" x 41").

The flying bridge in accessed by steps from port aft and contains an engine removal hatch with aluminum cover, Durable plastic seat/storage locker, full width console with helm.

The cabin is entered by watertight aluminum door from midships forward and contains from port aft the galley with cupboard and counter space, Princess three burner propane range/oven, single basin stainless steel sink, next forward the helm with seat, full engine controls, instruments, gauges, various electronics, to starboard the galley messing table with fore and aft seating, aft three tiered berths.

Hatches in cabin sole access engine room.

Vessel interior is finished with a vinyl sole, Formica and wood trimmed overhead, carpeted bulkheads with Diamond Sea Glaze aluminum frame windows.

MASTS/BOOMS/RIGGING: (1) 3 1/4" hinged aluminum pipe navigation mast with 1 3/4" aluminum forebraces

GROUND TACKLE/DECK GEAR: (1) 20 kg Bruce anchor with 1/2" chain, 3/4" double braided nylon, (1) Maritime Fabricators hydraulic net roller, (1) Kinematics Twister hydraulic driven 51" X 36" aluminum net reel with levelwind on aluminum slide rail with 360° swivel mount.

PROPULSION & ASSOCIATED EQUIPMENT:

ENGINES: two MAKE: Volvo Penta MODEL: TAMD-63-L FUEL: diesel

HORSEPOWER (each): 318 TOTAL: 626 HOURS: 2 hrs (reported overhaul April 2007)

COOLING: double keel cooled (engines & aftercoolers)

EXHAUST: dry exhaust to wet jacketed mufflers

MARINE GEAR MAKE: Borg Warner MODEL: Velvet Drive RATIO: 1:1

JET UNITS: Hamilton #273

HYDRAULICS: (1) Cessna 3.8 cu. in. load sensing pump direct driven from port main engine

STARTING SYSTEM: 12 volt FUEL SHUTOFFS AT ENGINES: YES

ENGINE ROOM VENTILATION: natural

ALARMS: high temperature, low lube oil

CLUTCH & THROTTLE CONTROLS: Solo electronic, (3) station

STEERING: Jastram hydraulic, (3) station

OTHER: (1) set Webber Marine electro-hydraulic trim tabs, (1) Propex 10,000 BTU propane fired forced air furnace with 12 volt blower (external air supply and exhaust), (1) Pacer 2" X 2" hydraulic driven centrifugal washdown pump, (2) engine exhaust pyrometers

FUEL:

NUMBER OF TANKS: one

LOCATION: forward compartment

TOTAL CAPACITY: 400 gallons

FUEL FEED LINES: neoprene

FILL CONNECTIONS: flush deck

CONSTRUCTION: aluminum

FILTERS: (2) pair Racor #75/1000

SHUTOFF VALVES AT TANKS: YES

VENTS: overboard

FLAME SCREENS: NONE

POTABLE WATER:

NUMBER OF TANKS: one

LOCATION: forward compartment

CONSTRUCTION: aluminum

TOTAL CAPACITY: 30 gallons

ELECTRICAL:

AUXILIARY GENERATOR SETS: NONE

BATTERIES & CHARGERS: (6) 12 volt Group 27 heavy duty batteries (arranged in 3 banks of 2 batteries each), secured in acid resistant trays with covers charged by engine alternator, fit with battery disconnect switches.

DISTRIBUTION, WIRING & OVERLOAD PROTECTION: Marine wiring, fuse panel and circuit breaker distribution, good condition.

ELECTRONICS & NAVIGATION:

RADIOTELEPHONES: (1) Standard #CMP847P VHF-FM, (1) Icom #IC-M58 VHF-FM,
(1) Midland business band radio

RADAR: (1) Furuno #1940, 24 mile

GPS: (1) Garmin #152 with plotter, (1) Northstar #941X with plotter

PLOTTER: (1) Echo Tec #CTM950

DEPTHSOUNDER: (1) Garmin #340C color video

COMPASS: (1) Ritchie 3 1/2" bubble

SEARCHLIGHT/DECKLIGHTS: (9) 12 volt sealed beam decklights, (1) ACR 12 volt searchlight

NAVIGATION LIGHTS: for type

AUTOPILOT: NONE

OTHER: (1) Dual #MX-D41 AM/FM/CD stereo deck with (2) speakers

GENERAL COMMENTS:

Vessel appears sound and well built, overall condition and maintenance very good. Vessel was attended afloat, underwater body was not inspected. Vessel ADF&G #69852

ESTIMATED VALUES:

MARKET: $175,000.00 **REPLACEMENT: $295,000.00**

RECOMMENDATIONS:

1. Procure and install an approved CO alarm in enclosed accommodation area.

2. Vessel to be fit with high water alarm in bilges.

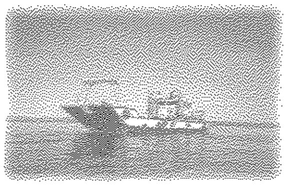
The above report is an unbiased opinion of the attending surveyor after careful examination of the vessel while it lay afloat and without making removals or opening up to expose parts normally concealed or testing for tightness or visibly and physically surveying the machinery internals or inaccessible areas, and without testing electronics, machinery and equipment. Further, no determination of intact stability or inherent structural integrity has been made. Although in the evaluated opinion of the attending surveyor the vessel is considered a good risk for the service intended, with the exceptions noted, it is fully understood by all that this report does not constitute a warranty of the vessel in any respect and that no liability is accepted by the reliance of anyone on the opinions set forth herein. It is further understood that this survey is for the benefit of Mr. Jeff Jenson only, and may not be relied upon by any other persons without written consent by surveyor and that anyone using this survey for any purpose agrees to hold Rocky Point Enterprises, Inc. and/or it's employees, representatives and surveyors harmless for any errors and/or omissions regarding this survey. Further, any prospective buyer should make his/her own personal inspection of the vessel including sea trialing of the vessel.

Submitted Without Prejudice,
Captain Dale W. Johnson
Rocky Point Surveys, Inc.

Dale W. Johnson

Dale W. Johnson, Marine Surveyor

Attending Surveyor: Dale W. Johnson
DWJ/DJ



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M/V Maxime spec sheet

New construction 2007
16x40 landing craft (jet drive)
2- 315hp cummings with 274 hamilton jets
1- 8kw gen set northern lights
Electronics- VHF radar, plotter, depth finder, full nav lights
4 bunks with galley, head with shower, table four 4 people, stove, sink
Duel hydraulics
Wash down / fire pump
Safety gear- one 12 man life raft/elliot, 4 survival suits, 4 type 1 life jackets
2 life rings, one 406 epirb, 2 swing stations for boat transfer, 4 fire extinguishers
1 high water alarm
Deck space approx 14'x20'
Draft 24"
250lb anchor with winch
Deck lights
Hydraulic bow ramp
800 gallons fuel
Fuel consumption 24 gallons per hour-8kt
10 gallons per hour 3-5kt working speed
Water capacity 1000 gallons
1 davit with pot puller

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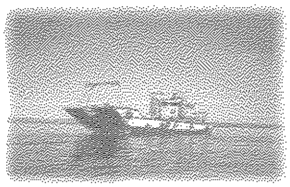
Jeff Johnson, Owner • (907) 258-6448 • Fax (907) 258-4654



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M/V QAYAQ Spirit

42'x14' USCG inspected 32 passenger
3 – 420hp yanman diesel
3 – 292 Hamilton jet with gears
Seating for 34 people
Covered back deck approx 14'x14'
2 side port r starboard loading swing stations
500 gallon fuel capacity
Large dry storage bow area
Fold down ladder ramp for loading people from beach
32kt cruise speed fully loaded
Fuel consumption cruise speed 33 gallons per hour
Safety equipment- two 20 man life raft eliott
32 type 1 life jackets, 1- 406 epirb
1 automatic engine room fire extinguisher, 4 ABC fire extinguishers
3 – 30" life rings, 4 survival suits.
USCG approved nav lights, Deck lights
Electronics- 2 VHF, 1 anemometer, 1 GPS
1 plotter depth finder,1 radar, 1 hailer
1 - 2500 watt inverter
1 – 50 gallon fresh water tank
1 head with sink
1 wash down 12 volt pump

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DHS, USCG, CG-1270 (REV. 06-04)

OMB APPROVED 1625-0027

UNITED STATES OF AMERICA

DEPARTMENT OF HOMELAND SECURITY
UNITED STATES COAST GUARD

NATIONAL VESSEL DOCUMENTATION CENTER

CERTIFICATE OF DOCUMENTATION

VESSEL NAME	OFFICIAL NUMBER	IMO OR OTHER NUMBER	YEAR COMPLETED
QAYAQ SPIRIT	1160606	PEB42120D904	2004

HAILING PORT	HULL MATERIAL	MECHANICAL PROPULSION
WHITTIER, AK	ALUMINUM	YES

GROSS TONNAGE	NET TONNAGE	LENGTH	BREADTH	DEPTH
27 GRT	22 NRT	42.0	14.0	7.0

PLACE BUILT
ANCHORAGE, AK

OWNERS	OPERATIONAL ENDORSEMENTS
GORDON P HEDDELL MARILYNN N HEDDELL	COASTWISE REGISTRY

MANAGING OWNER

GORDON P HEDDELL
200 W 34TH AVE #991
ANCHORAGE, AK 9950[illegible]

RESTRICTIONS
NONE

ENTITLEMENTS
NONE

REMARKS
NONE

ISSUE DATE
MARCH 19, 2007

THIS CERTIFICATE EXPIRES
APRIL 30, 2008

VDS

[signature]
DIRECTOR, NATIONAL VESSEL DOCUMENTATION CENTER

U.S. Department of Homeland Security
United States Coast Guard

Commanding Officer
United States Coast Guard
Marine Safety Office

510 L Street, Suite 100
Anchorage, AK 99501-1964
Phone: (907) 271-6700
FAX: (907) 271-6751

16711/QAYAQ SPIRIT
August 11, 2004

Honey Charters
200 W. 34th Ave #99
Anchorage, AK 99503

Subject: STABILITY LETTER FOR M/V QAYAQ SPIRIT, O.N. 1160606

Dear Mr. Heddell:

A simplified stability test, witnessed by the U.S. Coast Guard in accordance with Title 46, Code of Federal Regulations, Subpart 178.310, was performed on the M/V QAYAQ SPIRIT (O.N.1160606) in Seward, Alaska on May 12, 2004. On the basis of this test, stability calculations have been performed. Results indicate that the M/V QAYAQ SPIRIT, as presently outfitted and equipped and subject to the restrictions specified below, has satisfactory stability for the carriage of thirty-four (34) persons and eighteen (18) kayaks on exposed waters under all reasonable operating conditions. Since the passenger capacity and route are based on other criteria as well as stability and may be further limited thereby, you are cautioned that:

THE MAXIMUM PASSENGERS ALLOWED AND TOTAL PERSONS ALLOWED SHALL BE AS SPECIFIED ON THE CERTIFICATE OF INSPECTION.

The following restrictions apply:

1. The superstructure shall not be altered without authorization and supervision of the cognizant Officer in Charge, Marine Inspection.

2. Bulkheads and structures shall not be removed or altered without authorization and supervision of the cognizant Officer in Charge, Marine Inspection.

3. No permanent ballast or other weights shall be added, removed, altered, and/or relocated without authorization and supervision of the cognizant Officer in Charge, Marine Inspection.

4. Bilges shall be kept pumped to a minimum content.

5. It shall be the responsibility of the licensed master to maintain the vessel in a satisfactory, stable condition at all times.

6. A maximum of 1080 pounds of kayaks may be carried evenly distributed on the cabin top on exposed waters

16710/P007566
Serial: H1-0103426
May 29, 2002

QAYAQ SPIRIT; O.N. 1116427; Stability Letter

7. HULL OPENINGS: Any openings that could allow water to enter the hull should be kept closed when rough weather or sea conditions exist or are anticipated

8. WEIGHT CHANGES: This stability letter has been issued based upon the following light ship parameters:

Displacement	10.18	Long Tons
VCG	3.65	Feet Above the Baseline
LCG	7.67	Feet aft of Amidships

Amidships is 21 feet aft of the bow. Any alteration resulting in a change in these parameters will invalidate this stability letter. No fixed ballast or other such weights shall be added, removed, altered and/or relocated without the authorization and supervision of the cognizant OCMI. This vessel is not fitted with permanent ballast.

9. BILGES: The vessel's bilges and voids shall be kept pumped to minimum content at all times consistent with pollution prevention requirements.

10. LIST: You should make every effort to determine the cause of any list of the vessel before taking corrective action.

11. TOWING: This vessel is not authorized for towing.

This stability letter shall be posted under glass or other suitable transparent material in the pilothouse of the vessel so that all pages are visible.

A. D. Wiest
A. D. WIEST
Lieutenant Commander, U. S. Coast Guard
By direction of the Commanding Officer

United States of America
Department of Homeland Security
United States Coast Guard

Certification Date:	27 May 2004
Expiration Date:	27 May 2009
IMO Number:	

Certificate of Inspection

Vessel Name	Official Number	Call Sign	Service
CAYAC SPIRIT	1160606		Passenger (Inspected)

Hailing Port	Hull Material	Horsepower	Propulsion
WHITTIER AK	Aluminum	420	Jet Drive

Place Built	Delivery Date	Date Keel Laid	Gross Tons	Net Tons	DWT	Length
ANCHORAGE, AK UNITED STATES	27May2004	08Jan2004	R-27			R-42

Owner	Operator
GORDON P HEDDELL 200 W 34TH AVE # 991 ANCHORAGE, AK 99503-3969 UNITED STATES	GORDON P HEDDELL 200 W 34TH AVE # 991 ANCHORAGE, AK 99503-3969 UNITED STATES

This vessel must be manned with the following licensed and unlicensed personnel. Included in which there must be <u>0 certified lifeboatmen, 0 certified tankermen, 0 HSC type rating, and 0 GMDSS Operators.</u>

1 Master	0 Master & 1st Class Pilot	0 Radio Officer(s)	0 Chief Engineer	0 QMED/Rating
0 Chief Mate	0 Mate & 1st Class Pilot	0 Able Seamen/ROANW	0 1st Asst. Engr/2nd Engr.	0 Oilers
0 2nd Mate/OICNW	0 Lic. Mate/OICNW	0 Ordinary Seamen	0 2nd Asst. Engr/3rd Engr.	
0 3rd Mate/OICNW	0 1st Class Pilot	1 Deckhands	0 3rd Asst. Engr.	
			0 Lic. Engr.	

In addition, this vessel may carry 30 passengers, 0 other persons in crew, 0 persons in addition to crew, and no others. Total persons allowed: 32

Route Permitted and Conditions of Operation:

---Lakes, Bays, and Sounds plus Limited Coastwise---

[illegible] OF ALASKA, BETWEEN CAPE ST ELIAS AND CAPE ELIZABETH, ALASKA, NOT MORE THAN 20 MILES FROM A HARBOR OF SAFE REFUGE.

IF THE VESSEL IS AWAY FROM THE DOCK, OR PASSENGERS ARE ON BOARD OR HAVE ACCESS TO THE VESSEL FOR A PERIOD EXCEEDING 12 HOURS IN A 24 HOUR PERIOD AN ALTERNATE CREW SHALL BE PROVIDED.

WHEN OPERATING AS AN UNINSPECTED PASSENGER VESSEL (CARRYING SIX [illegible] OR LESS PASSENGERS FOR HIRE) ON A LIMITED COASTWISE ROUTE, THE CREW MAY BE REDUCED TO ONE (1) "OPERATOR OF UNINSPECTED PASSENGER VESSELS" OR EQUIVALENT. VESSEL MUST BE IN COMPLIANCE WITH THE

SEE NEXT PAGE FOR ADDITIONAL CERTIFICATE INFORMATION

With this Inspection for Certification having been completed at Anchorage, AK, the Officer in Charge, Marine Inspection, Western Alaska certified the vessel, in all respects, is in conformity with the applicable vessel inspection laws and the rules and regulations prescribed thereunder.

Annual/Periodic/Quarterly Reinspections

Date	Zone	A/P/Q	Signature
15May2005	SEC Anchorage	A	Woods, Scott A
08Jun2006	SEC Anchorage	A	Howells, Darre
6 Jun 07	Anchorage	A	[signature]

This Amended certificate issued by:

M. E. DeLuca LT, USCG By direction
Officer in Charge, Marine Inspection

Western Alaska
Inspection Zone

Department of Homeland Security
United States Coast Guard

Certificate of Inspection

QAYAQ SPIRIT

Certification Date: 27May2004

REQUIREMENTS OF 46 CFR PART 25.

ALL LOADING OR UNLOADING OF PASSENGERS, GEAR, OR CARGO AT REMOTE SITES AND OVER THE BOW OF THE VESSEL MUST BE CONDUCTED WITH THE ASSISTANCE OF THE CREW AND SHORESIDE PERSONNEL.

ONE CHILD LIFE PRESERVER SHALL BE CARRIED FOR EACH CHILD ON BOARD.

Overnight accommodations for 0 passengers.

---Lifesaving Equipment---

	Number	Persons		Required
Total Equipment for		32	Life Preservers(Adult)	32
Lifeboats(Total)	0	0	Life Preservers(Child)	4
Lifeboats(Port)*	0	0	Ring Buoys(Total)	1
Lifeboats(Starbd)*	0	0	With Lights*	1
Motor Lifeboats*	0	0	With Line Attached*	1
Lifeboats W/Radio*	0	0	Other*	0
Rescue Boats/Platforms	0	0	Immersion Suits	0
Inflatable Rafts	0	0	Portable Lifeboat Radios	0
Life Floats/Buoyant App	4	32	Equipped with EPIRB?	Yes
			(* included in totals)	

---Fire Fighting Equipment---

Fixed Extinguishing Systems

Capacity	Agent	Space Protected
1300	Halocarbon (Formerly: FM 200, FE241)	ENGINE ROOM

Fire Extinguishers - Hand portable and semi-portable

Qty	Class Type
1	B-I
3	B-II

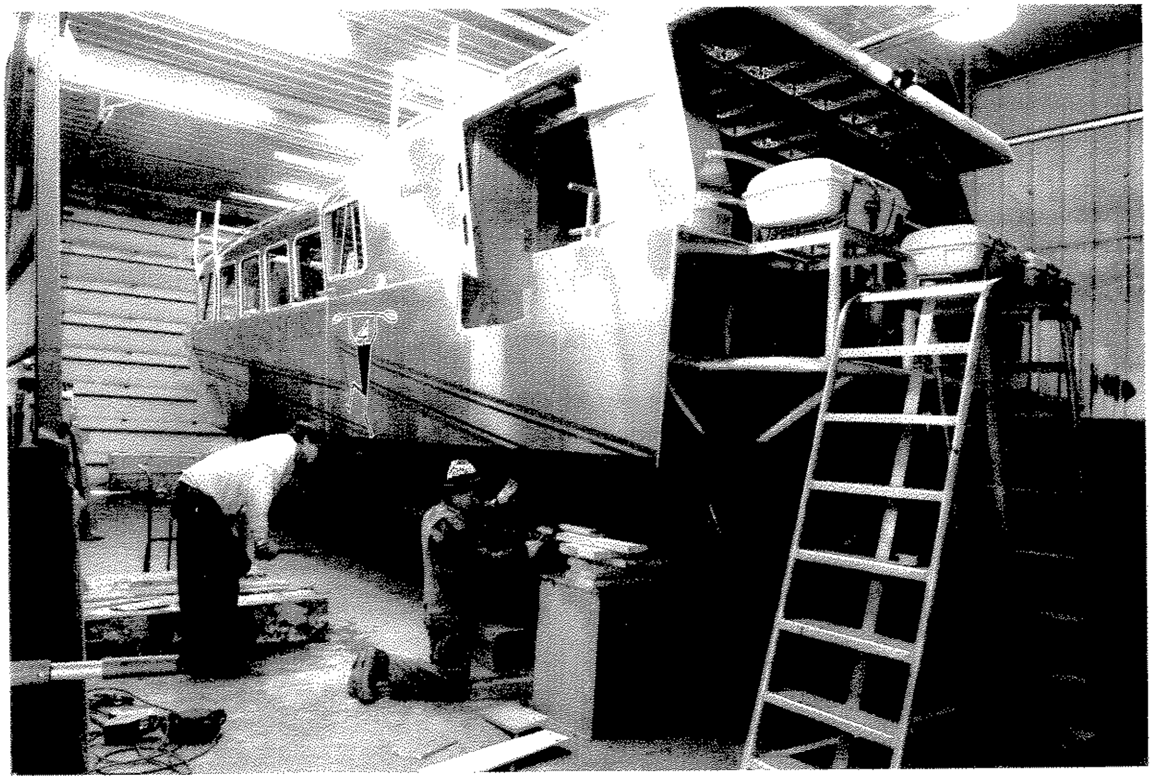
END

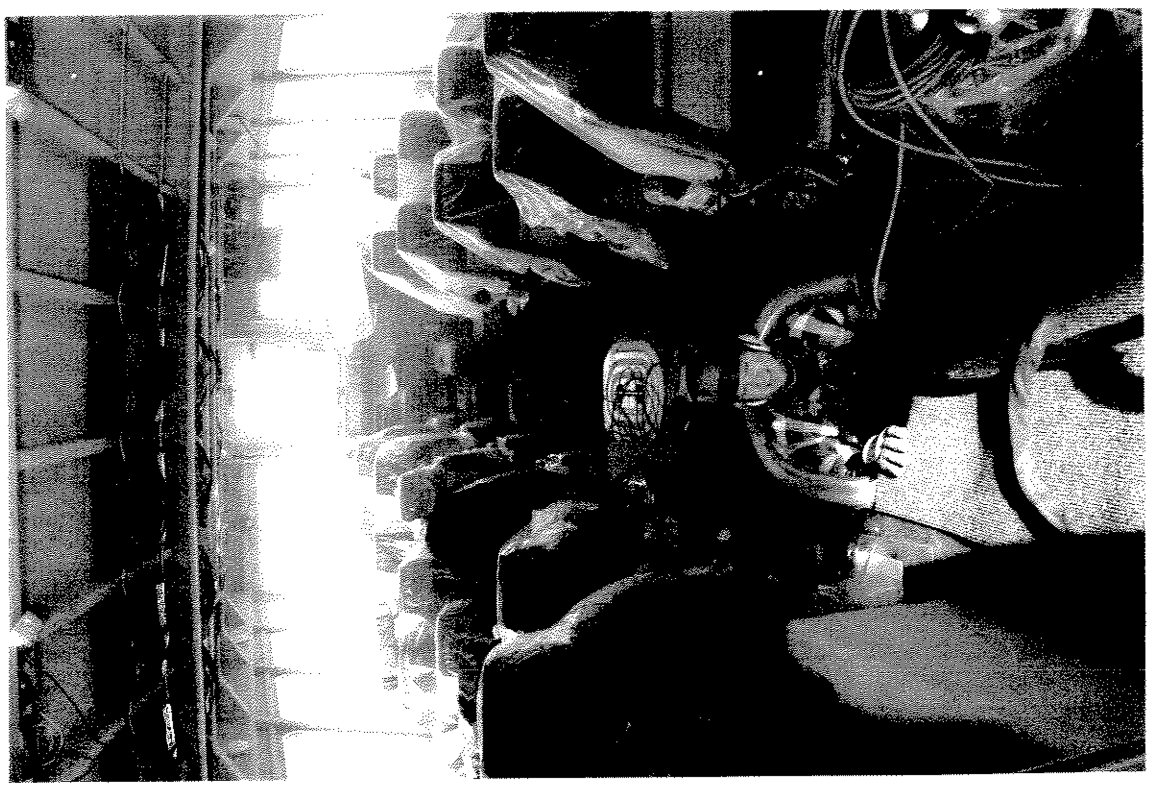

BAY BARGE COMPANY
QAYAQ SPIRIT


HONEY CHARTERS


OVERSIZE


PEREGRINE BOATS





M/V PEREGRINE

PEREGRINE FALCON, INC.
JEFF JOHNSON

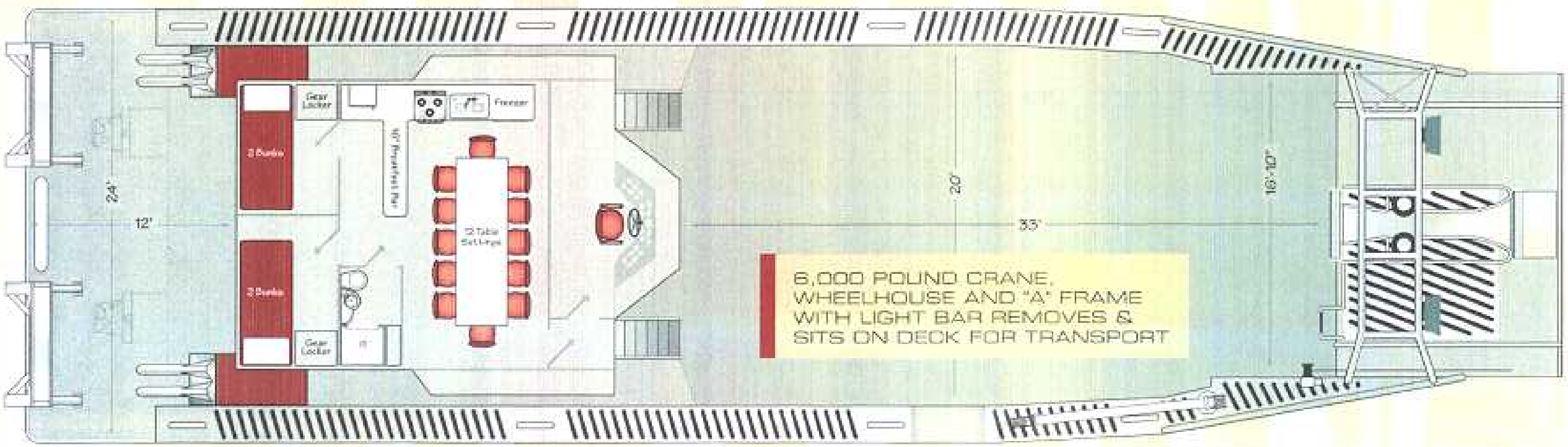
BOAT DRAFTS 2.5 FT.

3@405 HP CUMMINS MAINS
24" TRACTOR JETS OUTSIDE ENGINES
34" TUNNEL PROP

HYDRAULIC SYSTEMS:
- JETS / STEERING
- GUN "A" FRAMES AND CRANE
- SYSTEM RUNS SQUIRTER DECK & TWO ANCHOR WINCHES

20 KW NORTHERN LIGHT GENERATOR SET
30 KW NORTHERN LIGHT GENERATOR SET
800 GALLON P/DAY WATER MAKER

SLEEPING QUARTERS FOR 13 PEOPLE



6,000 POUND CRANE, WHEELHOUSE AND "A" FRAME WITH LIGHT BAR REMOVES & SITS ON DECK FOR TRANSPORT

SPEC SHEET

Grayling Marine International, Inc. and Peregrine Marine International, Inc built the M/V Peregrine in 1990. Her Length Overall is 90', with Beam of 24', and Depth 8.' 3", Drafting 36". Her Gross and net tons are 131 and 111 respectively. The M/V Peregrine is an all aluminum plate constructed landing craft style vessel. She has a semi-v bottom square transom stern and a raked bow with a bow gate that raises hydraulically with cable and pulley operations from port and starboard sides. The vessel is designed with a reverse chine, gull wing design to a square chine, straight sides with raised, compartmental bulwarks to port and starboard sides, and small bow compartments forward at the bow gate.

OAL: 90' BEAM: 24 ' DRAFT: 36" DEPTH: 8' 3"

Bow Gate/Winches: Bow Gate is 15' 6" wide, all aluminum 5086 construction with non-skid applications, and aluminum pipe safety rails around the entire bow compartment and gate area. 2-Hydraulic Ramp Winchs, maximum line pull 12,000 lbs (top wrap).

Aft Work Deck Area: 15' long x 24' wide. Approximately 360 sq ft deck space.

Cargo Deck: 33' x 20' x 6' x 10' = 720 sq ft of usable space – 50 Ton Capacity.

Deck: All decks are aluminum star plate aft walkways or plate construction with non-skid applications on stairs and lower cargo decks. Forward bow deck and main weather deck are aluminum plate construction.

EXPERIENCE

The M/V Peregrine and crew has an excellent safety and environmental record working for Western Geco, Northern Geophysical, Fairweather Geophysical, BP Phillips, Arctic Geo Science, and Veritas.

The M/V Peregrine has worked in the seismic field in Cook Inlet and Prudhoe Bay as a shallow water cable boat, air gun boat and streamer boat. Owner/Captain Jeff Johnson has 17 years experience working Cook Inlet and 6 years experience in Prudhoe Bay and is very familiar with extreme tides, shallow water, and working around ice in shallow water.

Other work experience includes oil spill response, freight hauling, and tendering.

Owner/Captain Jeff Johnson is also the owner/operator of Sea State One Marine, LLC, a custom boat manufacturing company that constructs the "Peregrine" boat line.

PROPULSION/STEERING

M/V PEREGRINE

Main Engine(s):	3-Cummins 2006 QSL9, 405 HP, 6 cylinder, diesel engine. 12 V DC start
Tractor Jets:	2-North American Marine Jets (port and starboard side jet drive units) 24", Jet I 300 with 2 Twin Disc 1-34" Propeller in Tunnel
Fuel Consumption:	35 GPH at Cruise.
Controls:	Morse flexible cable controls at main helm.
Cooling:	Integral aluminum pipe keel cooler.
Vessel Speed:	Cruise @ 8 knots, normal operation.
Generator:	2-Northern Lights Volts: 120V/220V AC 1 phase 1-KW: 20kw 60 cycles 1-Kw: 30kw 60 cycles

CAPACITIES & INFORMATION

Fuel Capacity: 7200 gallons - 16 tanks

Hydraulic Capacity: 3 separate systems- (2)-59 gallon and (1)-30 gallon aluminum tanks.

Water Capacity: 1500 gallons, 4-tanks, all aluminum.

Waste Oil Capacity: Portable 5 gallon buckets.

Watermaker: 800 GPD - Filtration Concepts

Fuel Transfer Station at aft deck

2 - Sodium driving lights

8 – Halogen deck lights

1 USCG Approved Sewage System (Humphrey)

Crane: 1 - Auto Crane, straight boom hydraulic crane with 20' extension, starboard forward deck, 1 - Ramsey hydraulic winch/worm drive, 50' of 7/16 galvanized cable and full hydraulic controls inset mounted at the crane pedestal.

New 2007 Marine Crane Model T-7000M/3S 27' Reach #6000 Maximum Lift Capacity.

Hydraulic Control Station: H-Frame Seismic gun rack frames is located on starboard forward back deck.

2 - 4" x 12" x 1/2" X 16' aluminum channel H-Frames on port and starboard sides of stern. These articulate on lower aluminum brackets with 2 each hydraulic rams, 4" bore x 48" stroke, rated 3000 psi. With #8000 capacity including Winch.

1 - Centerline forward, all aluminum hydraulic seismic cable Squirter, dual horizontal cable discharge unit with articulating rubber tire hydraulic roller assembly with aluminum pipe hand rails port and starboard sides. Roller assembly is operated by dual hydraulic ram on aluminum bar stock for thwart ship movements.

1 - Kolstrand power block 12" steel shivs with aluminum plate lower frame and #12 aluminum ship's cleat attached to the crane for seismic cable operations.

2 – Swing Boarding Stations Midship.

1 - 800 GPD Watermaker – Filtration Concepts

1 - Miller Welding Machine – wire/stick feed for aluminum/steel.

16 – Survival Suits

16 – Life Jackets

2 – Solas Liferaft (20-man capacity) & 1 – Solas Liferaft (12-man capacity)

1 – 16' Achilles raft with 35HP jet drive

ELECTRONICS & NAVIGATION

Furuno 36 mile Radar	1831 Mark II
Goldstar 24 mile radar	Turbo 951
Furuno Auto Pilot	FAP-300
Stephen SSB Radio	SEA-222
Cetrek GPS	Chart Link
Simrad 12 Color Plotter/Sounder	CA54
Magellan GPS Navigation Compass	5000 DX
Uniden VHF Radio	MC 625
Raytheon VHF Radio/Hailer	Ray 202
Set of 3-5" brass clock, barometer and anemometer	Downeaster
2-Standard VHF Radios	GX2320S
2-Low Range digital depth sounder	System 3000
Data Marine digital depth sounder	CD 400
Jensen AM/FM Cassette Player w/ 4 remote speakers	XCC 7100
31" Liquid-filled navigational Ritchie compass	Power Damp
Focus closed circuit TV system with 1 remote station	
2 Satellite Telephone s	Iridium 9505 and Globalstar

LIVING QUARTERS & FACILITIES

- M/V Peregrine accommodates (13) people with two rear cabin staterooms sleeping two each, upper quarters sleeping four, and lower crew quarters sleeping five. Sleeping areas are equipped with a TV/DVD/VCR. Video library of 750+ movies.

- Removable deck housing unit sleeps six.

- Full Galley

  Full size refrigerator
  Full size upright freezer and two chest freezers
  Ceramic top stove/oven - standard size
  Two Microwave ovens
  Dishwasher
  Large double-sink
  Seating for eight

- Washer/Dryer – stackable, front-loading

- Heads - two complete heads with shower, upper & lower cabin – USCG-approved system

M/V Peregrine
U.S.C.G. Classified Oceanographic Research Vessel

Commercial Charter Clients

Veritas Geophysical

2001 Seismic Cable & Gunboat (Marathon Oil)
2005 Seismic (Conoco/Phillips)
2002 Seismic (Andarco) Cook Inlet
2006 Seismic Well Shoot

Terra Surveys

2005 Survey Vessel - Norton Sound – 10 people

American Marine Corporation

2005 Supply Vessel/Crew Housing/Beach Support – Cook Inlet – 12 people

NOAA

2004 Research Vessel for Seal Tagging
2005 Cook Inlet Seal Tagging
2006 Cook Inlet Seal Tagging

Northern Geophysical

1996 Streamer Vessel/Gunboat – Cook Inlet (Phillips)
1996 Beaufort Sea/Northstar Island (BP)
1997 Beaufort Sea (BP)

Western Geophysical

1998 Cable Boat - Beaufort Sea (BP)
1999 Supply Vessel – Beaufort Sea (BP)
2000 Supply Vessel – Beaufort Sea (BP)
2001 Gunboat – Beaufort Sea (BP)
2006 Supply Vessel Beaufort and Chukchi Seas

Offshore Divers

2004 Dive Boat – Cook Inlet (State of Alaska)

Deepwater Corrosion

2002 Survey Streamer – Cook Inlet (Phillips Pipeline)
2004 Survey Streamer – Cook Inlet (Tesoro Pipeline)

U.A.F.

2006 Augustine Island Research