Application
for
Incidental Harassment Authorization and Letter of Authorization for the Non-Lethal Taking of Marine Mammals Resulting from the Operation
of the
Neptune Deepwater Port, Massachusetts Bay

Revision 3

Submitted to:

Office of Protected Resources
National Marine Fisheries Service
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Submitted by:

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Acronyms and Abbreviations

ABR	auditory brainstem response
Applicant, the	Neptune LNG LLC
AUV	autonomous underwater vehicle
CeTAP	Cetacean and Turtle Assessment Program
CFR	Code of Federal Regulations
dB	decibel
DP	dynamic positioning
EIR	Environmental Impact Report
ESA	Endangered Species Act
FEIS	Final Environmental Impact Statement
HubLine^{SM}	Algonquin HubLine^{SM}
Hz	Hertz
IHA	Incidental Harassment Authorization
kHz	kilohertz
km	kilometers
LNG	liquefied natural gas
LOA	Letter of Authorization
MARAD	Maritime Administration
mg/L	milligram(s) per liter
MMPA	Marine Mammal Protection Act
mmscfd	million standard cubic feet per day
MRA	Marine Resources Assessment
Neptune	proposed *Neptune* deepwater port
NM	nautical miles
NOAA	National Oceanic and Atmospheric Administration
NMFS	National Marine Fisheries Service
OCS	Outer Continental Shelf
PAM	passive acoustic monitoring
port, the	proposed *Neptune* deepwater port
PTS	permanent threshold shift
ROD	Record of Decision

RPM	revolutions per minute
SBNMS	Stellwagen Bank National Marine Sanctuary
SMA	Seasonal Management Area
SPL	sound pressure level
SPUE	sightings per unit effort
SRV	shuttle and regasification vessel
STL	submerged turret loading
TSS	Traffic Separation Scheme
TTS	temporary threshold shift
UMT	unidentified measure type
USCG	United States Coast Guard

Information Submitted in Response to the Requirements of 50 CFR § 216.104

Neptune LNG LLC (the Applicant), a Delaware limited liability company, submits this request for an Incidental Harassment Authorization (IHA) and Letter of Authorization (LOA) for non-lethal incidental takes by harassment during the port commissioning and operations, including maintenance and repair activities, at its *Neptune* deepwater port (*Neptune*). This application is submitted in accordance with the guidance under 50 Code of Federal Regulations (CFR) Part 216, Subpart I (216.101 through 21.106). Section 216.104 sets out 14 specific items that must be addressed in requests for rulemaking and renewal of regulations pursuant to Section 101(a)(5) of the Marine Mammal Protection Act (MMPA). Each of these items is addressed in detail below.

1.0 A Detailed Description of the Specific Activity or Class of Activities That Can Be Expected to Result in Incidental Taking of Marine Mammals

The Applicant's deepwater port called *Neptune* will be located in the federal waters of the Outer Continental Shelf (OCS) in blocks NK 19-04 6525 and NK 19-04 6575, approximately 22 miles northeast of Boston, Massachusetts, in a water depth of approximately 260 feet. The purpose of *Neptune* will be for import of liquefied natural gas (LNG) into the New England region.

The Applicant anticipates completion of construction and commissioning of *Neptune* between February and April 2010. (Neptune LNG LLC will commission its first built shuttle and regasification vessel [SRV], the *GDF SUEZ NEPTUNE*, during this period.) These final stages of the port construction/commissioning activities will be completed under the current second IHA issued July 1, 2009. With this application, Neptune LNG LLC is seeking a third IHA for the period July 1, 2010, through June 30, 2011, for the commissioning of the second SRV, the *GDF SUEZ CAPE ANN*, and limited port operations. Additionally, this application is for an LOA to be effective July 1, 2011, to cover full port operations and any major repairs.

Neptune will be capable of mooring LNG SRVs with a capacity of approximately 140,000 cubic meters. Up to two SRVs will temporarily moor at the deepwater port by means of a submerged unloading buoy system. Two separate buoys will allow natural gas to be delivered in a continuous flow, without interruption, by having a brief overlap between arriving and departing SRVs. The annual average throughput capacity will be around 500 million standard cubic feet per day (mmscfd) with an initial throughput of 400 mmscfd, and a peak capacity of approximately 750 mmscfd.

The SRVs will be equipped to store, transport, and vaporize LNG, and to odorize, meter, and send out natural gas by means of two 16-inch flexible risers and one 24-inch subsea flowline. These risers and flowline will lead to a 24-inch gas transmission pipeline connecting the deepwater port to the existing 30-inch Algonquin HubLine^{SM} (HubLine^{SM}) located approximately 9 miles west of the deepwater port location. The deepwater port will be designed, constructed, and operated in accordance with applicable codes and standards and will have an expected operating life of approximately 25 years. Figure 1-1 is an isometric view of the deepwater port.

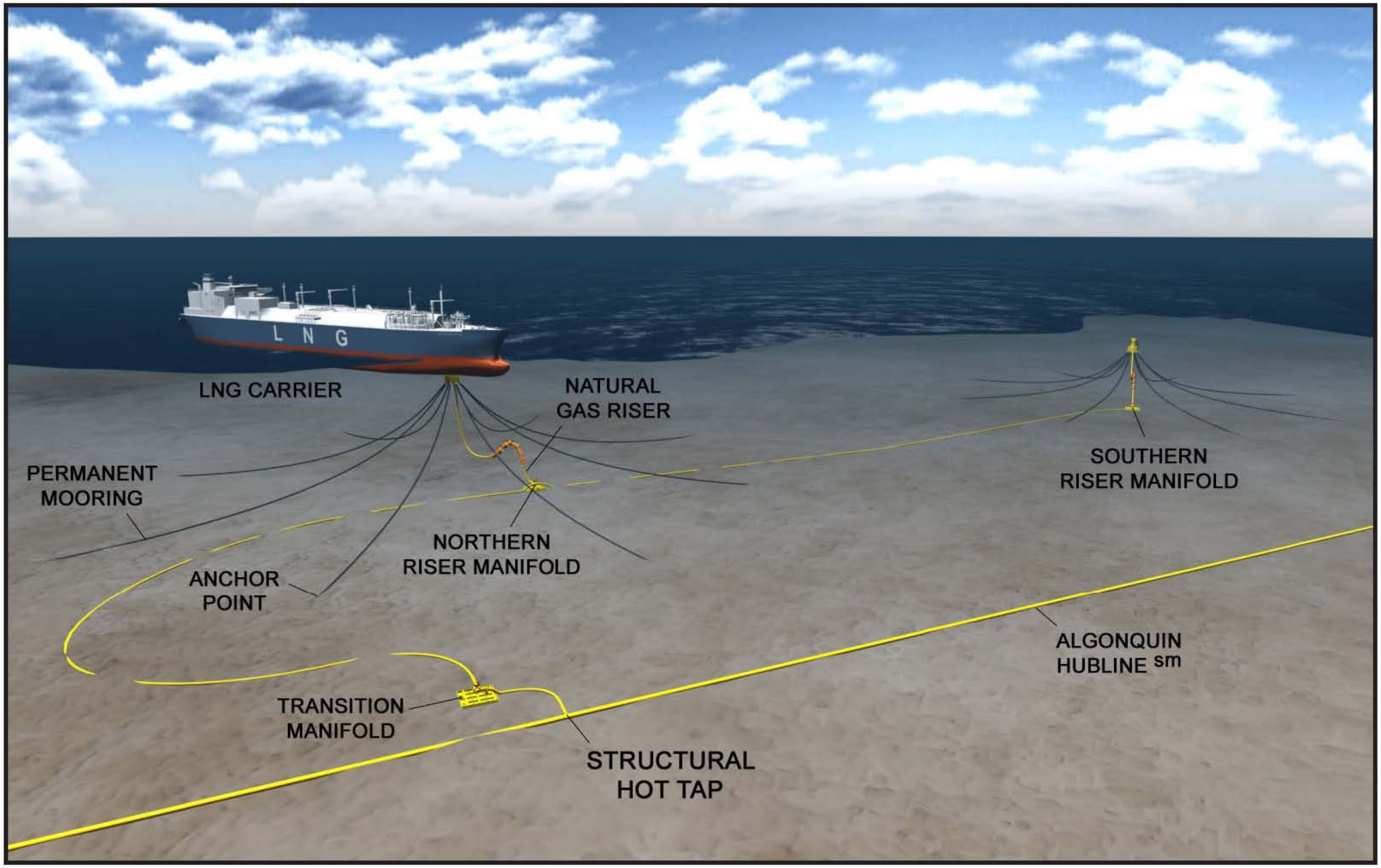


Figure 1-1 Isometric View of the Deepwater Port

On February 15, 2005, Neptune LNG LLC submitted an application to the United States Coast Guard (USCG) and the Maritime Administration (MARAD) under the Deepwater Port Act for all federal authorizations required for a license to own, construct, and operate a deepwater port off the coast of Massachusetts. The project was assigned Docket Number USCG-2005-22611.

On November 3, 2006, the USCG published a final Environmental Impact Statement/Environmental Impact Report (FEIS/EIR) for the *Neptune* LNG Deepwater Port License Application. This FEIS/EIR provides detailed information on the project facilities, construction methods, and the analysis of potential impacts on marine mammals. The MARAD Record of Decision (ROD) on the FEIS/EIR was issued on January 29, 2007. The FEIS/EIR and ROD are incorporated herein by reference (USCG 2006), as is the Biological Opinion issued by the Northeast Regional Office of the National Oceanic and Atmospheric Administration's (NOAA's) National Marine Fisheries Service on January 12, 2007 (Appendix A).

A comprehensive underwater acoustic impact analysis of the proposed construction and operation of the port was provided in *Neptune*'s Deepwater Port License Application, Appendix H (Volume II). This study, prepared by LGL Limited and JASCO Research Limited in October 2005, is provided in this application as Appendix B. Also appended to this application, as Appendix C.1, are two supplements to the 2005 LGL Limited/JASCO Research Limited report. In addition, a recent underwater noise study by Samsung on the newly constructed SRV is provided as Appendix C.2. An assessment of the Samsung underwater noise study by JASCO Applied Sciences and a reassessment of takes by LGL Limited are provided together as Appendix C.3. These supplements focus on an additional analysis of the impacts of the use of dynamic thrusters (for maintaining position while on buoy) and SRV transits through the Boston Harbor Shipping Channel.

1.1 Description of Port Operations

During *Neptune* port operations, sound will be generated by the regasification of the LNG aboard the SRVs and the use of thrusters by vessels maneuvering and maintaining position at the port. Another potential sound source would be sound generated from large construction-type dynamic positioning (DP) vessels used for a major repair of the subsea pipeline or unloading facility, although necessity for such repair is unlikely. Of these potential operations and maintenance/repair sound sources, thruster use for DP is the most significant. The following text describes the activities that will occur at the port upon its commissioning.

1.1.1 Vessel Activity

The SRVs will approach the port using the Boston Harbor Traffic Separation Scheme (TSS), entering the TSS within the Great South Channel and remaining in the TSS until they reach the Boston Harbor Precautionary Area. At the Boston Lighted Horn Buoy B (at the center of the Boston Harbor Precautionary Area), the SRV will be met by a pilot vessel and a support vessel. A pilot will board the SRV, and the support vessel will accompany the SRV to the port. SRVs carrying LNG typically travel at speeds up to 19.5 knots; however, *Neptune* SRVs will reduce speed to 10 knots within the TSS year-round in the Off Race Point Seasonal Management Area (SMA) and to a maximum of 10 knots when traveling to and from the buoys once exiting the shipping lanes at the Boston Harbor Precautionary Area. In addition, the Applicant is committed to reducing speed to 10 knots in the Great South Channel SMA from April 1 to July 31.

To supply a continuous flow of natural gas into the pipeline, about 50 roundtrip SRV transits will take place each year on average (one transit every 3.65 days). As an SRV approaches the port, vessel speed will gradually be reduced. Upon arrival at the port, one of the submerged unloading buoys will be located and retrieved from its submerged position by means of a winch and recovery line. The SRV is designed for operation in harsh environments and can connect to the unloading buoy in up to 11.5 feet significant wave heights and remain operational in up to 36 feet significant wave heights providing high operational availability.

The vessel's aft/forward thrusters will be used intermittently. *Neptune* SRVs will use both bow and stern thrusters when approaching the unloading buoy and when docking the buoy inside the Submerged Turret Loading (STL) compartment, as well as when releasing the buoy after the regasifying process is finished. The thrusters will be energized for up to two hours during the docking process and up to one hour during the undocking/release process. When energized, the thrusters will rotate at a constant RPM with the blades set at zero pitch. There will be little cavitation when the thruster propellers idle in this mode. The sound levels in this operating mode are expected to be approximately 8 decibels (dB) less than at 100 percent load, based on measured data from other vessels.

When the thrusters are engaged, the pitch of the blades will be adjusted in short bursts for the amount of thrust needed. These short bursts will cause cavitation and elevated sound levels. The maximum sound level with two thrusters operating at 100 percent load will be 180 dB re 1 μPa @ 1m. This is not the normal operating mode, but a worst-case scenario. Typically, thrusters are operated for only seconds at a time and not at continuous full loading. These thrusters will be engaged for no more than 20 minutes, in total, when docking at the buoy. The same applies for the undocking scenario.

During normal conditions, the vessel will be allowed to weathervane on the single-point mooring system. However, aft thrusters may be used under certain conditions to maintain the vessel's heading into the wind when competing tides operate to push the vessel broadside to the wind. The Applicant has assumed a total of 200 hours per year operating under these conditions. In these circumstances, the ambient sound will already be high because of the wind and associated wave sound.

1.1.2 Regasification System

Once an SRV is connected to a buoy, the vaporization of LNG and send-out of natural gas can begin. Each SRV will be equipped with three vaporization units, each with the capacity to vaporize 250 mmscfd. Under normal operation, two units will be in service. The third vaporization unit will be on standby mode, though all three units could operate simultaneously.

1.1.3 Maintenance/Repairs

Routine maintenance activities typically are short in duration (several days or less) and require small (vessels less than 300 gross tons) vessels to perform. Such activities include attaching and detaching and/or cleaning the buoy pick up line to the STL buoy, performing surveys and inspections with a remotely operated vehicle, and cleaning or replacing parts (e.g., bulbs, batteries, etc.) on the floating navigation buoys. Every seven to 10 years, the Applicant will run an intelligent pig down the pipeline to assess its condition. This particular activity will require several larger, construction-type vessels and several weeks to complete.

Unplanned repairs can be either relatively minor, or in some cases, major requiring several large, construction-type vessels and an extensive mitigation program similar to that employed during the construction phase of the project. Minor repairs are typically shorter in duration and could include fixing flange or valve leaks, replacing faulty pressure transducers, or repairing a stuck valve. These kinds of repairs require one diver support vessel with three or four anchors to hold its position. Minor repairs could take from a few days to one to two weeks depending on the nature of the problem.

Major repairs, on the other hand, are longer in duration and typically require large construction vessels similar to those used to install the pipeline and set the buoy and anchoring system. These vessels will typically mobilize from local ports or the Gulf of Mexico. Major repairs require upfront planning, equipment procurement, and mobilization of vessels and saturation divers. Examples of major repairs – although unlikely to occur – are damage to a riser or umbilical and their possible replacement, damage to the pipeline and manifolds, or anchor chain replacement. These types of repairs could take one to four weeks and possibly longer.

1.2 Operations Sound

The acoustic effects of using the thrusters for maneuvering at the unloading buoys were modeled by JASCO Research Limited (2005) (see Appendix B for supplemental analysis). The analysis assumed the use of four thrusters (two bow, two stern) at 100% power during the spring, summer, fall, and winter seasons. The one-third (1/3)-octave band source levels for the thrusters ranged from 148.5 dB re 1 µPa at 1 m at 2000 Hertz (Hz) to 174.5 dB re 1 µPa at 1 m at 10 Hz. Figures 1-2 through 1-5 show the received sound level at 50-meter depth at the south unloading buoy during each of the four seasons.

The acoustic effects of operating the regasification system at the unloading buoys were also modeled by JASCO Research Limited (2005) (see Appendix B). In addition, supplemental analysis was performed to assess the potential underwater acoustic impacts of using the two aft thrusters after mooring for maintaining the heading of the vessel in situations when competing tides operate to push the vessel broadside to the wind. The details of this analysis are provided in Appendix C.1. Additionally, Samsung performed an underwater noise study on the newly constructed SRV (Appendix C.2) and an evaluation of these data was performed by JASCO Applied Sciences (Appendix C.3).

1.3 Maintenance/Repair Sound

Acoustic modeling originally performed to predict received levels of underwater sound that could result from the construction of *Neptune* also could be applicable to major maintenance/repair during operations (see Appendices B and C for a discussion of the acoustic modeling methodology employed). Activities considered to be potential sound sources during major maintenance/repair activities include excavation (jetting) of the flowline or main transmission pipeline routes and lowering of materials (pipe, anchors, and chains) to the sea floor. These analyses evaluated the potential impacts of construction of the flowline and pipeline using surrogate source levels for vessels that could be employed during *Neptune's* construction. One surrogate vessel used for modeling purposes was the *Castoro II* (and four accompanying vessels). Figures 1-6 and 1-7 illustrate the worst-case received sound levels that would be associated with major maintenance/repair activities along the flowline between the two unloading buoys and along the pipeline route at the 50-meter depth during the spring season if a vessel similar to the *Castoro II* were used.

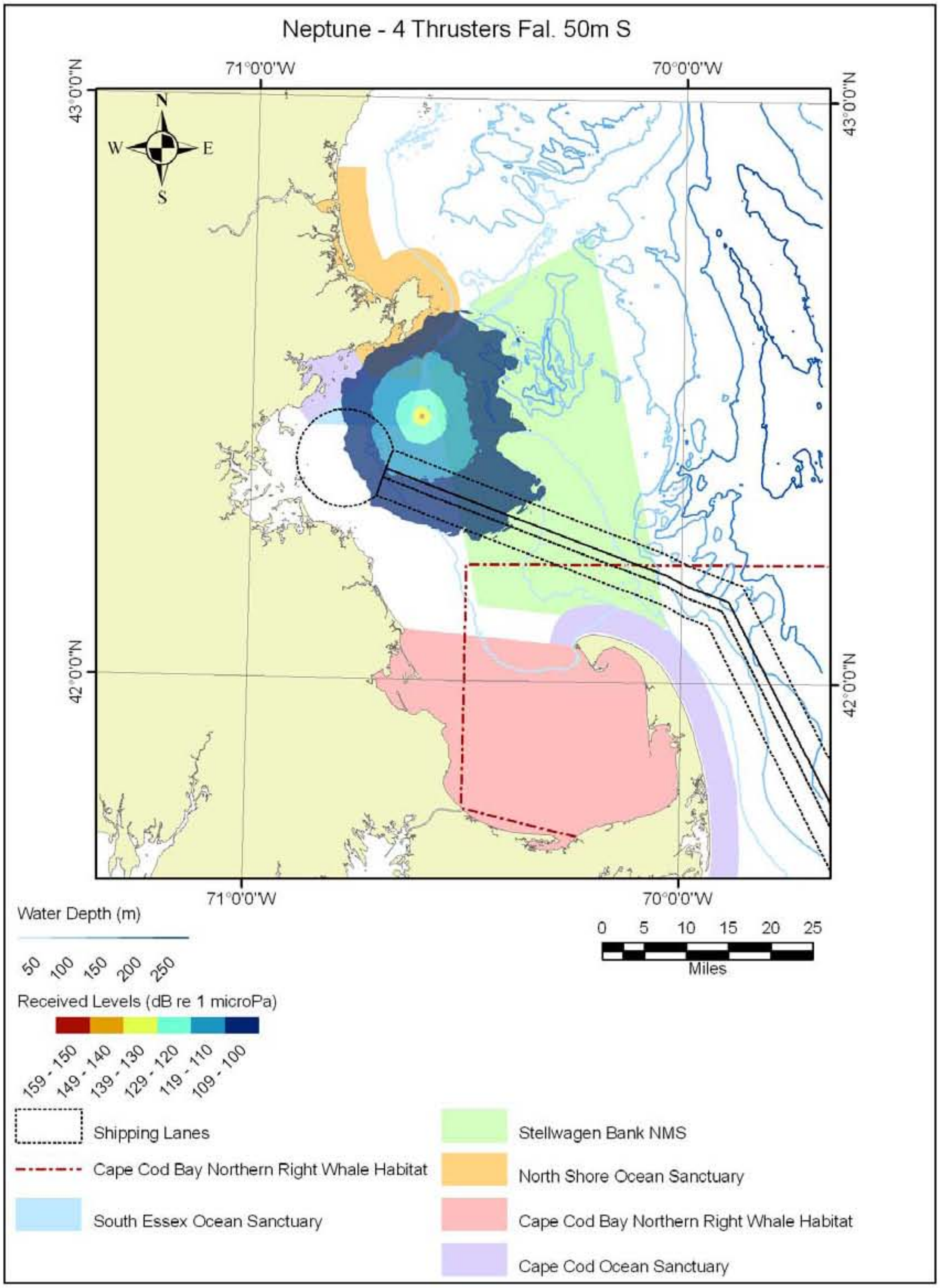


Figure 1-2 Received Sound Level at 50-meter Depth at the South Unloading Buoy During Spring

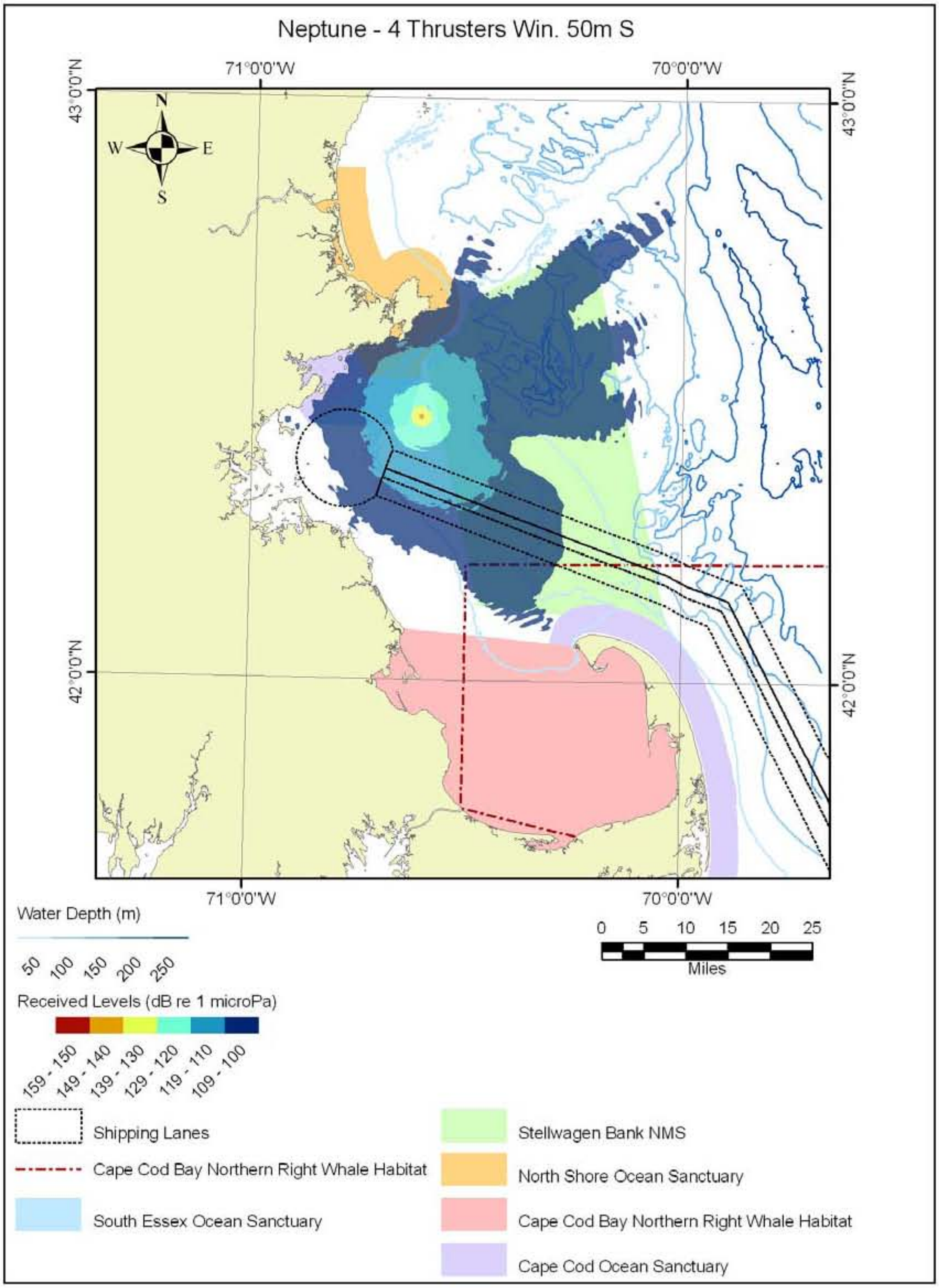


Figure 1-3 Received Sound Level at 50-meter Depth at the South Unloading Buoy During Summer

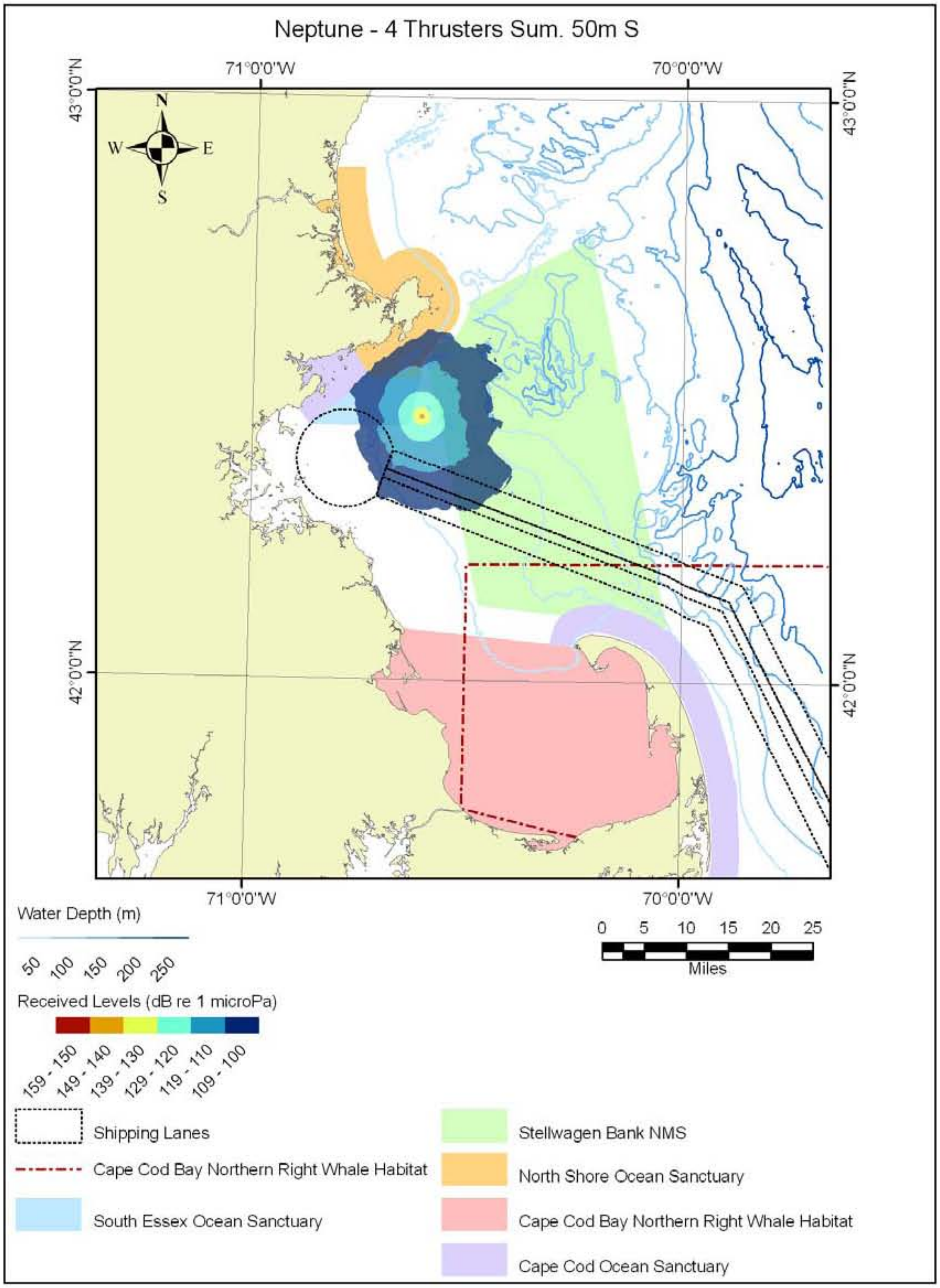


Figure 1-4 Received Sound Level at 50-meter Depth at the South Unloading Buoy During Fall

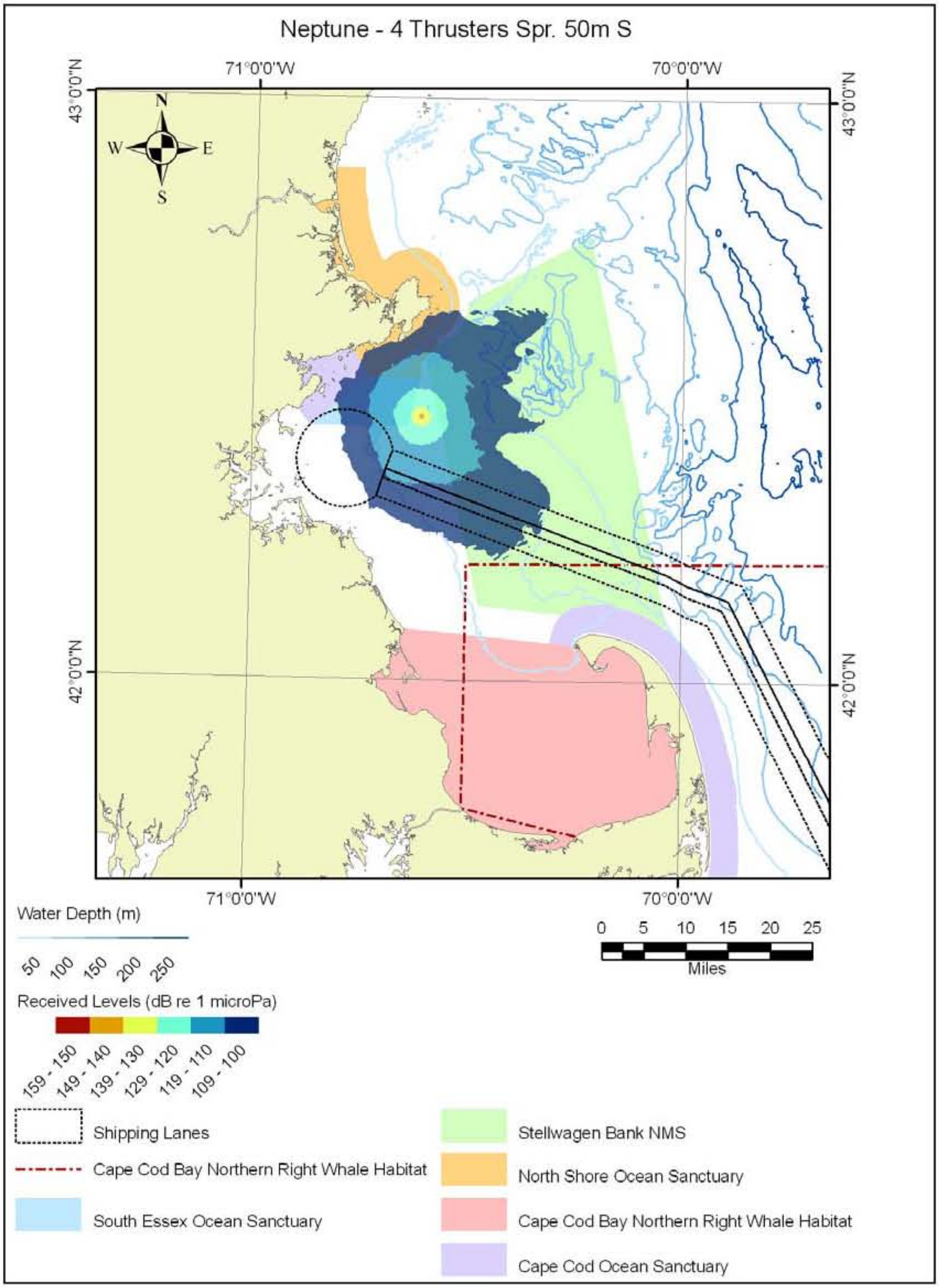
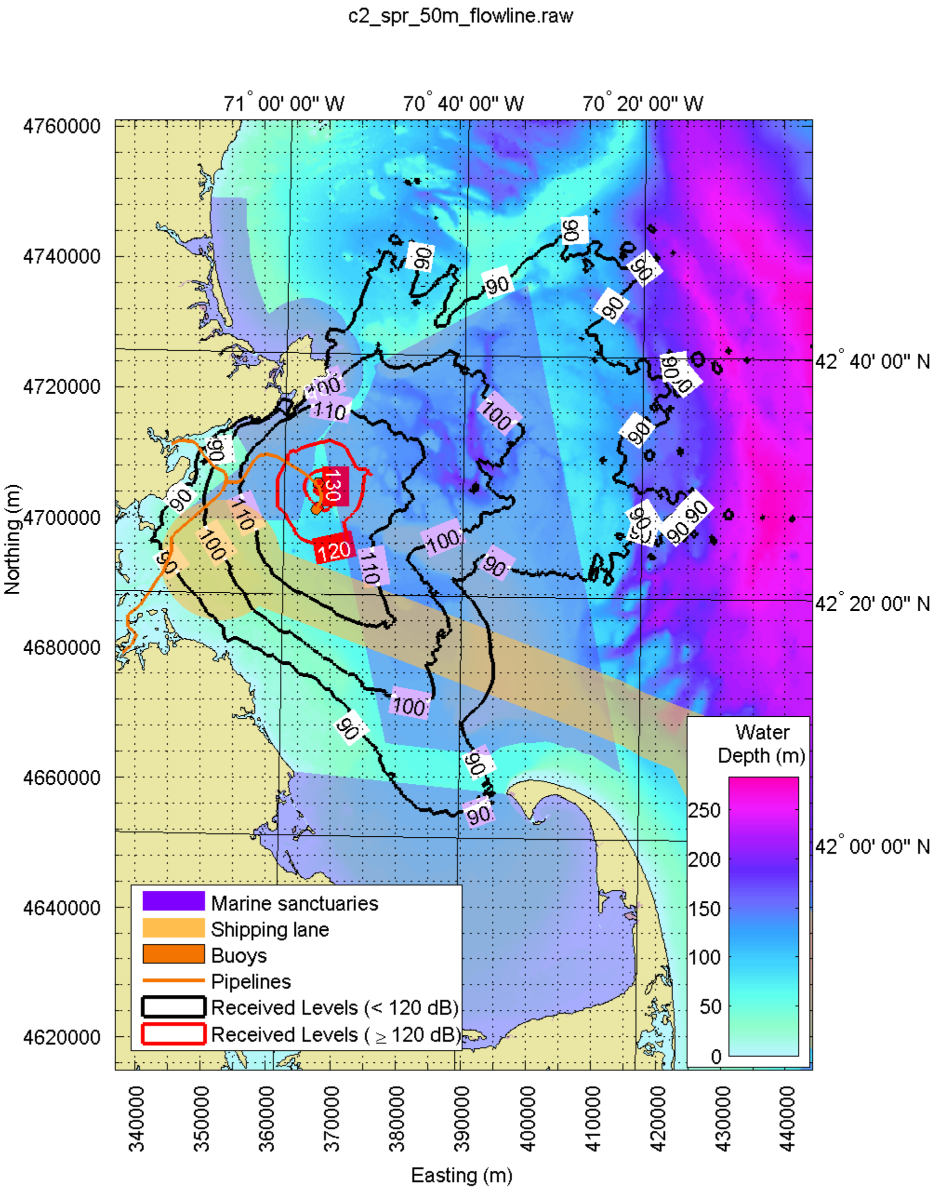
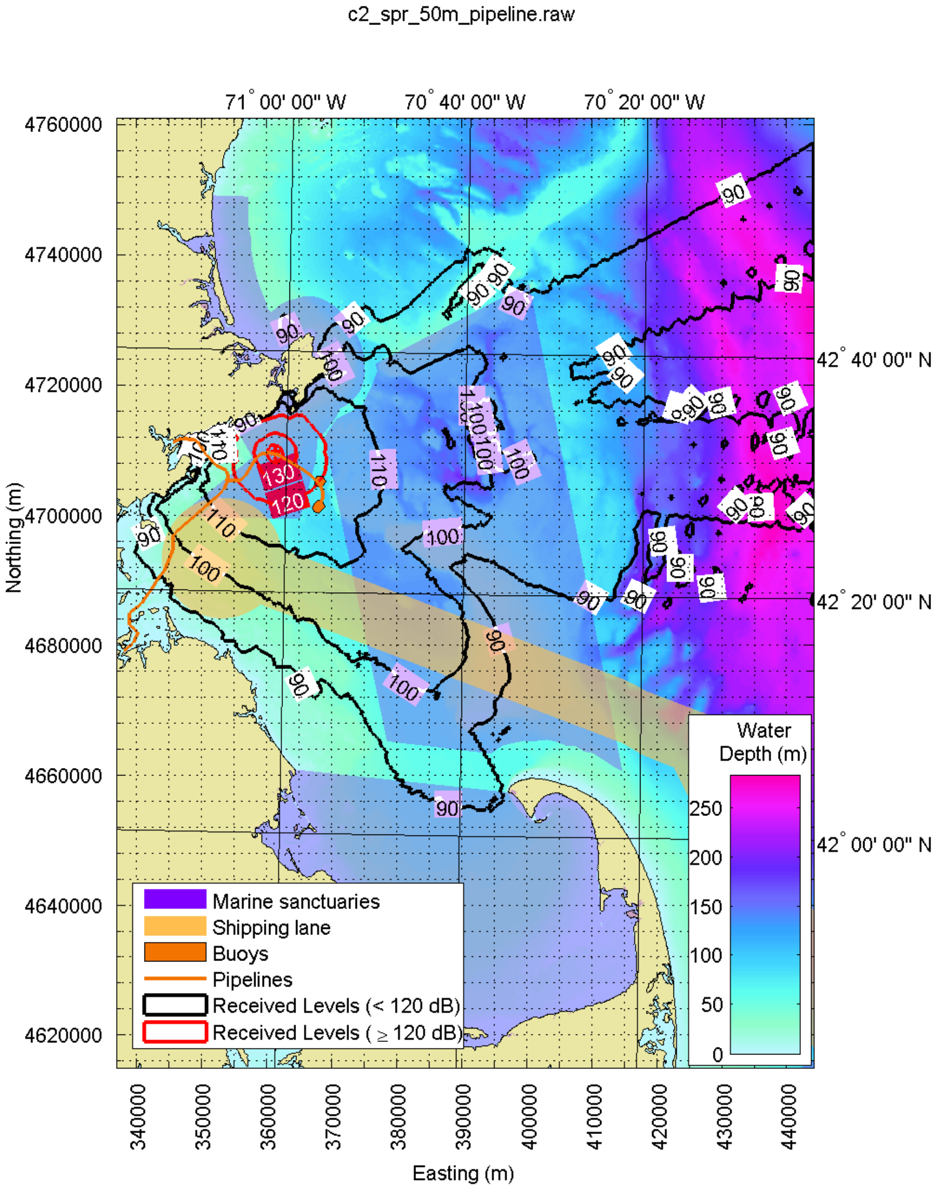


Figure 1-5 Received Sound Level at 50-meter Depth at the South Unloading Buoy During Winter



Source: LGL Limited 2005.
(Note: For modeling purposes, *Castoro II* was selected as a surrogate for vessels that might be used in the flowline and pipeline construction at *Neptune*)

Figure 1-6 Received Sound Levels at 50-meter Depth of Pipelaying by *Castoro II* Spread along Flowline Between North and South Buoys in Spring



Source: LGL Limited 2005.

(Note: For modeling purposes, *Castoro II* was selected as a surrogate for vessels that might be used in the flowline and pipeline construction at *Neptune*)

Figure 1-7 Received Sound Levels at 50-meter Depth of Pipelaying by *Castoro II* Spread along Northern Route Pipeline in Spring

2.0 The Dates and Duration of Such Activity and the Specific Geographic Region Where It Will Occur

2.1 Operation Start Dates and Duration

Operation of the deepwater port is expected to begin in late spring 2010 following the completion of construction and port commissioning which is expected to take place February through April 2010. The first built SRV, the *GDF SUEZ NEPTUNE*, will be commissioned in this period and the second vessel, the *GDF SUEZ CAPE ANN*, is anticipated to be commissioned in October 2010. The port is expected to operate over the next 25 years.

2.2 Specific Geographic Region

The *Neptune* port will be located in Massachusetts Bay within OCS blocks NK 19-04 6525 and NK 19-04 6575, at approximately 42º28’09” North Latitude and 70º36’22” West Longitude. The gas transmission pipeline will begin at the existing HubLine^{SM} pipeline approximately 3 miles east of Marblehead Neck, Massachusetts. From this point, the pipeline will extend toward the northeast crossing the territorial waters of the town of Marblehead, the city of Salem, the city of Beverly, and the town of Manchester-by-the-Sea for approximately 6.4 miles. The transmission line route will continue to the southeast for approximately 4.5 miles crossing state and federal waters. The locations of *Neptune* and the associated pipeline are shown on Figure 2-1.

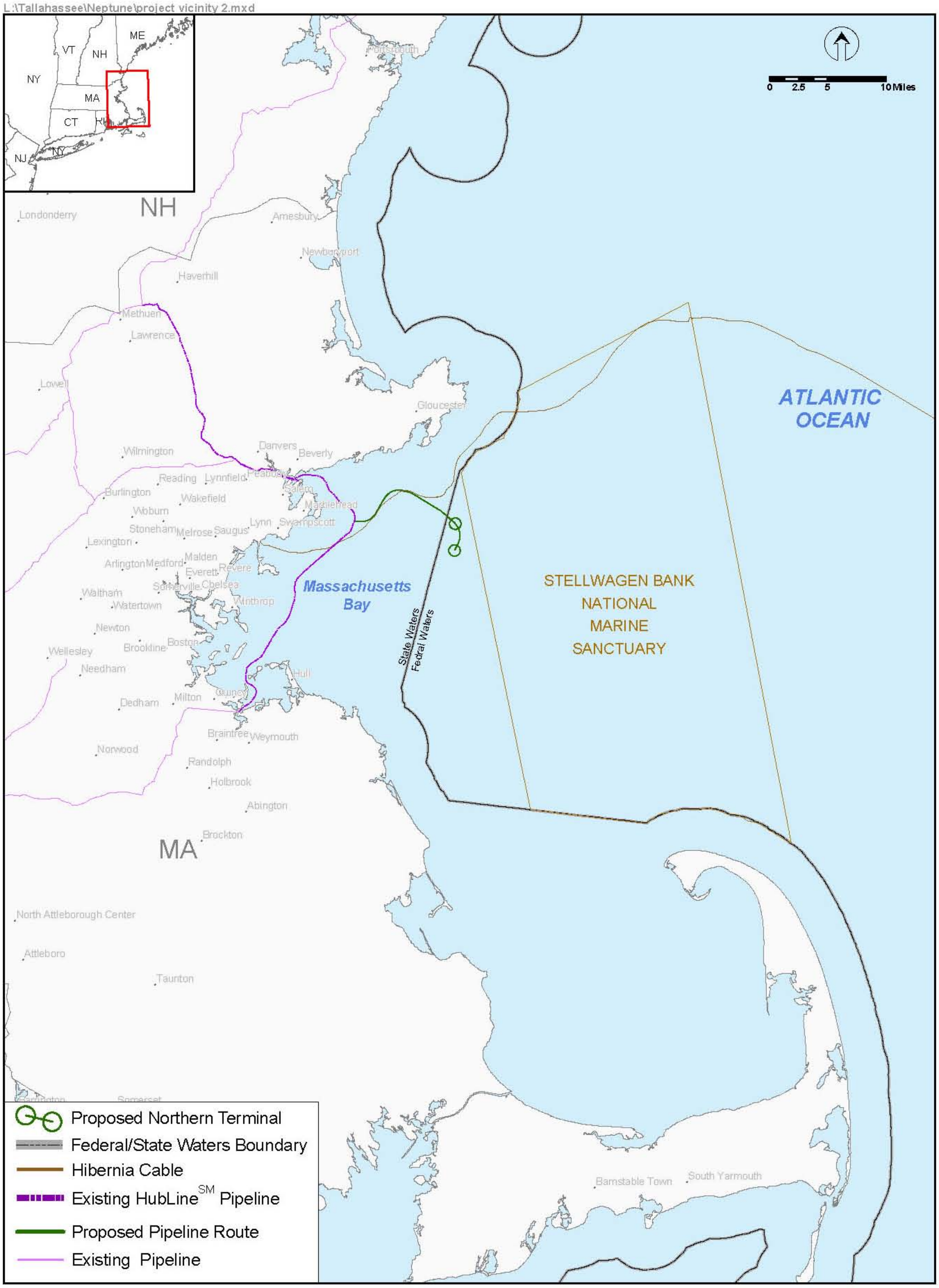


Figure 2-1 *Neptune* Port and Pipeline Route

3.0 Species and Numbers of Marine Mammals in Area

Table 3-1 lists the species of marine mammals likely to be seen in the *Neptune* Project area. Sections 3.2.3 and 3.2.5 of the FEIS/EIR discuss marine mammals both protected under the MMPA and listed as threatened and endangered under the Endangered Species Act (ESA).

Table 3-1 Mammals Occurring in Massachusetts Bay

Common Name	Scientific Name	Likelihood of Occurrence	Federal ESA Status	Time of Year in Massachusetts Bay
Baleen Whales (Mysticetes)				
North Atlantic right whale	*Eubalaena glacialis*	Common	Endangered	Year round (Jan-Jul peak)
Blue whale	*Balaenoptera musculus*	Rare	Endangered	Aug-Oct
Fin whale	*Balaenoptera physalus*	Common	Endangered	April-Oct
Sei whale	*Balaenoptera borealis*	Rare	Endangered	May-Jun
Minke whale	*Balaenoptera acutorostrata*	Common	--	April-Oct
Humpback whale	*Megaptera novaeangliae*	Common	Endangered	April-Oct
Toothed Whales (Odontocetes)				
Killer (orca) whale	*Orcinus orca*	Occasional	--	July-Sep
Long-finned pilot whale	*Globicephala melas*	Occasional	--	Year round (Sept-April peak)
Sperm whale	*Physeter macrocephalus*	Occasional	Endangered	Pelagic
Atlantic white-beaked dolphin	*Lagenorhynchus albirostris*	Occasional	--	April-Nov
Atlantic white-sided dolphin	*Lagenorhynchus acutus*	Common	--	Year round
Bottlenose dolphin	*Tursiops truncates*	Occasional	--	Late summer, early fall
Common dolphin	*Delphinus delphinium*	Occasional	--	
Harbor porpoise	*Phocoena phocoena*	Common	--	Year round (Sept-April peak)
Risso's dolphin	*Grampus griseus*	Rare	--	Spring, summer, autumn
Striped dolphin	*Stenella coeruleoalba*	Occasional	--	Year round
Earless of True Seals (Pinnipeds)				
Gray seal	*Halichoerus grypus*	Common	--	Year round
Harbor seal	*Phoca vitulina*	Common	--	Late Sept-early May
Harp seal	*Pagophilus groenlandica*	Occasional	--	Jan-March
Hooded seal	*Cystophora cristata*	Occasional	--	Jan-March

Note: The short-finned pilot whale (G. macrorhynchus), which is difficult to distinguish from the long-finned species at sea, has also been reported from Massachusetts (Cardoza, Jones, and French 1999); however, this species is predominantly a tropical species, with the northernmost limit of its range in the North Atlantic at Cape Hatteras (Leatherwood and Reeves 1983), and is very unlikely to be seen in the Massachusetts Bay area.
Source: USCG 2006 and LGL Limited 2005.

4.0 Status, Distribution, and Seasonal Distribution of Affected Species or Stocks of Marine Mammals

Sixteen (16) species of cetaceans, including dolphins, small and large toothed whales, and baleen whales may occur in the Massachusetts Bay area; 16 occur either regularly or occasionally and three rarely occur (Table 3-1). Some of these species – the North Atlantic right whale, humpback whale, blue whale, fin whale, and sei whale – are listed under the ESA as endangered. Note that the North Atlantic coastal stock of bottlenose dolphins (*Tursiops truncates*) is listed under the MMPA as "depleted." Because of its endangered listing under the ESA, the sperm whale (*Physeter macrocephalus*) is also included in Table 3-1, although it is one of the species rarely seen in Massachusetts Bay. The sperm whale is generally a deepwater animal, and its distribution off the northeastern U.S. is concentrated around the 13,280-foot-depth contour, with sightings extending offshore beyond the 6,560-foot-depth contour. Sperm whales can also be seen in shallow water south of Cape Cod from May to November (Cetacean and Turtle Assessment Program 1982).

In addition to the 16 cetacean species listed in Table 3-1, ten other cetacean species have been recorded for Massachusetts as rare vagrants or from strandings (Cardoza, Jones, and French 1999). The following six species of beaked whale are all pelagic and recorded mostly as strandings: the northern bottlenose whale (*Hyperoodon ampullatus*), Cuvier's beaked whale (Ziphius *cavirostris*), Sowerby's beaked whale (*Mesoplodon bidens*), Blainville's beaked whale (*M. densirostris*), Gervais' beaked whale (*M. europaeus*), and True's beaked whale (*M. mirus*). Vagrants include the beluga whale (*Delphinapterus leucas*), a northern species with rare vagrants reported as far south as Long Island (Katona, Rough, and Richardson 1993); the pantropical spotted dolphin (*Stenella attenuata*) and false killer whale (*Pseudorca crassidens*), which are primarily tropical species with rare sightings in Massachusetts waters (Cardoza, Jones, and French 1999); and the pygmy sperm whale (*Kogia breviceps*), which is generally an offshore species that occasionally wanders inshore. These vagrant species are not considered further in this application.

Four species of pinnipeds occur in the Massachusetts Bay area (Table 3-1). None of these species are listed under the ESA. Harbor seals (*Phoca vitulina*) and gray seals (*Halichoerus grypus*) can be found year-round in northeastern U.S. waters, while harp seals (*Pagophilus groenlandica*) and hooded seals (*Cystophora cristata*) are seasonal visitors from much farther north, seen mostly in the winter and early spring. Prior to 1990, harp and hooded seals were sighted only very occasionally in the Gulf of Maine, but recent sightings suggest increasing numbers of these species now visit these waters (Harris *et al.* 2001; Harris, Lelli, and Jakush 2002). Juveniles of a third Arctic seal species, the ringed seal (*Pusa hispida*), are seen on occasion as far south as Cape Cod in the winter, but this species is considered to be quite rare in these waters (Provincetown Center for Coastal Studies 2005) and is not considered further in this application.

The marine mammal species for which the Applicant is seeking a five-year harassment authorization under this application for operational/maintenance/repair-related effects are:

- North Atlantic right whale;
- Humpback whale;
- Fin whale;
- Sei whale;
- Minke whale;
- Long-finned pilot whale;
- Atlantic white-sided dolphin;
- Harbor porpoise;
- Common dolphin;
- Risso's dolphin;
- Bottlenose dolphin; and
- Harbor seal.
-

The status, distribution, and seasonal distribution of the above-listed species for which the Neptune LNG is seeking a one-year harassment authorization for July 2010 to July 2011 and a five-year harassment authorization for July 2011 to July 2016 under this application for operational/

maintenance/repair-related effects are discussed below. Additional details can be found in Sections 3.2.3 and 3.2.5 of the FEIS/EIR.

North Atlantic Right Whale (Eubalaena glacialis)

Right whales are the most endangered of the large whale species and have been federally listed under the ESA since 1970. The western North Atlantic right whale population ranges from winter calving grounds in coastal waters of the southeastern United States to spring and summer feeding and nursery grounds in the northeastern United States and Canada (Waring *et al.* 2005). Right whales are found in mid-Atlantic waters as a migratory population. Right whales are typically found in coastal or shelf waters, but are also known to occur over abyssal depths (National Marine Fisheries Service [NMFS] 2005).

During much of the year, North Atlantic right whale distribution strongly correlates to the distribution of their primary prey, calanoid copepods. These dense zooplankton patches are a primary characteristic of spring, summer, and fall right whale habitats (Waring *et al.* 2005). Right whales then move into the Great South Channel region east of Cape Cod to feed during the late spring and early summer. They then move east along the northern edge of Georges Bank, and into the Bay of Fundy and Nova Scotian shelf during the rest of summer and into the fall (Weinrich, Tackaberry, and Sardi 2006). In winter, pregnant females migrate to the coastal waters of the southeastern U.S. to calve, while the distribution of much of the rest of populations remains unknown (NMFS 2005). Recent research suggests that Jeffreys Ledge, immediately to the north of Cape Ann, Massachusetts, may serve as a feeding habitat from October through at least December (Weinrich and Sardi 2004, Weinrich, Tackaberry, and Sardi 2006).

In addition to being a primary feeding habitat for right whales, New England waters also serve as a mating area for adults and nursery ground for calves. Right whales occur off New England at various times throughout the year, and right whales have been sighted off Massachusetts in most months (Waring *et al.* 2005). Some individuals have been observed feeding opportunistically in Cape Cod Bay in all months of the year, but many individuals abruptly depart the area in late April for the Great South Channel. Right whale arrival and departure from the Great South Channel region varies from year to year, but data suggest that most right whales arrive in the region in April, peak in May, and depart at some point in June or July. Although virtually no sighting data exist, right whales may also be present in the study area during the late fall and winter months.

Humpback Whale

Humpback whales have been federally listed as endangered since 1970, but no critical habitat has been designated for them. The western North Atlantic humpback whale population feeds during the spring, summer, and fall over a range that encompasses the eastern coast of the United States, the Gulf of St. Lawrence, Newfoundland/Labrador, and western Greenland. In winter, many humpback whales migrate to the West Indies to mate and calve, but significant numbers of individuals remain in the mid and high latitudes during this time. In early March, humpback whales arrive in Massachusetts Bay from calving and mating grounds in the Caribbean. Stellwagen Bank serves as a primary feeding area, as well as an important nursery area for mothers with calves. Humpback whales are commonly found feeding in the shallow waters directly over Stellwagen Bank, but may also frequent the deeper waters of Stellwagen Basin to the north and west of the Bank. Humpback whales typically remain in this area until mid-November, when they begin their migration south to breed in warmer waters (NOAA 1993). Humpback whales could be present in some numbers in Massachusetts Bay between November and December, but are not likely to be present in January through March.

Fin Whale (Balaenoptera physalus)

The fin (or finback) whale has been federally listed as endangered under the ESA since 1970, but no critical habitat has been designated for the fin whale. Fin whales are most commonly found in U.S. Atlantic Exclusive Economic Zone waters, principally from Cape Hatteras northward. Their preferred habitat is over deeper waters of the continental shelf (91 to 183 m [300 to 600 ft]), although they are regularly observed anywhere from coastal to abyssal areas (Waring *et al.* 2005). New England waters represent a major feeding ground for fin whales, and fin whales are present off New England throughout the year, but with decreased abundance in the winter (Cetacean and Turtle Assessment Program [CeTAP] 1982). Fin whales are frequently sighted in Massachusetts and Cape Cod Bays, and they occur year-round in the Stellwagen Bank area (NOAA 1993). Some fin whales over-winter in Cape Cod Bay (McLeod 2002), but mating, calving, and wintering locations for most of the population are unknown. Limited data suggest that calving takes place in the U.S. mid-Atlantic region between October and January (Waring *et al.* 2005).

Sei Whale (Balaenoptera borealis)

Sei whales occurring in the Atlantic waters of the United States are typically concentrated in the northern waters during the feeding season. During the spring and summer months, their range extends further south, including the northern portions of the U.S. Exclusive Economic Zone, the Gulf of Maine, and Georges Bank. Sei whales are generally sighted offshore, but they are known to occasionally follow prey species inshore (Waring *et al.* 2005). Sei whales were first positively observed feeding in the vicinity of Stellwagen Bank in 1986. The number of sei whales recorded since then has been relatively low (NOAA 1993). There are no recent population estimates for sei whales in the North Atlantic (Waring *et al.* 2005). They have been federally listed since 1970, but do not have any designated critical habitat.

Minke Whale (Balaenoptera acutorostrata)

Minke whales are typically seen in the Stellwagen Bank area during spring, summer, and fall. During the winter, minke whale sightings in New England decline dramatically (Waring *et al.* 1999), but some minke whales might overwinter in these areas (CeTAP 1982, Pett and McKay 1990, McLeod 2002).

Long-Finned Pilot Whale (Globicephala melaena)

Long-finned pilot whales are sighted occasionally in the Gulf of Maine between May and December, typically along the shelf edge.

Atlantic White-Sided Dolphin (Lagenorhynchus acutus)

Atlantic white-sided dolphins are common in Stellwagen Bank and Cape Cod Bay in spring, but occurrences are less common in fall.

Harbor Porpoise (Phocoena phocoena)

Harbor porpoises occur in Stellwagen Bank and Cape Cod Bay from December through June.

Common Dolphin (Delphinus delphis)

Common dolphins are seen occasionally in the Gulf of Maine during fall and winter.

Risso's Dolphin (Grampus griseus)

Risso's dolphins are generally considered absent from the Gulf of Maine, although several individuals have been recorded in the past (NOAA 1993).

Bottlenose Dolphin (Tursiops truncates)

Bottlenose dolphins are occasionally seen in the Gulf of Maine during late summer and fall.

Harbor Sea (Phoca vitulina)

Harbor seals are most frequently sighted in the Stellwagen Bank and Cape Cod areas during winter and early spring, although some harbor seal sightings have been recorded in late September (McLeod 2002).

5.0 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 Take

A third IHA and a five-year LOA are sought for the commissioning of the second SRV and the operational phase of the *Neptune* port beginning July 1, 2010 (at the expiration of the second IHA obtained for construction/port commissioning). The LOA would be effective July 1, 2011. The only type of incidental taking sought by Neptune LNG LLC in this application for commissioning/operational/maintenance/repair effects is for takes by Level B harassment. During operations of the port, the only sound that will exceed the 120-dB threshold is associated with the thruster sound during maneuvering of the SRVs while docking and undocking, occasional weathervaning at the port, and during thruster use of DP maintenance vessels should a major repair be necessary. The loudest source of underwater sound during operation of *Neptune* will be the use of thrusters for dynamic positioning (see Sections 1.2 and 1.3 of this application).

6.0 Numbers of Marine Mammals That May Potentially Be Taken

Neptune LNG LLC seeks authorization for potential "taking" of small numbers of marine mammals under the jurisdiction of the National Marine Fisheries Service in the region of activity. Species for which authorization is sought during operation of the port include 12 of the 20 species identified in Section 4.0 that have the highest likelihood of occurring, at least occasionally, in the project area during all seasons.

The only anticipated impact to marine mammals during operations would be the short-term displacement of marine mammals from areas ensonified by sound generated by equipment operation and vessel movement (thruster use). The operational/maintenance/repair activities proposed by the Applicant are not expected to "take" more than small numbers of marine mammals or have more than a negligible effect on their populations based on their seasonal density and distribution and their known reactions to exposure to such underwater sound sources.

The information contained in this section relies heavily on assessments completed by LGL Limited (2005 and 2006) and JASCO Research Limited (2006) of the effects of underwater sound generated by the proposed project on marine mammals (see Appendices B and C.1, respectively), the Samsung study (Appendix C.2), the JASCO evaluation of the Samsung study (Appendix C.3), and the LGL reassessment of takes based on these noise studies (Appendix C.4).

The National Marine Fisheries Service recognizes three kinds of sound: continuous, intermittent (or transient), and pulsive. *Neptune* will not cause pulsive noise activities. Rather, the sound sources of potential concern will be continuous and intermittent sound sources, including underwater sound generated by regasification/offloading (continuous) and dynamic positioning of vessels (SRVs and large repair vessels) using thrusters (intermittent). Both continuous and intermittent sound sources are subject to the National Marine Fisheries Service's 120 dB re 1µPa threshold for determining levels of underwater sound that may result in the disturbance of marine mammals.

6.1 Port Operation Underwater Noise Effects

The results of the modeled underwater analysis (LGL Limited 2005, JASCO Research Limited 2006, JASCO Applied Sciences 2009, and Samsung 2009) for the operation of *Neptune* are summarized as follows:

- ***SRV Maneuvering at the Port.*** When an SRV arrives at *Neptune*, it will use its thrusters intermittently for up to two hours to position the vessel to connect to the unloading buoy and up to one hour during the undocking procedure. This will occur at alternate unloading buoys every four to eight days because only one unloading buoy will be occupied at a time, with a small overlap at changeover. It is assumed that the thrusters will be used on 50 SRV cargos per year and that the average period of use will be three hours per cargo, thus the total period of use of thrusters for maneuvering at the port will be 150 hours. The results of underwater acoustic modeling show that the average area ensonified by sound levels 120 dB and greater will range from 1.8 to 33.6 square nautical miles (NM) and extend out to 0.75 to 3.27 NM from the source. The sound from the thrusters will be intermittent during the periods that they are used and they will always be used at, or close to, one of the port's two unloading buoys.

  The underwater acoustic modeling shows that with intermittent use of the two aft thrusters during certain wind and tidal conditions, the average area ensonified by sound levels 120 dB and greater will range from 0.8 to 14.1 square NM and extend out to 0.05 to 2.12 NM from the source. The measured two-thruster source data are comparable to the modeled two-thruster data and show the area ensonified by sound levels 120 dB and greater will range from 2.2 square NM to 14.0 square NM, depending on water depth. This will occur no more than 200 hours per year based on anticipated metocean conditions in Massachusetts Bay.
- ***Regasification.*** The SRV will operate on-board equipment to regasify its LNG cargo while fixed to the unloading buoy. The results of underwater sound modeling show that received sound levels for regasification will not exceed 110 dB to any significant distance. In fact, the source level modeled may be higher than might be expected at 1 meter in the water because the measurements were taken in air and do not take into consideration sound dampening by the hull of the vessel.

6.2 Major Repair-Related Underwater Sound Effects

The results of the modeled underwater analysis (LGL Limited 2005 and JASCO Research Limited 2006) for *Neptune*'s construction vessels were used for this scenario and are summarized as follows:

- ***Pipe Repair Activities.*** Pipe repair activities will generate continuous but transient sound and will likely result in variable sound levels during the repair period (estimated to be one to four weeks). Modeling conducted by JASCO

> Research Limited indicates that, depending on water depth, the 120-dB contour during pipe repair activities will extend from the source (the port) in varying directions from 3.8 to 5.9 NM encompassing an area ranging from 37 to 47 square NM for the flowline at the port and will extend from the pipeline route out 3.5 to 4.1 NM encompassing an area from 35 to 44 square NM for the pipeline route. This worst-case scenario is anticipated to occur no more than once per five-year period, lasting no more than 28 days or 672 hours.

The basis for the "take" estimate is the number of marine mammals that potentially will be exposed to sound levels in excess of 120 dB. Typically, this is determined by applying the modeled zone of influence (e.g., the area ensonified by the 120-dB contour) to the seasonal use (density) of the area by marine mammals and correcting for seasonal duration of sound-generating activities and estimated duration of individual activities when the maximum sound-generating activities are intermittent to occasional. Nearly all the required information is readily available in the FEIS/EIR with the exception of marine mammal density estimates for the project area.

In their assessment of the biological sound effects of *Neptune* construction and operation, LGL Limited (2005 and 2006) evaluated the marine mammal density data available from two sources:

- ***Cetacean and Turtle Assessment Program*** (1982). A series of dedicated surveys of marine mammals and turtles in the Mid- and North Atlantic regions of the U.S. (which included the Gulf of Maine and Massachusetts Bay) conducted between 1978 and 1982; and
- ***U.S. Navy's*** **Marine Resources Assessment** ***(MRA) for the Northeast Operating Areas*** (Department of the Navy 2005). In this assessment the U.S. Navy used data from National Marine Fisheries Service shipboard and aerial line-transect surveys (1991 to 2003) and from other rigorously collected line-transect surveys found in the North Atlantic Right Whale Consortium database to calculate seasonal sightings per unit effort (SPUE) values for marine mammals in northeastern U.S. waters (Figure 6-1). In addition, the U.S. Navy applied geospatial and statistical interpolation to predict SPUE values at unsampled locations and provide a model of marine mammal occurrence for the entire MRA area.

The results and methodologies used by both surveys are discussed in detail in Appendix B to this application.

Using the results from the U.S. Navy's (2005) geospatial analysis model, LGL Limited developed average density-indices for marine mammals known to occur in the *Neptune* area. The LGL Limited analysis assumed that the Navy's adopted method of converting linear density-indices into areal density estimates was reasonable and assumed that the highest numbers of marine mammals in the density-index ranges would be present during *Neptune* operations.

Table 6-1 shows estimated densities for Massachusetts Bay. LGL Limited cautions, however, that the linear data identified by the Department of the Navy in its MRA (2005) provide an index of abundance based on all the usable available data. To convert the linear data into densities for the purpose of assessing the underwater sound effects of the operation of *Neptune*, it was assumed that the effective survey width was a 0.5-kilometer (500-meter) strip on each side of the survey vehicle. Thus, each linear kilometer of survey would encompass an area of 1 square kilometer. This, of course, is a gross oversimplification of reality. For most whale species, individuals are sighted well beyond the assumed distance of 0.5 kilometer on each side of the trackline. Thus, the adopted approach overestimates the actual numbers of animals per square kilometer because the linear estimates actually include animals beyond the 0.5-kilometer strip width. On the other hand, all surveys fail to detect a portion of the animals that are actually present on the surface or underwater. Therefore, the approach adopted here accounts for an unknown fraction of the missed animals. Because these biases cannot be quantified, it is important to treat the following numerical assessments as approximations.

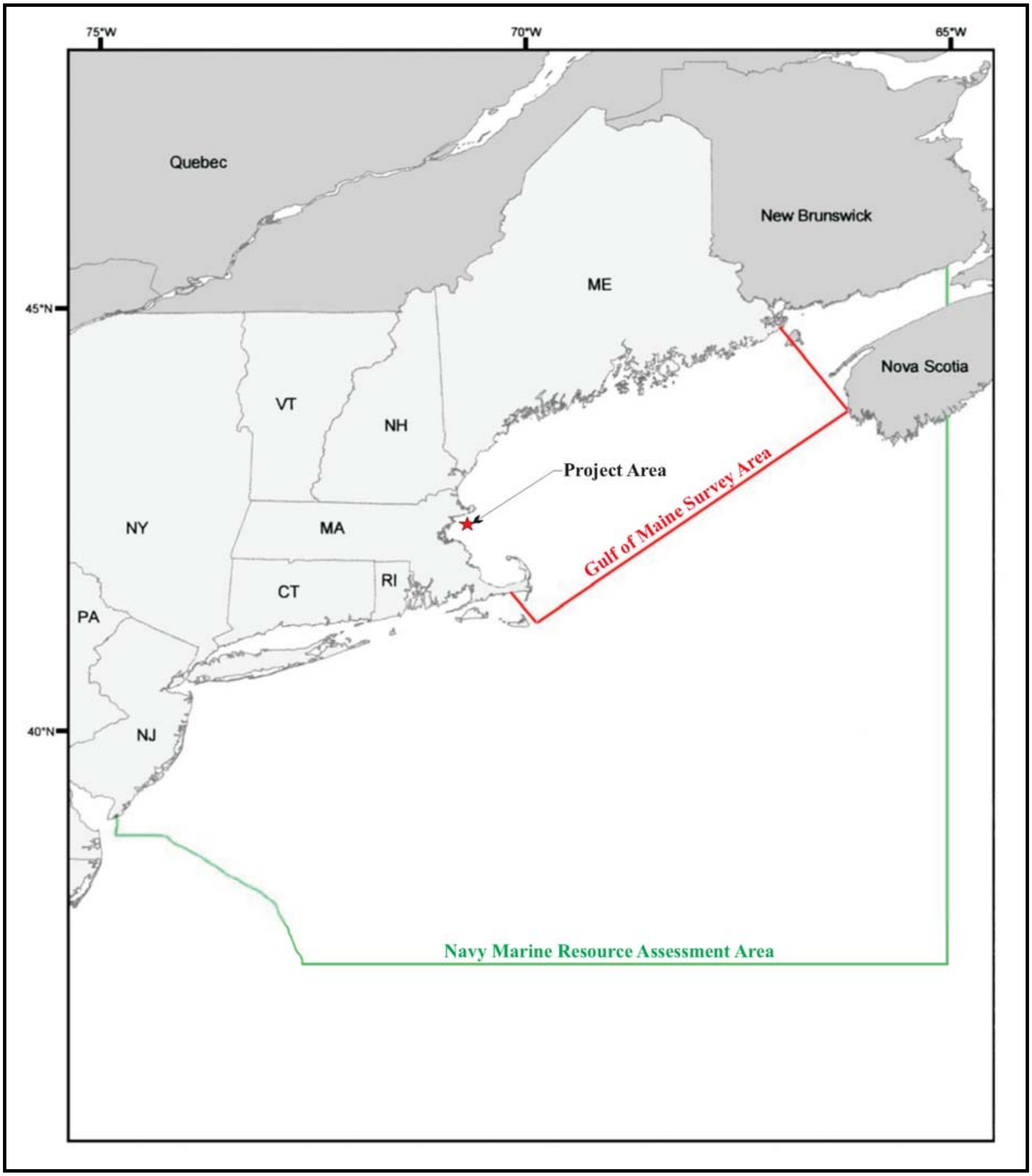


Figure 6-1 Navy Marine Resources Assessment Area

Table 6-1 Estimated Marine Mammal Densities for Massachusetts Bay and the Numbers of Marine Mammals of Potential Risk of Harassment "Take" by *Neptune*

Species	Season	Estimated Density per 1,000 sq km	Estimated Take and Requested Authorization		
			Docking/Undocking	Weathervaning	Major Maintenance/ Repair Activities
North Atlantic right whale	All Seasons	0.01-21.14	2	2	3
Humpback whale	Winter/Spring Summer/Fall	0.00-13.85 13.85-27.72	3	3	4
Blue whale[1]	--	--	--	--	--
Fin whale	Fall/Winter Spring/Summer	0.00-16.45 0.00-32.89	2	2	3
Sei whale (not Winter)	Fall Winter/Spring/Summer	0.00-17.27 --	2	2	3
Minke whale	All Seasons	0.00-4.66	1	1	1
Sperm whale	--	--	--	--	--
Killer whale	--	--	--	--	--
Long-finned pilot whale	All Seasons	0.01-271.42	31	30	41
Atlantic white-sided dolphin[2]	All Seasons	0.00-265.21	31	30	40
Atlantic white-beaked dolphin	--	--	--	--	--
Harbor porpoise[2]	All Seasons	0.00-162.36	19	18	25
Risso's dolphin[2]	Fall Only	0.00-503.06	58	57	76
Common dolphin[2]	Fall Only	0.00-464.07	53	52	70
Striped dolphin	--	--	--	--	--
Bottlenose dolphin[2]	Fall Only	0.03-278.81	32	32	42
Gray seal	--	--	--	--	--
Harp seal	--	--	--	--	--
Hooded seal	--	--	--	--	--
Harbor seal	Winter only	--	8	7	10

Key: sq km = square kilometers.
Note:
1. Blue whale sightings are rare and densities not estimated.
2. Dolphin distribution is generally patchy with a few large pods being present rather than an even distribution.

Source: LGL Limited 2009.

7.0 The Anticipated Impact of the Activity on the Species or Stock

During the operational life of the project, marine mammals will be exposed to intermittent sound from the use of thrusters positioning the carriers at the unloading buoys and the sounds associated with the regasification process. Under certain wind and tidal conditions, the two aft thrusters will be intermittently operated to maintain the heading of the vessel into the wind when competing tides operate to push the vessel broadside to the wind. These activities will occur at each of the two fixed-location unloading buoys. The sound from the regasification process is low and does not reach the National Marine Fisheries Service's 120 dB re 1µPa disturbance criterion for continuous sound. However, the brief bursts (up to two hours for docking and up to one hour for undocking) of sound associated with use of four thrusters to position the ships would have the potential to disturb marine mammals near the port. This thruster sound could affect a maximum of about 10 baleen whales, 224 toothed whales, and eight pinnipeds. The use of two thrusters during certain weather conditions (assumed up to 200 hours per year) would affect about 10 baleen whales, 219 toothed whales, and seven pinnipeds. The underwater sound generated by use of the thrusters during maneuvering or under certain wind and tidal conditions would not result in any important effects to individuals or constitute population-level harassment threat to local marine mammal stocks for the following reasons:

- Short duration and infrequency of the use of thrusters (up to two hours for docking and up to one hour for undocking) each episode for maneuvering, or intermittently to maintain heading during certain weather conditions);
- Relatively small but unknown amount of exposure;
- Fixed location of the sound sources; and
- Biological considerations, including the very small numbers of baleen whales involved, the patchy distribution of toothed whales in the area, and the observed ability of harbor seals to habituate to human activities including sound.

Major repair activities may occur over a period of one to four weeks with sound from DP pipe repair vessels causing some possible disturbance to small numbers of baleen whales (14), toothed whales (294), and pinnipeds (10). Because the duration and frequency of repairs cannot be accurately estimated, and will be relatively short in duration, the amount of disturbance to marine mammals should be minimal.

7.1 Effects of Anthropogenic Noise on Marine Mammals

Marine mammals rely heavily on the use of underwater sounds to communicate and gain information about their environment. The reactions of marine mammals to noise can be variable and depend on the species involved, time of year, and the activity of the animal at the time of exposure to noise. Because underwater noise sometimes propagates for long distances, the radius of audibility can be large for a strong noise. However, marine mammals usually do not respond overtly to audible, but weak, manmade sounds (Richardson *et al.* 1995). Thus, the zone of "responsiveness" is usually much smaller than the zone of audibility. Potential effects of noise on marine mammals include masking, disturbance (behavioral), hearing impairment (temporary threshold shift [TTS] and permanent threshold shift [PTS]), and non-auditory physiological effects.

7.1.1 Masking

Masking is the obscuring of sounds of interest by other sounds, often at similar frequencies. Marine mammals are highly dependent on sound, and their ability to recognize sound signals amid noise is important in communication, predator and prey detection, and, in the case of toothed whales, echolocation. Even in the absence of manmade sounds, the sea is usually noisy. Background ambient noise often interferes with or masks the ability of an animal to detect a sound signal even when that signal is above its absolute hearing threshold. Natural ambient noise includes contributions from wind, waves, precipitation, other animals, and (at frequencies above 30 kiloHertz [kHz]) thermal noise resulting from molecular agitation (Richardson *et al.* 1995). Background noise also can include sounds from distant human activities such as shipping and oil exploration and production. Masking of natural sounds can result when human activities produce high levels of background noise. Conversely, if the background level of underwater noise is high (e.g., on a day with strong wind and high waves), an anthropogenic noise source will not be detectable as far away as would be possible under quieter conditions and will itself be masked. Ambient noise is highly variable on continental shelves (e.g., Thompson 1965; Myrberg 1978; Chapman, Desharnais and Heard 1998; Desharnais *et al.* 1999). This inevitably results in a high degree of variability in the range at which marine mammals can detect anthropogenic sounds.

Although masking is a natural phenomenon to which marine mammals must adapt, introduction of strong sounds into the sea at frequencies important to marine mammals inevitably increases the severity and frequency of occurrence of masking. For example, if a baleen whale is exposed to continuous low-frequency noise from an industrial source, this will reduce the size of the area around that whale within which it can hear the calls of another whale. In general, little is known about the importance to marine mammals of detecting sounds from conspecifics, predators, prey, or other natural sources. In the absence of much information about the importance of detecting these natural sounds, it is not possible to predict the impacts if mammals are unable to hear these sounds as often, or from as far away, because of masking by industrial noise (Richardson *et al.* 1995). In general, masking effects are expected to be less severe when sounds are transient than when they are continuous.

Although some degree of masking is inevitable when high levels of manmade broadband sounds are introduced into the sea, marine mammals have evolved systems and behavior that function to reduce the impacts of masking. Structured signals, such as the echolocation click sequences of small toothed whales, may be readily detected even in the presence of strong background noise because their frequency content and temporal features usually differ strongly from those of the background noise (Au and Moore 1988 and 1990). The components of background noise that are similar in frequency to the sound signal in question primarily determine the degree of masking of that signal. Low-frequency industrial noise, such as shipping, has little or no masking effect on high-frequency echolocation sounds. Redundancy and context can also facilitate detection of weak signals. These phenomena may help marine mammals detect weak sounds in the presence of natural or manmade noise. Most masking studies in marine mammals present the test signal and the masking noise from the same direction. The sound localization abilities of marine mammals suggest that, if signal and noise come from different directions, masking would not be as severe as the usual types of masking studies might suggest (Richardson *et al.* 1995). The dominant background noise may be highly directional if it comes from a particular anthropogenic source such as a ship or industrial site. Directional hearing may significantly reduce the masking effects of these noises by improving the effective signal-to-noise ratio. In the cases of high-frequency hearing by the bottlenose dolphin, beluga whale, and killer whale (*Orcinus orca*), empirical evidence confirms that masking depends strongly on the relative directions of arrival of sound signals and the masking noise (Penner, Turl, and Au 1986; Dubrovskiy 1990; Bain, Kriete, and Dahlheim 1993; Bain and Dahlheim 1994). Toothed whales, and probably other marine mammals as well, have additional capabilities besides directional hearing that can facilitate detection of sounds in the presence of background noise. There is evidence that some toothed whales can shift the dominant frequencies of their echolocation signals from a frequency range with a lot of ambient noise toward frequencies with less noise (Au *et al.* 1974, 1985; Moore and Pawloski 1990; Thomas and Turl 1990; Romanenko and Kitain 1992; Lesage *et al.* 1999). A few marine mammal species are known to increase the source levels of their calls in the presence of elevated sound levels (Dahlheim 1987; Au 1993; Lesage *et al.* 1999; Terhune 1999).

These data demonstrating adaptations for reduced masking pertain mainly to the very high-frequency echolocation signals of toothed whales. There is less information about the existence of corresponding mechanisms at moderate or low frequencies, or in other types of marine mammals. For example, Zaitseva, Morozov, and Akopian (1980) found that, for the bottlenose dolphin, the angular separation between a sound source and a masking noise source had little effect on the degree of masking when the sound frequency was 18 kHz, in contrast to the pronounced effect at higher frequencies. Directional hearing has been demonstrated at frequencies as low as 0.5 to 2 kHz in several marine mammals, including killer whales (Richardson *et al.* 1995). This ability may be useful in reducing masking at these frequencies. In summary, high levels of noise generated by anthropogenic activities may act to mask the detection of weaker biologically important sounds by some marine mammals. This masking may be more prominent for lower frequencies. For higher frequencies, such as used in echolocation by toothed whales, several mechanisms are available that may allow them to reduce the effects of such masking.

7.1.2 Disturbance

Disturbance can induce a variety of effects, such as subtle changes in behavior, more conspicuous dramatic changes in activities, and displacement. Disturbance is one of the main concerns of the potential impacts of manmade noise on marine mammals. For many species and situations, there is no detailed information about reactions to noise. Behavioral reactions of marine mammals to sound are difficult to predict because they are dependent on numerous factors including species, state of maturity, experience, current activity, reproductive state, time of day, and weather state. If a marine mammal does react to an underwater sound by changing its behavior or moving a small distance, the impacts of that change may not be important to the individual, 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 important. Based on the literature reviewed in Richardson *et al.* (1995), it is apparent that most small and medium-sized toothed whales exposed to prolonged or repeated underwater sounds are unlikely to be displaced unless the overall received level is at least 140 dB re 1 μPa. The limited available data indicate that the sperm whale is sometimes, though not always, more responsive than other toothed whales. Baleen whales probably have better hearing sensitivities at lower sound frequencies, and in several studies have been shown to react at received sound levels of approximately 120 dB re 1 μPa. Toothed whales appear to exhibit a greater variety of reactions to manmade underwater noise than do baleen whales. Toothed whale reactions can vary from approaching vessels (e.g., to bow ride) to strong avoidance, while baleen whale reactions range from neutral (little or no change in behavior) to strong avoidance. In general, pinnipeds seem more tolerant of, or at least habituate more quickly to, potentially disturbing underwater noise than do whales.

7.1.3 Hearing Impairment

Temporary or permanent hearing impairment is a possibility when marine mammals are exposed to very strong sounds. 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 temporary hearing loss or 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. Current NOAA

Fisheries Service 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). *(Note: rms = root mean square, a mathematical/statistical method for measuring something that varies. Typically rms power is contrasted with peak power.)*

7.1.4 Temporary Threshold Shift

TTS is the mildest form of hearing impairment. It is the process whereby exposure to a strong sound results in a non-permanent elevation in hearing threshold making it more difficult to hear sounds (Kryter 1985). TTS can last from minutes or hours to days. The magnitude of the TTS depends on the level and duration of the noise exposure, among other considerations (Richardson *et al.* 1995). For sound exposures at or somewhat above the TTS level, hearing sensitivity recovers rapidly after exposure to the noise ends. TTS commonly occurs in mammals, including humans.

Few data on sound levels and durations necessary to elicit mild TTSs have been obtained for marine mammals, and all of these data are quite recent. TTS studies in humans and terrestrial mammals provide information helpful in understanding general principles of TTS, but it is unclear to what extent these data can be extrapolated to marine mammals.

7.1.5 Permanent Threshold Shift

There are no data on noise levels that might induce permanent hearing impairment in marine mammals. In theory, physical damage to a marine mammal's hearing apparatus could occur immediately if it is exposed to sound impulses that have very high peak pressures, especially if they have very short rise times. Also, very prolonged exposure to a noise strong enough to elicit a TTS, or shorter-term exposure to noise levels well above the TTS level, could cause hearing injury. Such damage can result in a permanent decrease in functional sensitivity of the hearing system at some or all frequencies. Richardson *et al.* (1995) hypothesized that permanent hearing impairment caused by prolonged exposure to continuous manmade noise is not likely to occur in marine mammals for sounds with source levels up to ~200 dB re 1 µPa-m. Single or occasional occurrences of mild TTS do not cause permanent auditory damage in humans or other terrestrial mammals and, presumably, do not do so in marine mammals. Sound impulse duration, peak amplitude, and rise time are the main factors thought to determine the onset and extent of PTS. Based on existing data, Ketten (1995) noted that the criteria for differentiating the sound pressure levels (SPLs) that result in a PTS (or TTS) are location and species specific. PTS effects may also be influenced strongly by the health of the receiver's ear.

For sound exposures at or somewhat above the TTS level, hearing sensitivity recovers rapidly after exposure to the noise ends. At least in terrestrial mammals, the received sound level from a single noise exposure must be far above the TTS level for there to be any risk of PTS (Kryter 1985, 1994; Richardson *et al.* 1995). Relationships between TTS and PTS levels have not been studied in marine mammals, but are assumed to be similar to those in humans and other terrestrial mammals.

7.1.6 Non-Auditory Physiological Effects

Non-auditory physiological effects may also occur in marine mammals exposed to very strong underwater sound. Possible types of non-auditory physiological effects or injuries that, in theory, might occur, include stress, neurological effects, bubble formation, resonance effects, 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 strongly pulsed sounds, particularly at higher frequencies. None of the activities associated with the *Neptune* project will generate sounds loud enough to cause physiological effects.

7.2 Noise Associated with the *Neptune* Project

Underwater sounds produced during the construction and operation of facilities such as the *Neptune* LNG deepwater port can be classified into three broad categories. Sounds of short duration that are produced intermittently or at regular intervals, such as sounds from pile driving, are classified as "pulsed." Sounds produced for extended periods, such as sounds from generators, are classified as "continuous." Sounds from moving sources, such as ships, can be continuous, but for an animal at a given location, these sounds are "transient" (i.e., increasing in level as the ship approaches and then diminishing as it moves away). Studies indicate that marine animals respond somewhat differently to the three categories of noise. In general, baleen whales tend to react to lower received levels of continuous sound than of pulsed sound. Masking effects are expected to be less severe when sounds are pulsed or transient than when they are continuous.

Pulsed sounds are not expected to be produced at the *Neptune* site during operations or major repairs. Little information is available about the effects on marine mammals of the two specific noise sources likely to be produced at the site during operations and major repairs (continuous and transient); therefore, marine mammal reactions to these two broad categories of noise produced by other industrial activities are reviewed below.

7.2.1 Continuous Sounds

Drilling Operations

No drilling activity will be associated with the *Neptune* LNG project. However, because no studies are available on the reactions of marine mammals to sounds produced at an LNG facility, examples of marine mammals' reactions to drilling sounds are presented here as an example of how these animals react to the continuous sounds from a stationary offshore industrial facility.

Baleen Whales. Baleen whales sometimes show behavioral changes in response to received broadband drillship noises of 120 dB or greater. On their summer range in the Beaufort Sea, bowhead whales (*Balaena mysticetus*, a species closely related to the right whale) reacted to drillship noises within 4 to 8 kilometers (km; 2.2 to 4.3 NM) of a drillship at received levels 20 dB above ambient, or about 118 dB (Richardson, Würsig, and Greene 1990). Reactions were stronger at the onset of the sound (Richardson *et al.* 1995). Migrating bowhead whales avoided an area with a radius of 10 to 20 km (5.4 to 10.8 NM) around drillships and their associated support vessels, corresponding to a received noise level around 115 dB (Greene 1987; Koski and Johnson 1987; Hall *et al.* 1994; Davies 1997; Schick and Urban 2000). For gray whales (*Eschrichtius robustus*) off California, the predicted reaction zone around a semi-submersible drill rig was less than 1 km (0.54 NM), at received levels of approximately 120 dB (Malme *et al.* 1983, 1984). Humpback whales (*Megaptera novaeangliae*) showed no obvious avoidance response to broadband drillship noises at a received level of 116 dB (Malme *et al.* 1985).

Toothed Whales. Dolphins and other toothed whales may show considerable tolerance of floating and bottom-founded drillrigs and their support vessels. Kapel (1979) reported many pilot whales (*Globicephala melas*) within visual range of drillships and their support vessels off West Greenland. Beluga whales have been observed swimming within 100 to 150 meters of an artificial island while drilling was underway (Fraker and Fraker 1979, 1981), and within 1,600 meters of the drillship *Explorer I* while the vessel was drilling (Fraker and Fraker 1981). Some belugas in Bristol Bay and the Beaufort Sea, Alaska, when exposed to playbacks of drilling sounds, altered course to swim around the source, increased swimming speed, or reversed direction of travel (Stewart, Evans, and Awbrey 1982; Richardson *et al.* 1995). Reactions of beluga whales to semi-submersible drillship noise were less pronounced than were reactions to motorboats with outboard engines. Captive belugas exposed to playbacks of recorded semi-submersible noise seemed quite tolerant of that sound (Thomas, Kastelein, and Awbrey 1990).

Pinnipeds. Responses of pinnipeds to drilling noise have not been well studied. Richardson *et al.* (1995) summarized the few available studies, which showed ringed seals (*Pusa hispida*) and bearded seals (*Erignathus barbatus*) in the Arctic to be rather tolerant of drilling noise. Seals were often seen near active drillships and approached, to within 50 meters, a sound projector broadcasting low-frequency drilling sound.

Other Continuous Sounds

Toothed Whales. Harbor porpoises (*Phocoena phocoena*) off Vancouver Island, British Columbia, were found to be sensitive to the simulated sound of a 2-megawatt offshore wind turbine (Koschinski *et al.* 2003). The porpoises remained significantly further away from the sound source when it was active, and this effect was seen out to a distance of 60 meters. The device used in that study produced sounds in the frequency range of 30 to 800 Hz, with peak source levels of 128 dB re 1 µPa at 1 m at the 80- and 160-Hz frequencies. TTSs were measured in a single, captive bottlenose dolphin after exposure to a continuous tone with maximum SPLs at frequencies ranging from 4 to 11 kHz that were gradually increased in intensity to 179 dB re 1 µPa and in duration to 55 minutes (Nachtigall, Pawloski, and Au 2003). No threshold shifts were measured at SPLs of 165 or 171 dB re 1 µPa. However, at 179 dB re 1 µPa, TTSs greater than 10 dB were measured during different trials with exposures ranging from 47 to 54 minutes. Hearing sensitivity was apparently recovered within 45 minutes after noise exposure.

Pinnipeds. Reactions of harbor seals (*Phoca vitulina*) to the simulated noise of a 2-megawatt windpower generator were measured by Koschinski *et al.* (2003). Harbor seals surfaced significantly further away from the sound source when it was active and did not approach the sound source as closely. The device used in that study produced sounds in the frequency range of 30 to 800 Hz, with peak source levels of 128 dB re 1 µPa at 1 m at the 80- and 160-Hz frequencies. Kastak *et al.* (1999) reported that they could induce mild TTSs in California sea lions (*Zalophus californianus*), harbor seals, and northern elephant seals (*Mirounga angustirostris*) by exposing them to underwater octave-band noise at frequencies in the 100 to 2,000 Hz range for 20 to 22 minutes. Mild TTSs became evident when the received levels were 60 to 75 dB above the respective hearing thresholds, that is, at received levels of about 135 to 150 dB. Three of the five animals tested showed shifts of approximately 4.6 to 4.9 dB, and all recovered to baseline hearing sensitivity within 24 hours of exposure. Schusterman *et al.* (2000) showed that TTS by these seals occurred at somewhat lower received levels when the animals were exposed to the sound for 40 minutes than for 20 to 22 minutes, confirming that there is a duration effect in pinnipeds. There are some indications that, for corresponding durations of sound, pinnipeds may incur a TTS at a somewhat lower received level than do small odontocetes (Kastak *et al.* 1999; Au 2000).

7.2.2 Transient Sounds

Broadband source levels (at 1 meters) for most small ships where marine mammal reactions have been measured are in the 170 to 180 dB re 1 µPa range, excluding infrasonic components (Richardson *et al.* 1995). Broadband underwater sounds from the offshore supply ship *Robert Lemeur* in the Beaufort Sea were 130 dB at a distance of 0.56 km (0.3 NM) (Greene 1987) and were 11 dB higher when bow thrusters were operating than when they were not (Greene 1985, 1987). The *Robert Lemeur* had nozzles around the thruster propellers. Broadband noise levels from ships lacking nozzles or cowlings around the propellers can be about 10 dB higher than those from ships with the nozzles (Greene 1987).

Baleen Whales. Reactions of baleen whales to boat noises include changes in swimming direction and speed, blow rate, and the frequency and kinds of vocalizations (Richardson *et al.* 1995). Baleen whales, especially minke whales, occasionally approach stationary or slow-moving boats, but more commonly avoid boats. Avoidance is strongest when boats approach directly or when vessel noise changes abruptly (Watkins 1986; Beach and Weinrich 1989). Humpback whales responded to boats at distances of at least 0.5 to 1 km (0.3to 0.54 NM), and avoidance and other reactions have been noted in several areas at distances of several kilometers (Jurasz and Jurasz 1979; Dean *et al.* 1985; Bauer 1986; Bauer and Herman 1986).

During some activities and at some locations, humpbacks exhibit little or no reaction to boats (Watkins 1986). Some baleen whales seem to show habituation to frequent boat traffic. Over 25 years of observations in Cape Cod waters, minke whales' reactions to boats changed from frequent positive interactions to a general lack of interest, while humpback whales reactions changed from being often negative to being often positive and finback whales (*B. physalus*) reactions changed from being mostly negative to being mostly uninterested (Watkins 1986).

Right whales (*Eubalaena glacialis*) also show variable responses to boats. There may be an initial orientation away from a boat, followed by a lack of observable reaction (Atkins and Swartz 1989). A slowly moving boat can approach a right whale, but an abrupt change in course or engine speed will elicit a reaction (Goodyear 1989; Mayo and Marx 1990; Gaskin 1991). When approached by a boat, right whale mothers will interpose themselves between the vessel and calf and will maintain a low profile (Richardson *et al.* 1995). In a long-term study of baleen whale reactions to boats, while other baleen whale species appeared to habituate to boat presence over the 25-year period (see above), right whales continued to show either uninterested or negative reactions to boats with no change over time (Watkins 1986). In a recent study, using a multi-sensor acoustic recording tag and controlled sound exposure experiments, right whales were found to show no response to playbacks of the sound of an approaching 120-meter container ship or to actual vessels (Nowacek, Johnson, and Tyack 2004). The closely related bowhead whale typically begins avoiding diesel-powered boats at distances of approximately 4 km (2.2 NM); the whale often first attempts to "outrun" the vessel, but may turn to swim perpendicular to the boat's track when it approaches within a few hundred meters (Richardson *et al.* 1985; Koski and Johnson 1987). Bowheads may be displaced by a few kilometers when fleeing, although some return to the area within a day.

Toothed Whales. Some species of small toothed cetaceans avoid boats when they are approached to within 0.5 to 1.5 km (0.3 to 0.8 NM), with occasional reports of avoidance at greater distances (Richardson *et al.* 1995). Some toothed whale species appear to be more responsive than others. Beaked whales and beluga whales seem especially responsive to boats. Dolphins may tolerate boats of all sizes, often approaching and riding the bow and stern waves (Shane, Wells, and Wursig 1986). At other times, dolphin species that are known to be attracted to boats will avoid them. Such avoidance is often linked to previous boat-based harassment of the animals (Richardson *et al.* 1995). Coastal bottlenose dolphins that are the object of whale-watching activities have been observed to swim erratically (Acevedo 1991), remain submerged for longer periods of time (Janik and Thompson 1996; Nowacek, Wells, and Solow 2001), display less cohesiveness among group members (Cope, St. Aubin, and Thomas 1999), whistle more frequently (Scarpaci *et al.* 2000), and rest less often (Constantine, Brunton, and Dennis 2004) when boats were nearby. Pantropical spotted dolphins (*Stenella attenuata*) and spinner dolphins (*S. longirostris*) in the eastern Tropical Pacific, where they have been targeted by the tuna fishing industry because of their association with these fish, show avoidance of survey vessels up to 6 NM (Au and Perryman 1982; Hewitt 1985), whereas spinner dolphins in the Gulf of Mexico were observed bowriding the survey vessel in all 14 sightings of this species during one survey (Würsig *et al.* 1998).

Harbor porpoises tend to avoid boats. In the Bay of Fundy, Polacheck and Thorpe (1990) found harbor porpoises to be more likely to be swimming away from the transect line of their survey vessel than swimming toward it and more likely to be heading away from the vessel when they were within 400 meters of it. Similarly, off the west coast of North America, Barlow (1988) observed harbor porpoises avoiding a survey vessel by moving rapidly out of its path within 1 km (0.54 NM) of that vessel. Beluga whales are generally quite responsive to vessels. Belugas in Lancaster Sound in the Canadian Arctic showed dramatic reactions in response to icebreaking ships, with received levels of sound ranging from 101 dB to 136 dB re 1 μPa in the 20 to 1,000-Hz band at a depth of 20 m (Finley *et al.* 1990). Responses included emitting distinctive pulsive calls that were suggestive of excitement or alarm and rapid movement in what seemed to be a flight response. Reactions occurred out to 80 km (43.2 NM) from the ship. Although belugas in the St. Lawrence River occasionally show positive reactions to ecotourism boats by approaching and investigating those boats, one study found the belugas to surface less frequently, swim faster, and group together in the presence of boats (Blane and Jaakson 1994). Another study found belugas to use higher-frequency calls, a greater redundancy in their calls (more calls emitted in a series), and a lower calling rate in the presence of vessels (Lesage *et al.* 1999). The level of response of belugas to vessels is partly a function of habituation. The distant fleeing responses in the High Arctic do not occur in the Beaufort Sea and the Gulf of St. Lawrence where ship traffic is much more frequent and regular.

Most beaked whales tend to avoid approaching vessels (e.g., Würsig *et al.* 1998). They may also dive for an extended period when approached by a vessel (e.g., Kasuya 1986). Northern bottlenose whales (*Hyperoodon ampullatus*), on the other hand, are sometimes quite tolerant of slow-moving vessels (Reeves, Mitchell, and Whitehead 1993; Hooker *et al.* 2001). Sperm whales generally show no overt reactions to vessels unless they are approached to within several hundred meters (Watkins and Schevill 1975; Würsig *et al.* 1998; Magalhães *et al.* 2002). Observed reactions include spending more (Richter, Dawson, and Slooten 2003) or less (Watkins and Schevill 1975) time at the surface, increasing swimming speed or changing heading (Papastavrou, Smith, and Whitehead 1989; Richter, Dawson, and Slooten 2003), and diving abruptly (Würsig *et al.* 1998).

Pinnipeds. Ship and boat noise do not seem to have strong effects on seals in the water, but the data are limited. When in the water, seals appear to be much less apprehensive of approaching vessels. Some will approach a vessel out of apparent curiosity, including noisy vessels such as those operating seismic airgun arrays (Moulton and Lawson 2002). Gray seals have been known to approach and follow fishing vessels in an effort to steal catch or the bait from traps. In contrast, seals hauled out on land often are quite responsive to nearby vessels. Terhune (1985) reported that northwest Atlantic harbor seals (*Phoca vitulina concolor*) were extremely vigilant when hauled out and were wary of approaching (but less so passing) boats. Suryan and Harvey (1999) reported that Pacific harbor seals (*P. vitulina richardii*) commonly left the shore when powerboat operators approached to observe the seals. Those seals detected a powerboat at a mean distance of 264 meters, and seals left the haul-out site when boats approached to within 144 meters.

8.0 The Anticipated Impact of the Activity on the Availability of the Species or Stocks of Marine Mammals for Subsistence Use

There are no traditional subsistence hunting areas in the project area.

9.0 Anticipated Impact on Habitat

9.1 Short-Term Impacts

Overall, no significant short-term impacts from operational procedures or major repair activities are anticipated. Impacts from operational procedures are discussed below under long-term impacts.

Major repairs to the *Neptune* port and pipeline may affect marine mammal habitat in several ways: cause disturbance of the seafloor, increase turbidity slightly, and generate additional underwater sound in the area. Sediment transport modeling conducted by the Applicant on construction procedures indicated that initial turbidity from installation of the pipeline could reach 100 milligrams per liter (mg/L), but will subside to 20 mg/L after four hours. Turbidity associated with the flowline and hot-tap will be considerably less and also will settle within hours of the work being completed. Therefore, any increase in turbidity from a major repair during operations is anticipated to be insignificant.

Repair activities will not create long-term habitat changes, and marine mammals displaced by the disturbance to the seafloor are expected to return soon after the repair is completed.

During repair of the *Neptune* port and the pipeline, underwater sound levels will be temporarily elevated. These underwater sound levels will cause some species to temporarily disperse from or avoid repair areas, but they are expected to return shortly after the repair is completed.

9.2 Long-Term Impacts

Operation of *Neptune* will result in long-term effects on the marine environment, including continued disturbance of the seafloor, regular withdrawal of seawater, and generation of underwater sound:

- ***Seafloor Disturbance.*** The structures associated with the port (flowline and pipeline, unloading buoys and chains, suction anchors) will be permanent modifications to the seafloor. Up to 63.7 acres of additional seafloor will be subject to disturbance due to chain and flexible riser sweep while the buoys are occupied by SRVs.
- ***Ballast and Cooling Water Withdrawal.*** Withdrawal of ballast and cooling water at the port as the SRV unloads cargo (approximately 2.39 million gallons per day) could potentially entrain zooplankton and ichthyoplankton that serve as prey for whale species. This estimate includes the combined seawater intake while two SRVs are moored at the port (approximately nine hours every six days). The estimated zooplankton abundance in the vicinity of the seawater intake ranges from 25.6 to 105 individuals per gallon (Libby *et al.* 2004). This means that the daily intake will remove approximately 61.2 to 251 million individual zooplankton in a day, the equivalent of approximately 7.65 to 31.4 pounds. Since zooplankton are short-lived (most copepods live from one week to several months), these amounts will be indistinguishable from natural variability.
- ***Underwater Sound.*** During the operations of the port and major repair activities, underwater sound will principally be generated by use of thrusters when SRVs are mooring at the unloading buoy and at other times for maintaining position under certain wind and tidal conditions. As previously mentioned, thruster use will be intermittent, equating to about 350 hours of use per year (150 hours for docking maneuvers and 200 hours for weathervaning). The frequency and duration of the use of the thrusters, coupled with the fixed location of occurrence, will not result in significant effects to individual marine mammals.

Impacts to fish from noise generated during operations or major repair activities were addressed in Section 4.2.1.8 “Fisheries Resources” of the 2006 FEIS and are summarized below. Based on acoustic modeling, noise generated by vessel operations could have long-term, minor, direct, adverse impacts on fish. Noise generated by SRV engine/boiler operations could have negative direct impacts on fish, including essential fish habitat (EFH) species. Impacts on fish could include TTS, physical damage to the ear region, physiological stress responses, and behavioral responses such as startle response, alarm response, avoidance, and a potential lack of response due to masking of acoustic cues. Noise from routine port operations would be associated with ship transits between the existing or proposed Boston TSS and the port, the regasification process on the carriers when moored to the port, and carrier-maneuvering activities at the port.

Noise impacts to zooplankton communities were not evaluated in the FEIS. In a recent report the National Research Council expressed concern about the potential adverse effects of low-frequency sound to marine food chain components, including zooplankton. Bailey, Doney, and Lima (2004) have developed a nonlinear time series approach to quantify the effects of different types of noise on ecosystem dynamics. Their ecosystem model used a model of plankton dynamics and nitrogen cycling. Studies of noise impact on invertebrates and planktonic organisms have a general consensus of very few effects, unless the organisms are very close to the powerful noise source (Greenpeace International 2005). To date, no information is available on specific adverse effect levels to zooplankton components from anthropogenic noise.

9.2.1 Sound Effects on Fish

The groups of important fish that occur in the vicinity of the *Neptune* deepwater port is comprised of species showing considerable diversity in hearing sensitivity, anatomical features related to sound detection (e.g., swim bladder, connections between swim bladder and ear), habitat preference, and life history. The discussion of continuous sound effects on fish in the following sections will pinpoint relevancies to the identified important fish species in the area of concern.

Sound Production

Fishes produce sounds that are associated with behaviors that include territoriality, mate search, courtship, and aggression. It has also been speculated that sound production may provide the means for long distance communication and communication under poor underwater visibility conditions (Zelick, Mann, and Popper 1999) although the fact that fish communicate at low-frequency sound levels where the masking effects of ambient noise are naturally highest suggests that very long distance communication would rarely be possible. Fishes have evolved a diversity of sound-generating organs and acoustic signals of various temporal and spectral contents. Ladich (2000) measured the hearing sensitivities of closely related species that use different channels (acoustic vs. non-acoustic) for communication. Major differences in auditory sensitivity were indicated, but they did not show any apparent correspondence to the ability to produce sounds. Fish sounds vary in structure, depending on the mechanism used to produce them (Hawkins 1993). Generally, fish sounds are predominantly composed of low frequencies (less than 3 kHz). Most of the sounds are probably produced in a social context that involves interaction among individuals (i.e., communication). One of the most common contexts of sound production by fish is during reproductive behavior (Hawkins 1993). Recent research in Canada investigated the reproductive function of sound production by Atlantic cod (Rowe and Hutchings 2004). In support of other studies on cod sound production (e.g., Finstad and Nordeide 2004), Rowe and Hutchings (2004) concluded that sound production by cod could potentially be important to spawning behavior by acting as a sexually selected indicator of male size, condition, and fertilization potential.

Sound Detection

Since objects in the water scatter sound, fish are able to detect these objects through monitoring the ambient noise. Therefore, fish are probably able to detect prey, predators, conspecifics, and physical features by listening to the environmental sounds (Hawkins 1981). Lagardère *et al.* (1994) concluded from their experiment with sole (*Solea solea*) that this species perceives and reacts to horizontal variability in ambient noise levels. Their results indicated positive relationships between wind speed and (1) amplitude of ambient noise measured above the bottom, (2) amount of small-scale (2 to 3 meters) sound variability, (3) reduction of swimming trajectory size, and (4) increase in swimming speed. The authors suggested that wind-generated acoustic gradients are suitable as environmental cues for positioning and that fish use them for this purpose. Such behavior may be a factor in influencing movements of fish populations at sea during poor weather conditions. Studies also have been conducted on the abilities of larval fish to detect sound and respond to it in order to achieve successful settlement (Tolimieri *et al.* 2004; Leis, Carson-Ewart, and Cato 2002; Leis *et al.* 2003). There are two sensory systems that enable fish to monitor the vibration-based information of their surroundings. The two sensory systems, the inner ear and the lateral line, constitute the acoustico-lateralis system.

The Inner Ear. Both vestibular and auditory functions in fishes are mediated by the inner ear, which consists of several mechano-sensory end organs that are located in interconnected fluid-filled chambers (Platt and Popper 1981). Among fishes, at least two major pathways for sound transmittance between source and ear have been identified. The first and most primitive is the conduction of sound directly from the water to tissue and bone. Otoliths, bones of the inner ear of fish, are denser than the rest of the fish and the surrounding water. When sound waves pass through a fish, the denser otolith moves differently than the remainder of the fish, stimulating cilia on the sensory hair cells in the inner ear. This motion is interpreted as sound. The shape and size of otoliths vary among species, resulting in interspecific differences in interpretation of and sensitivity to sound stimuli (Popper and Fay 1999). The otoliths are responsible for the acute sensitivity of some fish to sounds of frequencies less than 20 Hz (infrasound) (Sand and Karlsen 2000). At the other end of the sound spectrum, Popper (2000) indicated that the mechanism for ultrasound detection in some fishes (Mann *et al.* 2001; Mann *et al.* 1998) remains obscure, though it is hypothesized that the highly derived utricle of the inner ear of certain species (e.g., clupeiforms) is involved. One possible explanation for clupeid sensitivity to ultrasound is that it is an adaptation to predation from echolocating cetaceans (Wilson and Dill 2002).

The second sound pathway to the ear is indirect and often involves a swim bladder. Not all fish species have swim bladders. The swim bladder and any other gas bubble near the ear expands and contracts in volume in response to sound pressure fluctuations; this motion is transmitted to the otoliths (Blaxter, Gray, and Denton1981). In some fish (e.g., clupeids), the swim bladder is either very close to the inner ear or it is physically connected to the inner ear by a system of bones called Weberian ossicles (modified anterior vertebrae). Other connections between the swim bladder and the inner ear include elongated gas ducts or extensions of the swim bladder (e.g., Atlantic cod). Regardless of the connection mechanism, the energy of the pressure waves that compress the gas inside the swim bladder is transduced to particle displacement that is then interpreted by the inner ear as sound. Only some species of fish appear to be sound pressure sensitive via this indirect pathway to the ears and they are called “hearing specialists.” The sound pressure sensitivity of hearing specialists is typically higher and their upper frequency range of detection extended compared to those species that hear only by the previously described direct pathway. The species having only the direct pathway (i.e., without swim bladders, with reduced swim bladders, or with swim bladders that are not “connected” to the inner ear) tend to have relatively low auditory sensitivity and narrow auditory frequency range. These species are known as “hearing generalists” (Popper and Fay 1999).

Atlantic herring is the only species associated with the *Neptune* project that can be considered a hearing specialist. Typically, most fish detect sounds of frequencies up to 2 kHz but others, such as herring, can detect much higher frequencies. The methods used to determine the audiograms include auditory brainstem response (ABR), behavioral response, cardiac response, and conditioned response.

Numerous studies have been conducted on the inner ear (e.g., Platt, Jørgensen, and Popper 2004; Ramcharitar, Higgs, and Popper 2001; Ramcharitar *et al.* 2004; Saidel *et al.* 1995) and peripheral auditory structures of fishes (Akamatsu, Nanami, and Yan 2003; Higgs *et al.* 2003; Finneran and Hastings 2000; Yan and Curtsinger 2000; Yan 1998; Lewis and Rogers 1996). These studies reflect the considerable variability in mechanisms of hearing in fishes.

The Lateral Line. Most bony fishes and elasmobranchs (e.g., sharks, skates) possess lateral lines that detect water particle motion. The essential stimulus for the lateral line consists of differential water movement between the body surface and the surrounding water and this stimulus is detected by organs known as "neuromasts" that are located on the skin or just under the skin in fluid-filled canals (Denton and Gray 1988). As is the case with the inner ear, neuromasts have sensory hair cells that move in response to the particle displacement. Generally, fish use the neuromasts to detect low-frequency acoustic signals (160 to 200 Hz) over a distance of one to two body lengths. The lateral line is typically used in concert with other sensory information, including hearing (Sand 1981; Coombs and Montgomery 1999).

Variability of Fish Hearing Sensitivities

Although the hearing sensitivities of very few fish species have been studied to date, it is becoming obvious that the intra- and inter-specific variability is considerable (Coombs 1981). Nedwell *et al.* (2004) recently compiled and published available fish audiogram information. A non-invasive electrophysiological recording method known as 'auditory brainstem response' (ABR) is now commonly used in the production of fish audiograms (Yan 2004). Generally, most fish have their best hearing (lowest auditory thresholds) in the low-frequency range (i.e., less than 1 kHz). Even though some fish are able to detect sounds in the ultrasonic frequency range, the thresholds at these higher frequencies tend to be considerably higher than those at the lower end of the auditory frequency range. This generalization applies to the fish species occurring in the *Neptune* deepwater port area.

With respect to elasmobranch sound detection, most of the limited work done to date has involved sharks. Measurements have shown that sharks are sensitive to the displacement or kinetic component of sound. Since sharks lack any known pressure-to-displacement transducers, such as the swim bladder, they must presumably rely on the displacement sensitivity of their mechano-receptive cells. It has also been shown that sharks are sensitive to low frequencies (i.e., less than 300 Hz). The upper range of behavioral sensitivity in some sharks has been measured at around 600 to 800 Hz (Corwin 1981). Kelly and Nelson (1975) investigated the hearing thresholds of horn sharks using both conditioning and heart-rate techniques. The sharks responded within the frequency range 20 to 160 Hz, with the lowest pressure threshold at 40 Hz (approximately 142 dB re 1 μPa) and the lowest particle motion threshold at 80 Hz. Myrberg (2001) provided a comprehensive review of the acoustical biology of elasmobranchs. Using two different methods, ABR and behavioral conditioning, Casper, Lobel, and Yan (2003) determined the hearing sensitivity of the little skate (*Raja erinacea*) (Table 9-1). Their findings were in agreement with Corwin's hypothesis that hearing sensitivity is correlated with feeding behavior. That is, bottom dwelling elasmobranchs (e.g., little skate) appear to have less sensitive hearing than free-swimming raptorial elasmobranchs like lemon sharks and bull sharks (Kritzler and Wood 1961). Elasmobranchs identified in Table 9-1 include barndoor skate, thorny skate and spiny dogfish.

Frequency tuning and directional responses of single auditory nerve fibers in the lake sturgeon (*Acipenser fulvescens*) have recently been studied (Laboratory of Aquatic Bioacoustics 2003). Acoustic particle motion was simulated as a source stimulus emitting frequencies ranging from 50 to 1,000 Hz. The best responses were observed at frequencies between 100 and 200 Hz. The data from this test indicated that the auditory nerve fibers in sturgeon are frequency-tuned and directionally tuned, just as is found in most modern day bony fishes. Shortnose sturgeon and Atlantic sturgeon have been identified as species that occur around the deepwater port area. Sisneros and Bass (2003) studied the seasonal variability in fish auditory sensitivity. Their work suggested that the hearing sensitivity of female midshipman fish (*Porichthys notatus*) varied between seasons in order to optimize the detection of male-produced sounds during reproductive season.

Table 9-1 Measured Auditory Sensitivities of Fish that are most relevant to the *Neptune* Deepwater Port

Species	Auditory Threshold Range (db re 1 µPa)	Minimum Auditory Threshold Frequency (Hertz)	Auditory Frequency Range Tested (Hertz)	References
Atlantic Cod	60-139	20	10-600	Offut (1974) [1]
Atlantic Cod	75-110	160	30-450	Hawkins & Myrberg (1983) [1]
Atlantic Cod	95-118	17	17-400	Fay (1988) [1]
Atlantic Cod	80-150	200	?-38,000	Astrup & Møhl (1998)
Haddock	80-105	100-300	25-450	Fay (1988) [1]
Atlantic Herring	75-136	100	30-4,000	Enger (1967) [1]
Pollock	81-108	60	40-470	Fay (1988) [1]
Pollock	92-115	200-300	140-500	Chapman & Hawkins (1969) [1]
Atlantic Salmon	95-132	160	32-380	Fay (1988) [1]
Skate	123-141	200	100-800	Casper *et al*. (2003)[1]
Yellowtail Tuna	89-128	500	50-1,100	Fay (1988) [1]
American Shad	118-170	400	200-200,000	Mann *et al*. (1997) [1]
European Plaice	4×10^{-5}m s^{-2} rms	0.1 and 30	0.1-30	Karlsen (1992) [2]
European Plaice	4×10^{-5}m s^{-2} rms	30	30-200	Chapman & Sand (1974) [3]
Little Skate	123-140	200	100-800	Casper *et al*. (2003)[4]
Little Skate	123-152	200	200-800	Casper *et al*. (2003)[5]

Notes:
1. Cited in Nedwell et al. (2004)
2. auditory threshold measured in terms of particle acceleration (vibration)
3. Cited in Karlsen (1992)
4. Using ABR method.
5. Using behavioral conditioning.

9.2.2 Potential Impacts of Continuous Sound on Fish

Literature relating to the impacts of sound on marine fish species can be conveniently divided into the following categories: (1) pathological effects, (2) physiological effects, and (3) behavioral effects. Pathological effects include lethal and sub-lethal physical damage to fish; physiological effects include primary and secondary stress responses; and behavioral effects include changes in exhibited behaviors of fish. Behavioral changes might be a direct reaction to a detected sound or a result of the anthropogenic sound masking natural sounds that the fish normally detect and to which they respond. The three types of effects are often interrelated in complex ways. For example, some physiological and behavioral effects could potentially lead to the ultimate pathological effect of mortality. Hastings and Popper (2005) reviewed what is known about the effects of sound on fishes and identified studies needed to address areas of uncertainty relative to measurement of sound and the responses of fishes. Popper *et al.* (2003/2004) also published a paper that reviews the effects of anthropogenic sound on the behavior and physiology of fishes.

The following discussions of the three primary types of potential effects on fish from exposure to sound consider continuous sound sources since such sounds will be generated by operation and repair activities associated with the *Neptune* Project. Note that most research reported in the literature focuses on the effects of seismic airguns which produce pulsed sounds.

Pathological Effects

There remains considerable question about which aspects of an underwater sound are responsible for potentially impacting marine fish. In addition to peak pressure and pressure pulse rise and decay time, other aspects of underwater acoustics that need to be considered include energy densities over the frequency range of received sound, continuous versus pulsed sounds, temporal width of the pulse, and duty cycle of the exposure period. The potential pathological effects on fish from exposure to sound energy can be grouped by degree of severity: (1) acute sub-lethal effects, (2) chronic sub-lethal effects, and (3) acute and chronic mortality. Logically, acute and chronic sub-lethal effects have potential to indirectly lead to chronic mortality.

Temporary Threshold Shift (TTS). As is the case with marine mammals, it appears that loud sounds can temporarily affect the auditory sensitivity of fish by causing an upward shift in auditory threshold. This effect is known as temporary threshold shift (TTS). This temporary effect on fish hearing has been studied under laboratory conditions using controlled continuous sound sources and the ABR technique (Ramcharitar and Popper 2004; Smith, Kane, and Popper 2004; Scholik and Yan 2002). The sound is generally delivered via underwater speakers in these studies.

Smith, Kane, and Popper (2004) examined the effects of short- (10 minutes to one day) and long-term (one to 21 days) exposure to increased ambient sound on the hearing of goldfish (*Carassius auratus*) using continuous white noise with a bandwidth ranging from 100 Hz to 10 kHz and a loud source level of 160 to 170 dB re 1 μPa (UMT [denotes ‘unidentified measure type’]). The source level was constant across all frequencies. Using the ABR technique, auditory thresholds were measured before and after exposure to determine any changes in auditory sensitivity. The goldfish had a baseline bandwidth of auditory sensitivity that ranged from 100 Hz to 4 kHz and baseline auditory thresholds ranging from 60 to 120 dB re 1 μPa. TSS was apparent after only 10 minutes of exposure to the white noise and was as high as 28 dB after 24 hours of exposure. This difference in auditory sensitivity did not increase after longer exposure times. It took some fish as long as 14 days to return to pre-exposure auditory sensitivities. Amoser and Ladich (2003) studied the effects of intense white noise on the hearing abilities of two otophysine fish species (i.e., fish with Weberian ossicles connecting the swim bladder to the inner ear). Non-vocal goldfish and the vocalizing catfish (*Pimelodus pictus*) were exposed to continuous sound with an approximate received SPL of 158 dB re 1 μPa (UMT). The SPL was constant across all frequencies. Fish were exposed to the noise for either 12 or 24 hours. Using the ABR technique, hearing sensitivities were determined prior to exposure, immediately following exposure, and at three, seven, and 14 days after exposure. Both species showed a significant loss in hearing sensitivity, as much as 26 dB in the goldfish and 32 dB in the catfish. The greatest loss in hearing sensitivity occurred at the most sensitive frequencies for both species. The period of exposure did not seem to influence the degree of hearing sensitivity loss. The goldfish hearing sensitivity returned to normal after three days of recovery, but the catfish required a 14 days recovery time to regain pre-exposure sensitivity. Fathead minnows (*Pimephales promelas*) were exposed to continuous recorded sound from a small boat’s outboard motor for two hours (Scholick and Yan 2002). The received SPL was 142 dB re 1 μPa (UMT) with most of the energy at 1.3 kHz. The fathead minnow’s most sensitive hearing range had been previously determined as 0.8 to 2 kHz (Scholick and Yan 2001). Using the ABR technique immediately after exposure, Scholick and Yan (2002) demonstrated that the boat engine noise significantly elevated the fathead minnow auditory threshold at frequencies 1, 1.5, and 2 kHz. The auditory threshold elevations ranged from 7.8 to 13.5 dB. Elevations in auditory threshold were not observed at frequencies below 1 kHz and above 2 kHz. The time required for the auditory thresholds to return to pre-exposure level was not indicated.

Visible Ear Damage. In order to study the effects on the ear sensory epithelium and the lateral line, Hastings *et al.* (1996) exposed oscar fish (*Astronotus ocellatus*) to synthesized sounds with characteristics similar to those of commonly encountered manmade sources. The sounds used in the exposures varied in frequency (60 or 300 Hz), intensity (100, 140, or 180 dB re 1 μPa; UMT) and duty cycle (20% or continuous). Fish tissue was examined at one and four days after exposure. The only damage observed was in fish exposed for one hour to 300 Hz continuous tones at 180 dB re 1 µPa at 1 m (UMT), and sacrificed four days post-exposure. Enger (1981) provided the earliest evidence of the potential of loud sounds to pathologically affect fish hearing. He demonstrated that the sensory cells of the ears of Atlantic cod (*Gadus morhua*) were damaged after one to five hours of exposure to continuous synthesized sounds with a source SPL of 180 dB re 1 µPa at 1 m (UMT). The frequencies tested included 50, 100 200, and various frequencies between 300 and 400 Hz. The cod were exposed at less than 1 meter from the sound source.

Physiological Effects

The biochemical stress responses of marine fish to underwater sound have received limited study. The study of the various biochemical parameters influenced by acoustic stress could potentially provide some indication of the extent of the stress and any subsequent longer-term detrimental effect. Stressors could potentially affect animal populations by reducing reproductive capacity and adult abundance. Smith, Kane, and Popper (2004) examined the effects of short- (10 minutes to one day) and long-term (one to 21 days) exposure to increased ambient sound on the stress of goldfish by exposing them to continuous white noise with a bandwidth ranging from 0.1 to 10 kHz and a source SPL of 160 to 170 dB re 1 µPa at 1 m (UMT). The SPL was constant across all frequencies. The authors assessed noise-induced alterations in physiological stress by measuring plasma cortisol and glucose levels. Cortisol levels had significantly increased 10 minutes after exposure in the short-term exposure experiments but returned to normal after 60 minutes. Noise exposure did not significantly affect cortisol or glucose concentrations in the long-term noise experiment.

The heart rates of fish embryos within eggs were monitored as they were exposed to continuous pure tones in the range of 100 to 1,200 Hz at levels of 80 to 150 dB re 1 µPa at 1 m (UMT) (Simpson *et al.* 2005). Changes in heart rate were detected in embryos as early as three days after fertilization. The frequency range of sound to which there was a heart rate response widened as the embryos grew older.

Behavioral Effects

Because of an assumed low probability of serious pathological and physiological effects of underwater noise on marine fish, most concern about this issue now focused on the possible effects on fish behavior, namely those behaviors associated with reproduction, migration, and distribution. A small number of studies investigating the possible effects of noise, primarily seismic sound, on fish behavior have been conducted over the years. Studies looking at change in distribution are often conducted at larger spatial and temporal scales than are typical for studies that examine specific behaviors, such as startle response, alarm response and avoidance response. The studies that examine those specific defined responses often involve caged fish rather than free-ranging fish (Hirst and Rodhouse 2000). Masking of natural/ambient sounds (e.g., communication, detection of predators and prey, gleaning of information about the surrounding environment) also has the potential to affect fish behavior.

Captive Fish Studies. Schwarz and Greer (1984) defined three responses of fish in reaction to underwater noise: (1) startle, (2) avoidance, and (3) alarm. A startle response is defined as a single powerful flexion of the body followed by a five- to 10-second period of faster swimming. Fish that exhibit a startle response do not change swimming direction. An avoidance response is defined as a mildly negative behavior. Schooling fish will often tighten into a compact school and then slowly move away from the sound source. An alarm response contains elements of an avoidance response, but these occur at greater speed and intensity. The group of fish quickly packs, polarizes, and flees away and downward from the sound source. The school might dive to the bottom and lie motionless, or dive to midwater and then repeatedly and quickly change direction, or dive to midwater and break up into a number of smaller schools, each of which flees in a different direction and changes direction repeatedly.

Akamatsu *et al.* (1996) observed the reactions of captive Japanese anchovy (*Engraulis japonicus*) to continuous pure tones of frequencies 100, 200, 300, 500 and 700 Hz. Startle responses were observed over a received SPL range of 146.8 dB re 1 µPa at 300 Hz to 154.5 dB re 1 µPa at 100 Hz (UMT). There was no observable response to a received SPL of 158 dB re 1 µPa at 700 Hz. The Japanese anchovy exhibited its minimum behavioral threshold at frequency 300 Hz.

The reactions of penned herring and cod to playback of original, frequency filtered and time-smoothed vessel sounds were studied by Engås *et al.* (1996). Avoidance reactions by both herring and cod were observed during exposure to the original 60-to 300-Hz and 300-Hz to 3-kHz spectra, but less so at 20 to 60 Hz. The duration of response by cod was greater with exposure to the original sound compared to time-smoothed sound. The authors concluded that the main determinant for triggering avoidance reactions by cod and herring is vessel sound level within the most sensitive frequency ranges, although other sound characteristics such as temporal structure also seemed to be important. The maximum amplitudes measured in the 20- to 60-Hz, 60- to 300-Hz, and 300-Hz to 3-kHz bands were approximately 112 dB, 125 dB and 140 dB (UMT), respectively.

Schwarz and Greer (1984) described the behavioral responses of net-penned Pacific herring (*Clupea harengus pallasi*) to a variety of tape-recorded sounds. Sounds recorded in the field included those of moving and idling herring fishing vessels, sonar, echo sounder and deck gear. Natural sounds included rain on the water surface, gull cries, killer whale vocalizations, sea lion barks, and sounds made by herring. Sounds of more uniform structure were created by synthesizer and played back to determine the relative effectiveness of various combinations of amplitude, frequency and temporal pattern. Herring did not respond to any of the natural sounds nor to the sonar or echo sounder. The echo sounder produced regular broadband clicks within the 50-Hz to 2-kHz frequency range. Alarm responses, and less so startle responses, were elicited by those electronic sounds with very short rise times. Avoidance responses were elicited by sounds of large vessels approaching at constant speed, by smaller vessels on accelerated approach, and by some of the electronic sounds. Larger vessels tended to make sounds with more energy in the lower frequencies and higher amplitude SPLs than smaller vessels. The authors concluded that the magnitude, direction and rate of change of amplitude were among the most important factors affecting the duration and intensity of herring response. Irregular pulses were more effective in eliciting response than either regular pulses or continuous tones. The authors concluded that temporal pattern of sound rather than frequency spectrum of sound has the greatest impact on fish behavior.

Herring produced some interesting sounds other than those associated with feeding and hydrodynamics. Herring “chirps” consist of one or several bursts of pulses in the 1.8- to 3.2-kHz range, and they tended to occur in bouts. Herring “whistles” are narrow band continuous sounds in the 1.6- to 2-kHz range. Captive herring did not appear to respond to these chirps and whistles (Schwarz and Greer 1984). Blaxter, Gray, and Denton (1981) investigated the startle responses of captive herring to various welldefined sound stimuli. Three kinds of stimuli were used: (1) a single complete cycle, (2) a burst of about 10 complete cycles, and (3) a ramp-up of complete cycles of increasing amplitude. They found that a sound consisting of only one cycle of a sine wave was as effective in eliciting a fish response as a sound of the same amplitude lasting many cycles. The herring response threshold appeared to be raised during the ramp-up experiment. Amplitude pressures of single cycle stimuli that elicited responses (10.5 to 17.5 Pa, equivalent to 140 to 145 dB re 1 µPa [UMT]) were essentially independent of the duration of the stimuli (2 to 40 milliseconds). The frequency range of the stimulus sounds was between 80 and 92 Hz. Most responses began with a startle response away from the sound source. The authors contend that the directionality component of the responses is somewhat dependent on detection of particle displacement while the initiation of response is triggered by pressure alone. Therefore, the authors concluded that the herring can determine the amplitude of a sound and the direction from which it came.

Popper *et al.* (2004) published a review paper on the responses of clupeid fish to ultrasound. They discuss the physiological, developmental, and anatomical evidence suggesting that one end organ of the inner ear, the utricle, is likely the detector of ultrasound in most clupeid fish. Amoser, Wysocki, and Ladich (2004) studied the effects of sounds produced during a powerboat race on freshwater fish communities. Considering that the powerboats generated sound levels of about 180 dB re 1 µPa at 1 m (UMT) over a frequency range similar to the hearing sensitivity ranges of the whitefish, salmonids, perches and cyprinids used in the study, the authors concluded that most of the fish species would be disturbed within 200 to 400 m of the powerboats.

Free-ranging Fish Studies. The power of modern marine research vessels using diesel engines means significant levels of sound may be radiated underwater (Mitson and Knudsen 2003). Much of the necessary machinery to drive and operate a ship produces vibration within the frequency range of 10 Hz to 1.5 kHz, radiating pressure waves out from the hull. Avoidance behavior in cod in response to a bottom-trawling vessel using a split beam echo sounder system on a free-floating buoy was examined by Handegard, Michalsen, and Tjøstheim. (2003). Their study indicated significant horizontal and vertical displacements of cod during and after propeller passage. The horizontal distributional change seemed to occur slightly later than the diving reaction.

Fernandes *et al.* (2000) investigated fish avoidance in reaction to the presence of survey vessels. To study the potential bias caused by vessel noise in survey data, the authors deployed an autonomous underwater vehicle (AUV) that was located between 200 and 800 meters ahead of the vessel during a herring survey in the North Sea. The AUV was equipped with the same type of scientific echosounder as the survey vessel and therefore gathered equivalent acoustic data prior to the research vessel. There was not any significant difference in the amount of fish detected by the research vessel and that detected by the AUV. It is important to point out that the research vessel (*Scotian*) involved in this work is relatively quiet and built to minimize sound emission.

Misund, Øvredal, and Hafsteinson (1996) examined the reactions of herring schools to the sound field of a survey vessel. The survey vessel generated the highest sound intensities between 125 and 500 Hz, the highest source level equaling 146 dB re 1 µPa at 1 m (UMT) at 250 Hz. The lowest sound intensities were immediately off the bow of the vessel and the highest sound intensities were off either side of the vessel (butterfly effect). Of the 110 herring schools recorded during this work, only 21 appeared to react to the vessel. Sixteen of the 21 moved towards the path of the approaching vessel, seemingly influenced by the rising sound intensity to the side of the vessel path and consequently being herded ahead of the vessel. The herded schools first reacted to the approaching vessel at a distance of 25 to 1,000 meters ahead and within a sector of about 20º on each side of the vessel. Seventeen other schools detected within the same distance and sector limits did not appear to react to the vessel.

Misund (1993) examined the avoidance behavior of herring and mackerel in purse seine capture situations using true motion sonar. Operating purse seiners typically generate loud, low-frequency sound with peak energy around 100 Hz (Misund 1993) which falls within the hearing range of teleost fish. The specific vessel sound sources are propeller cavitation and engines that together generate a continuous sound spectrum. Schools of both herring and mackerel typically exhibited horizontal avoidance in response to the purse seiners. Daytime vertical movements of Spanish sardines (*Sardinella aurita*) in response to an approaching marine vessel were described by Gerlotto and Fréon (1992). All five of the observed schools dove before passage of the vessel, shifting, on average, about 5 meters deeper. The school that was initially closest to the surface dove deepest. The schools also showed compression in response to the approaching vessel. Overall, the diving reaction of this sardine species appears limited compared to herring. The diving reaction was only perceptible in the upper 20 meters of the school.

Wahlberg and Westerberg (2005) presented a review of the current knowledge regarding fish detection of, and reaction to, sound produced by offshore windmill farms. They concluded that a more careful analysis of the effects of windmill sound on fish is only possible with better data on the nature of the acoustic field around the windmills. This idea should be applied to any sound source to which behavioral effects are derived through modeling.

9.2.3 Summary of Potential Impacts of Continuous Sound on Fish

Potential effects of exposure to continuous sound on marine fish include TSS, physical damage to the ear region, physiological stress responses, and behavioral responses such as startle response, alarm response, avoidance, and perhaps lack of response due to masking of acoustic cues. Most of these effects appear to be either temporary or intermittent, and therefore probably do not significantly impact the fish at a population level. The studies that resulted in physical damage to the fish ears used noise exposure levels and durations that were far more extreme than would be encountered under conditions similar to those expected at the *Neptune* project.

The known effects of underwater noise on fish have been reviewed. The noise levels that are necessary to cause temporary hearing loss and damage to hearing are higher and last longer than noise that will be produced for the *Neptune* project. The situation for disturbance responses is less clear. Fish do react to underwater noise from vessels and move out of the way, move to deeper depths, or change their schooling behavior. The received levels at which fish react are not known and apparently are somewhat variable depending upon circumstances and species of fish. In order to assess the possible effects of underwater project noise, it is best to examine project noise in relation to continuous noises routinely produced by other projects and activities such as shipping, fishing, etc. and pulsive noises produced by seismic exploration.

Pulsive Sounds

The pulsive sounds expected during a major repair scenario are much less intense than the pulses from the air guns used in offshore seismic surveys by the oil and gas industry. Such surveys routinely have source levels of 250 dB re 1 μPa at 1 m. The available information suggests that seismic exploration has minimal effects on fish and fisheries, although there are some conflicting data. It is highly unlikely that the low levels of pulsed noise from the *Neptune* repair activities would have any effect on fish populations in the area.

Continuous Noise

The two long-term sources of continuous noise associated with the project are the ship transits between the Boston shipping lanes and the unloading buoys and the re-gasification process at the carriers when moored to the unloading buoys. Noise levels associated with these two activities are relatively low and unlikely to have any effect on biological resources of the area. One other activity expected to produce short periods of continuous noise is the carrier maneuvering bouts at the port. Although this activity is louder, it is still less than the noise levels associated with large ships at cruising speed. The carrier maneuvering using the ship's thrusters would produce short periods of louder noise for 10 to 30 minutes every four to eight days. On average, these thruster noises would be heard about 20 hours per year. Even in the unlikely event that these two activities caused disturbance to marine fish, the short periods of time involved serve to minimize the effects.

10.0 Anticipated Impact of Habitat Loss or Modification

10.1 Short-Term Impacts

None anticipated.

10.2 Long-Term Impacts

In the long-term, approximately 64.6 acres of seafloor will be permanently disturbed to accommodate the port (including the associated pipeline), corresponding to the permanent footprint dimensions of the 16 buoy anchors (0.1 acre); two riser manifolds, and two flowline transition areas (0.1 acre); the pipeline route's transition area, manifolds, and hot-tap tie-in (0.05 acre); areas along the pipeline where armoring is proposed (0.3 acre); the area of sweep associated with 16 anchor chains (56.9 acres); and the sweep associated with two flexible risers (6.8 acres). The area disturbed because of long-term chain and riser sweep includes 63.7 acres of soft sediment. This area will be similar in calm seas and in hurricane conditions. The chain weight will restrict the movement of the buoy or the vessel moored on the buoy. An additional 0.9 acre of soft sediments will be converted to hard substrate. The total affected area will be small compared to the soft sediments available in the project area. Long-term disturbance from installation of the port will comprise approximately 0.3 percent of the estimated 24,000 acres of similar bottom habitat surrounding the project area (northeast sector of Massachusetts Bay).

It is likely that displaced organisms will not return to the area of continual chain and riser sweep. A shift in benthic faunal community is expected in areas where soft sediment is converted to hard substrate (Algonquin Gas Transmission LLC 2005). This impact will be beneficial for species that prefer hardbottom structure and adverse for species that prefer soft sediment. Overall, because of the relatively small areas that will be affected (as described above), impacts on soft-bottom communities will be minimal.

Daily removal of seawater will reduce the food resources available for planktivorous organisms.

All species have fairly broad diets and are not dependent on any single species for survival. Because of the relatively low biomass that will be entrained by the *Neptune* port, the broad diet, and broad availability of organisms in the project area, indirect impacts on the food web that result from the entrainment of planktonic fish and shellfish eggs and larvae are expected to be minor.

11.0 The Availability and Feasibility (Economic and Technological), Methods, and Manner of Conducting Such Activity or Means of Effecting the Least Practicable Impact Upon Affected Species or Stock, Their Habitat, and of Their Availability for Subsistence Uses, Paying Particular Attention to Rookeries, Mating Grounds, and Areas of Similar Significance

The Applicant has committed to a comprehensive set of mitigation measures during operation, as well as ongoing consultations with the National Marine Fisheries Service. These measures include:

- Passive acoustics program;
- Visual monitoring program;
- Safety zones;

- Reporting; and
- Vessel speed.

Details of the proposed mitigations are discussed in the Marine Mammal and Turtle Monitoring and Mitigation Plan that is included as Appendix D to this application.

There are no traditional subsistence hunting areas in the vicinity of *Neptune*.

12.0 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 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 Use

There are no traditional Arctic subsistence hunting areas in the vicinity of *Neptune* and there are no activities related to the Port that may affect the availability of a species or stock of marine mammal for Arctic subsistence uses.

13.0 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 the Population 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

See the proposed Marine Mammal Detection, Monitoring, and Response Plan for the operation of the Project, which is included as Appendix D of this application.

14.0 Suggested Means of Learning of, Encouraging and Coordinating Research Opportunities, Plans, and Activities Relating to Reducing Such Incidental Taking and Evaluating Its Effects

Neptune LNG LLC has engaged personnel from the National Marine Fisheries Service and Stellwagen Bank National Marine Sanctuary (SBNMS) regarding available passive acoustic monitoring (PAM) technology that will be utilized to enhance the Plan. The primary goal of the real-time PAM program is to minimize vessel-whale interactions. The secondary goal of this program is to generate data to support research-based knowledge. Neptune LNG LLC will continue its discussions and consultations with the National Marine Fisheries Service and SBNMS personnel to develop the appropriate level of inclusion of this technology.

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Appendix A

NOAA / NMFS ESA Section 7 Consultation Biological Opinion (January 12, 2007)

NOTE:
The Biological Opinion was previously provided in
the original March 2007 IHA/LOA Application

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Appendix B

Assessment of the Effects of Underwater Noise from the Proposed *Neptune* LNG Project (October 2005)

NOTE:

The assessment was provided previously in the original March 2007 IHA/LOA Application.

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Appendix C

Supplements to the Assessment of the Effects of Underwater Noise from the Proposed *Neptune* LNG Project

C.1 Supplementary Acoustic Modeling and Biological Effects Reports (JASCO Research Ltd and LGL Limited, respectively, August 2006).

C.2 Underwater Noise Measurements for HN1688 145,000m^3 LNG SRV (Samsung, July 2009)

C.3 Neptune LNG Deep Water Port: Assessment of Underwater Noise from LNG Carrier Weathervaning on the Mooring (JASCO Applied Sciences, November 2009) and Assessment of the Effects of Underwater Noise from Thrusters to be Used on the Neptune LNG Project, 2nd Supplementary Biological Effects Report (LGL Limited, 3 December 2009)

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Appendix C.1

Supplementary Acoustic Modeling and Biological Effects Reports (JASCO Research Ltd and LGL Limited, respectively, August 2006)

NOTE:
The reports were provided previously in the
original March 2007 IHA/LOA Application.

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Appendix C.2

Underwater Noise Measurements for HN1688 145,000m^3 LNG SRV
(Samsung, July 2009)

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ISO9001·ISO14001

REPORT

UNDERWATER NOISE MEASUREMENTS
FOR
HN1688 145,000m^3 LNG SRV

/ Full Scale Measurements /

CUSTOMER

HOEGH

DEPARTMENT

Propulsor Research
Daedeok Ship R&D Center

July 2009

SAMSUNG

103-28, Munji-dong, Yuseong-gu,
Daejeon, Korea, 305-380

TEL : +82-42-865-4753
FAX : +82-55-630-7671

REPORT

TITLE

UNDERWATER NOISE MEASUREMENTS FOR HN1688 145,000m^3 LNG SRV

/ Full Scale Measurements /

CLIENT

CLASSIFICATION
Confidential

CLIENT REF.

REPORT NO.

PROJECT NO.

FILE LOCATION

PROJECT MANAGER
Seung Jae Lee

DATE
July 2009

DIRECTOR, SSMB
Jong Soo Seo

SUMMARY

This report describes the results of the underwater noise measurements during the sea trials for HN1688 LNG shuttle and regasification vessel (SRV) with a capacity of 145,000 cubic meters. The underwater noise measurements for the vessel had been carried out on June 30, 2009. The objective of these measurements was to quantify the underwater noise levels associated with the operation of two stern thrusters. The content of this report is focused on reporting underwater noise levels induced by stern thrusters as noise source.

According to the results of the underwater noise measurements, it is noted that no circumstances exceed the 180 dB Level A harassment criteria. For the stern thrusters operated at 100% load, it is expected that sound pressure levels at a distance over 3 kilometers from the subject vessel do not exceed the MMPA Level B harassment threshold of 120 dB for continuous noise.

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1. Introduction

This report describes the results of the underwater noise measurement during the sea trials for HN1688 LNG shuttle and regasification vessel (SRV) with a capacity of 145,000 cubic meters (㎥), as shown Figure 1. The principal particulars of this vessel is summarized in Table 1.

Regarding the underwater noise measurement, HOEGH, MOL and SHI had been discussed on the 18th ~ 19th of June, 2009 at owner's site office. According to this technical meeting, it was agreed that the underwater noise measurement for this subject vessel should be carried out under the following condition.

- Stern thrusters running at 100% rpm and 100% pitch without propulsion power
- Underwater noise shall be measured at the distance of 100m from the subject vessel Distance can be adjusted according to circumstances.

The underwater noise radiated from the subject vessel was measured on June 30, 2009. The draught condition of the subject vessel was 9.60 meters on even keel. The underwater noise measurement at 100% RPM running condition of both stern thrusters had been carried out. The test site was located at about 7 miles to the south direction from NamHyoung islands as shown in Figure 2. The water depth is approximately 80 ~ 90 meters.

The objective of these measurements was to quantify the underwater noise levels generated by stern thrusters. The content of this report is focused on reporting underwater noise levels produced by stern thrusters as a noise source. The overall effect of underwater noise on marine mammals is not discussed in this report.

Figure 1. Photographs of HN1688 145K LNG SRV

Table 1. Principal particulars of HN1688 LNG SRV

Dimensions	Length O.A.	Apprx.	280.0 m
	Length B.P.		270.0 m
	Breadth, mld.		43.4 m
	Depth, mld.		26.0 m
	Designed draught, mld.		11.4 m
	Summer draught, mld.		12.4 m
	Scantling draught, mld.		12.4 m
Deadweight	At designed draught	Apprx.	70,600 MT
	At summer draught	Apprx.	80,600 MT
Maximum propulsion shaft power		26,130 kW x 88 RPM	
Thrusters (Controllable Pitch Propeller)		Bow thrusters : Two(2) x 2,000 kW Stern thrusters : Two(2) x 1,200 kW	
Service speed at designed draught and at maximum propulsion shaft power including 21% sea margin		Apprx.	19.5 knots
Cruising range		Apprx.	12,000 NM

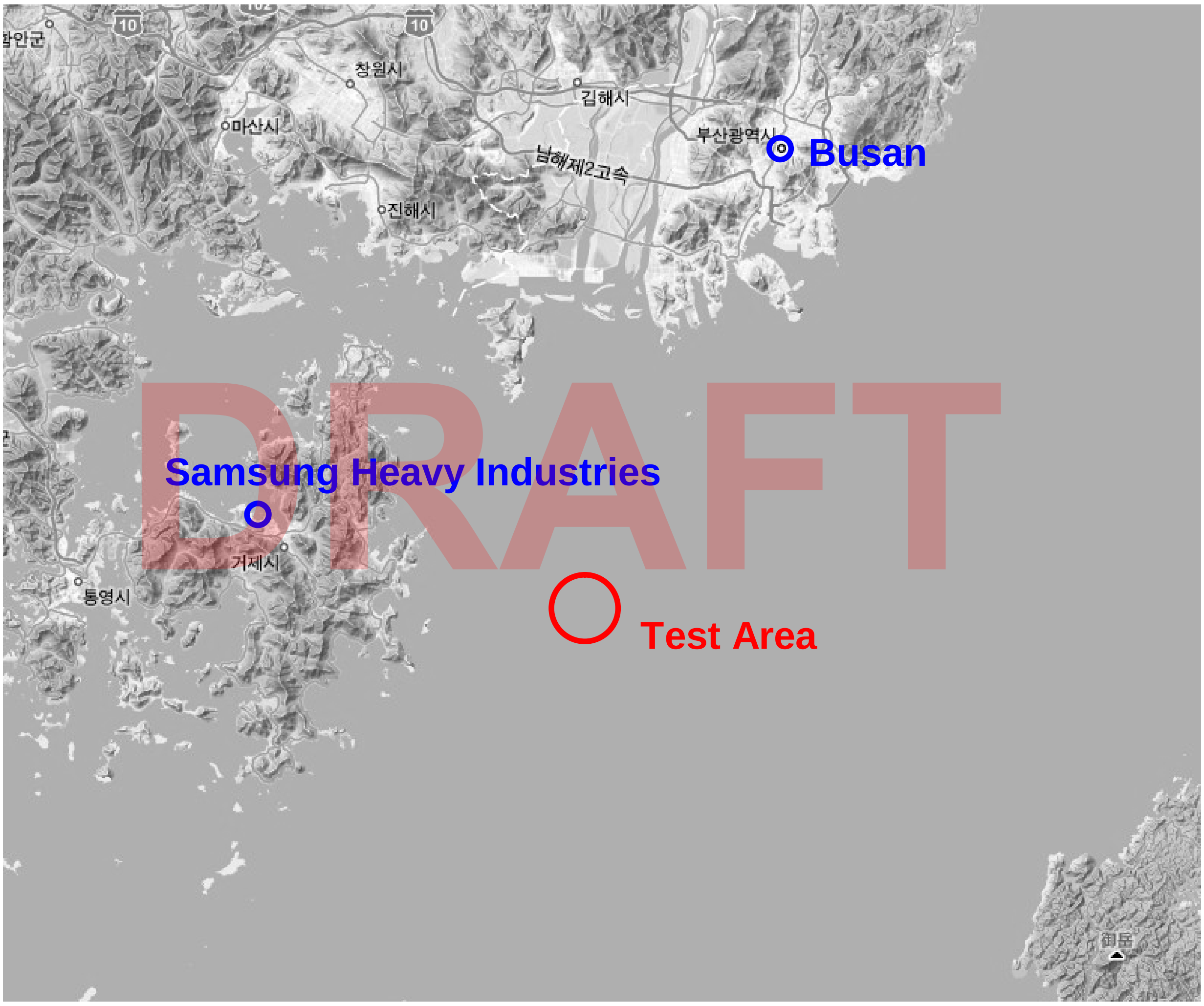


Figure 2. Location of test site for underwater noise measurements

2. Measurement Set-up

As shown in Figure 4, two hydrophones, power supplier and signal analyzer were used for the measurements of the underwater radiated noise. The hydrophone (B&K type 8101), which is the piezoelectric transducer used piezoelectric ceramics as sensing elements, has been employed. The hydrophone would give a signal suitable for transmission over long cables and it is usable down to 1,000 meters ocean depth. The frequency range of the hydrophone covers from 7 Hz to 80 kHz. On-board calibration of hydrophones was accomplished by the hydrophone calibrator (B&K type 4229) shown in Figure 5. The hydrophones were suspended in the depths of 30 and 50 meters behind the measuring boat. A balancing weight of 100 Kg was attached to the lowest hydrophone to neutralize water current effects. The distances from the vessel can be recognized in Figures 6 and 7

The weather conditions at the test site are described as follows;

- wind speed : 10 ~ 12 m/sec
- wave height : 1 ~ 2 meters (refer to Figure 3)
- water temperature : 23.5 degree Celsius (℃)
- salinity : 29.7 parts per thousand (ppt)
- conductivity : 4.53 Siemens per meter (S/m)

Figure 3. Sea state at test site

Hydrophone
(B&K type 8101)

Power Supply
(B&K type 2804)

Data Recorder & Analyser
(B&K Pulse)

Figure 4. Measurement set-up

Figure 5. Hydrophone calibrator for on-board calibration (B&K type 4229)

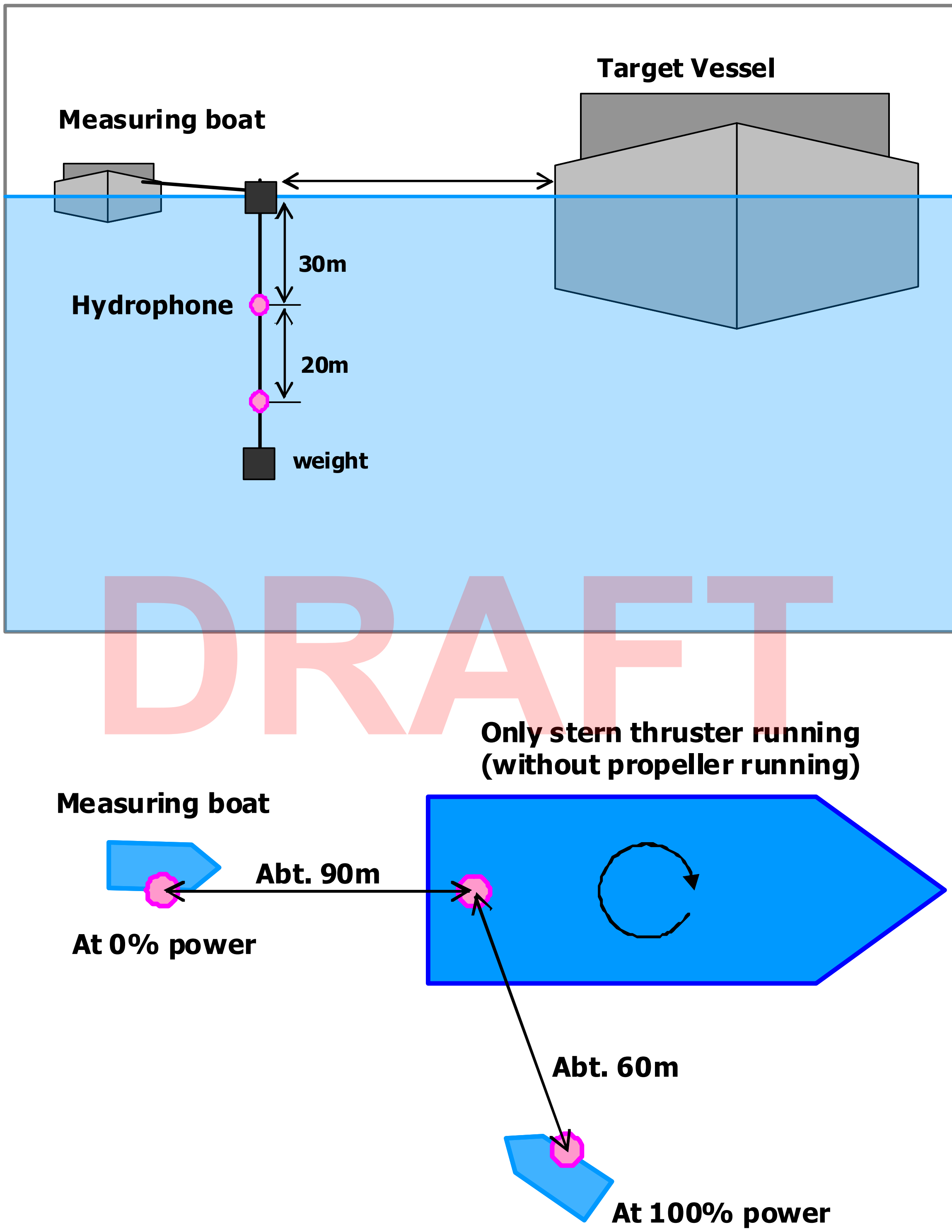


Figure 6. Schematics on underwater noise measurement

Figure 7. Measuring boat at test site

3. Analysis

These measurements were carried out during the operation of two stern thrusters. A measuring boat (hydrophone) was located at the starboard side of the subject vessel (stern thrusters). Sound pressure measurements were conducted in two channels simultaneously. The underwater noise levels were established by averaging the measured levels at each hydrophone.

In order to investigate the underwater noise levels induced by stern thrusters, the measured levels during the operation of stern thrusters should be appreciably higher than the background noise or ambient noise in the presence of the subject vessel. The background noise measurement is very important in setting a reference. Example of background noises are environmental noise such as waves, shipping traffic, bioacoustic noise from animals and mechanical noise from machinery devices such as engines, generator, pumps.

When the background noise was measured at the test site, there were no industrial activities and shipping traffic within a 3 km radius. The background noise did not vary in short period of time. The background noises were measured at idle running of stern thrusters. The measured background noise levels are presented in the second column of Table 3 and graphically shown in Figure 9. Although the subject vessel consisted of two bow thrusters and two stern thrusters with controllable pitch propeller (CPP), these underwater noise measurements were taken during the operation of only two stern thrusters at full power without propeller's running. The measured values are presented in the third column of Table 3. As the measured noises are appreciably higher than the background noise as shown in Figure 9, the measured data were recognized as meaning values. The operation of stern thrusters at full power would increase sound pressure level by an additional 7 to 31 dB re 1 μPa.

With knowledge of the distance from the measurement equipment to the sound source, the received noise levels are adjusted to a reference distance of 1 meter from noise source. Sound sources are typically presented as sound pressure levels at a distance of 1 meter from an idealized point source, i.e. dB re 1 μPa at 1 meter. This standardized reference distance was used for direct comparison of different sound source levels. Received sound pressure levels include the effects of propagation and attenuation that occurred between the source and receiver. The propagation and attenuation of sound waves under the water is a complex phenomena influenced by gradients of temperature, water depth, salinity, currents, scattering by sea floor and surface, and so on. To account for the fact that neither the surface nor seabed floor is perfectly reflective and free-field conditions seldom actually exist in the sea, the modified cylindrical spreading represented by decay rate of $TL = 15\log r$ has been utilized. The modified spreading law plus an added loss due to absorption can be expressed as

$$TL = 15\log r + \alpha r \times 10^{-3}$$

where r is a distance and α is the coefficient in the second term (refer to Appendix C).

Under the propagation conditions in shallow water environments, sound source levels were back-calculated to characterize an idealized point source which is submerged at a depth of 7 meters. Sound source levels representing the stern thrusters operated at 100% load are summarized in Table 4 and Figure 10. In this calculation, it is approximated that the measuring point (hydrophone) was located at a distance of about 60 meters from the source point (stern thrusters) as shown in Table 2 and Figure 6.

Using the source data shown in Table 4, the underwater sound levels were calculated at three distances (1000, 2000, and 3000 meters) with only a rough approximation of the transmission loss including an added loss due to the sound absorption in the sea, which is closely related with the water temperature, salinity, hydrostatic pressure, and frequency. However, in this calculation, the effect of hydrostatic pressure is neglected because of shallow water environments. The predicted underwater noise levels at three distances are described in Table 5 and shown in Figure 11.

As shown in Figure 11, all sound pressure levels at three distances would be below the MMPA (Marine Mammal Protection Act) Level B harassment threshold of 160 dB for impact noise. The sound pressure levels at the distance of 3,000 meters are predicted to fall below the MMPA Level B harassment threshold of 120 dB for continuous noise.

Table 2. Thruster's operation condition for underwater noise measurement

Thruster's Operation Condition		Distance between the idealized noise source and the measuring point
Power [%]	Rotational speed [RPM]	
0	0	Apprx. 90 m
100	300	Apprx. 60 m

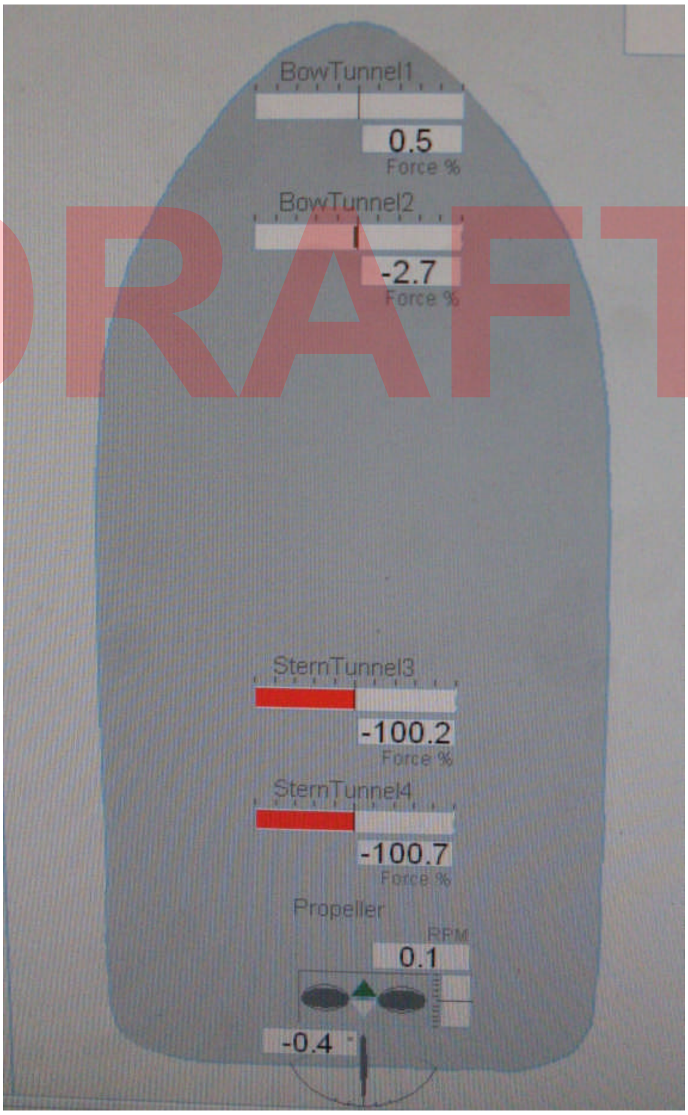


Figure 8. Thruster's operation condition for underwater noise measurement

Table 3. Summary of received sound pressure levels

Center Frequency	Sound Pressure Level (dB re 1μPa)	
Hz, 1/3 octave band	background noise	operation at 100% load
16	130.8	138.2
20	125.6	137.3
25	124.8	135.0
31.5	122.3	130.3
40	126.8	133.9
50	126.4	134.3
63	125.7	133.7
80	127.9	137.9
100	128.9	142.3
125	129.4	144.1
160	125.6	143.4
200	123.4	143.9
250	123.5	144.4
315	124.6	142.6
400	126.1	140.6
500	115.1	137.9
630	113.3	138.5
800	112.5	139.0
1000	111.7	139.8
1250	109.2	138.9
1600	108.1	138.7
2000	106.6	138.0
2500	107.3	138.1
3150	108.8	138.5
4000	107.3	136.6
5000	106.6	134.9
6300	106.4	133.3
8000	107.3	131.0
10000	107.5	129.0
12220	108.6	126.3
16000	109.4	123.3
20000	110.3	120.8
Overall	**138.6**	**154.1**

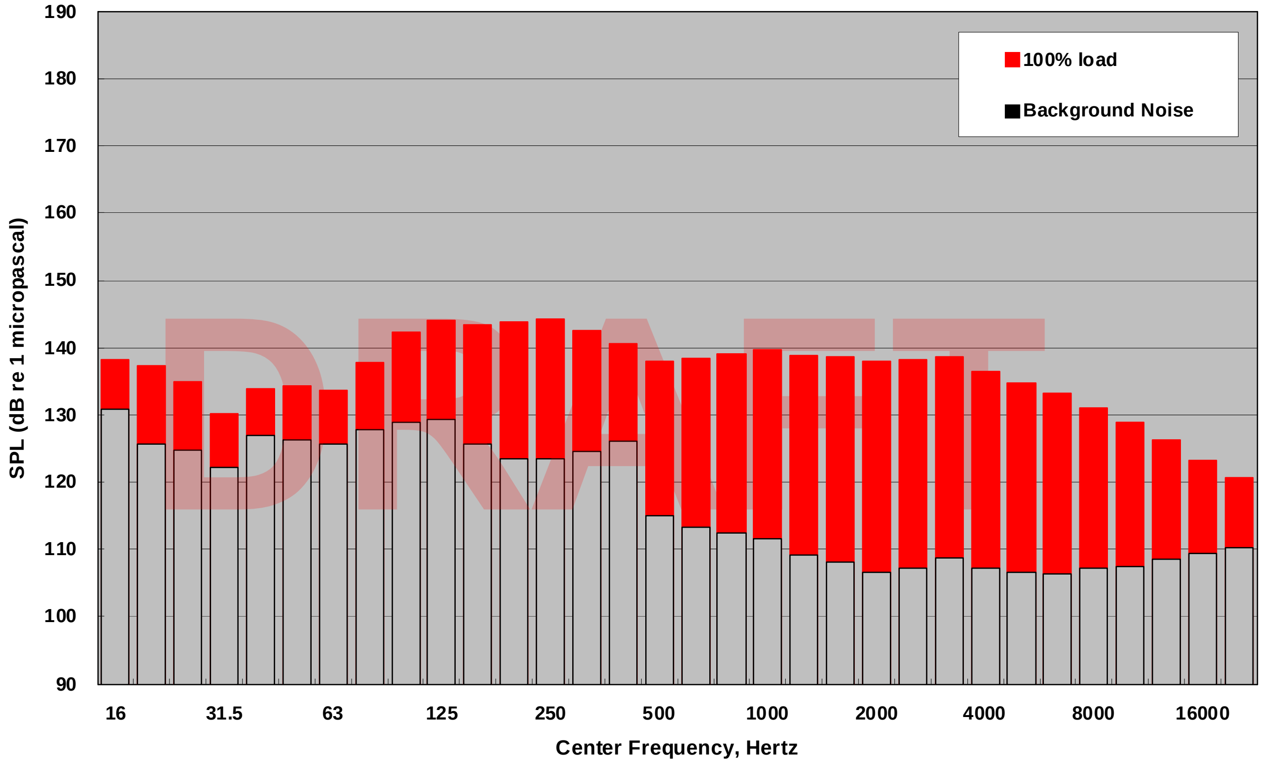


Figure 9. received sound pressure levels

Table 4. Summary of sound source levels

Center Frequency Hz, 1/3 octave band	Sound Pressure Level (dB re 1μPa at 1 meter) operation at 100% load
16	164.8
20	164.0
25	161.7
31.5	156.9
40	160.6
50	160.9
63	160.4
80	164.6
100	169.0
125	170.8
160	170.1
200	170.5
250	171.0
315	169.3
400	167.2
500	164.6
630	165.2
800	165.7
1000	166.4
1250	165.6
1600	165.4
2000	164.6
2500	164.8
3150	165.2
4000	163.3
5000	161.5
6300	160.0
8000	157.6
10000	155.7
12220	153.0
16000	150.0
20000	147.5
Overall	**180.7**

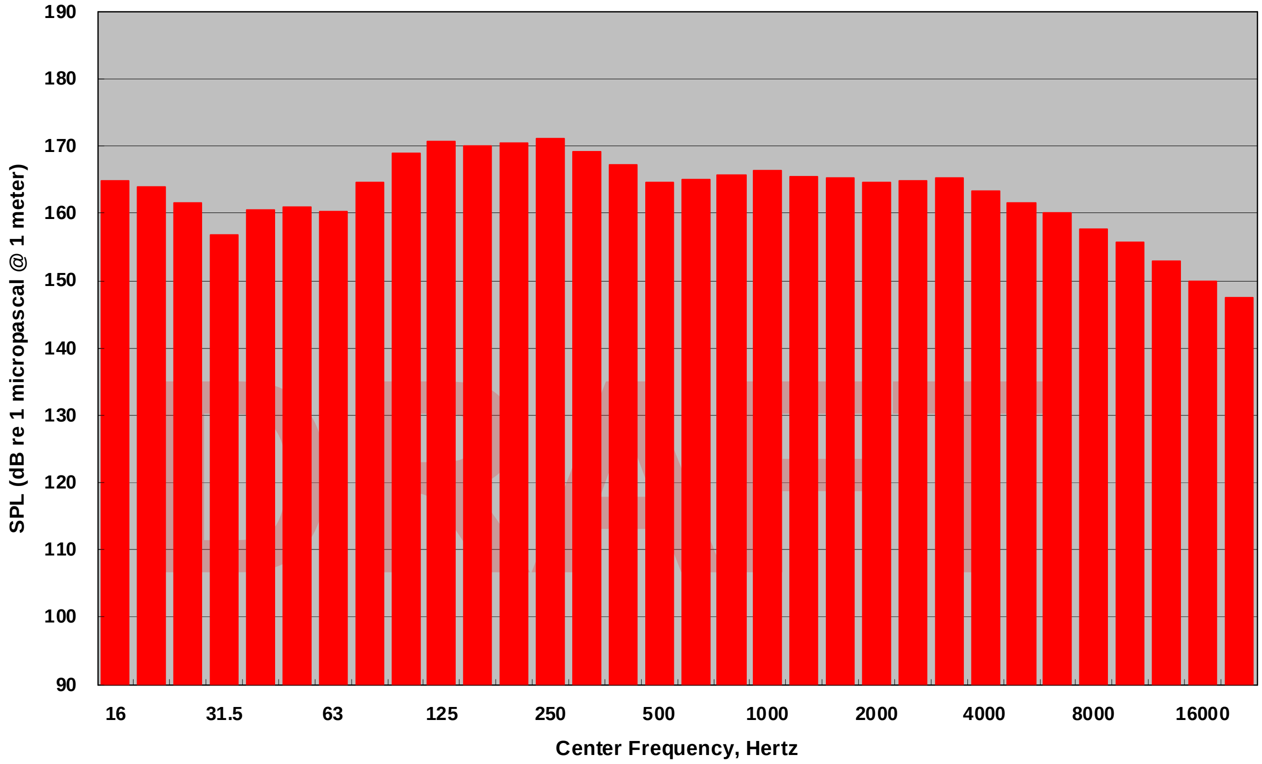


Figure 10. Sound pressure levels of stern thrusters operated at 100% load (dB re 1μPa at 1 meter)

Table 5. Summary of sound pressure levels radiated from stern thrusters (operation at 100% load)

Center Frequency Hz, 1/3 octave band	Sound Pressure Level (dB re 1μPa)		
	at 1000m	at 2000m	at 3000m
16	119.8	115.3	112.7
20	119.0	114.5	111.8
25	116.7	112.2	109.6
31.5	111.9	107.4	104.8
40	115.6	111.1	108.4
50	115.9	111.4	108.8
63	115.4	110.9	108.2
80	119.6	115.0	112.4
100	124.0	119.5	116.9
125	125.8	121.3	118.7
160	125.1	120.6	118.0
200	125.5	121.0	118.4
250	126.0	121.5	118.9
315	124.3	119.7	117.1
400	122.2	117.7	115.1
500	119.6	115.1	112.4
630	120.2	115.7	113.0
800	120.7	116.2	113.5
1000	121.4	116.9	114.3
1250	120.6	116.1	113.4
1600	120.4	115.8	113.2
2000	119.6	115.1	112.5
2500	119.8	115.3	112.6
3150	120.2	115.7	113.0
4000	118.2	113.7	111.1
5000	116.5	112.0	109.3
6300	115.0	110.4	107.7
8000	112.6	108.0	105.3
10000	110.6	106.0	103.2
12220	107.8	103.1	100.3
16000	104.8	100.0	97.1
20000	102.1	97.2	94.1
Overall	**135.7**	**131.2**	**128.6**

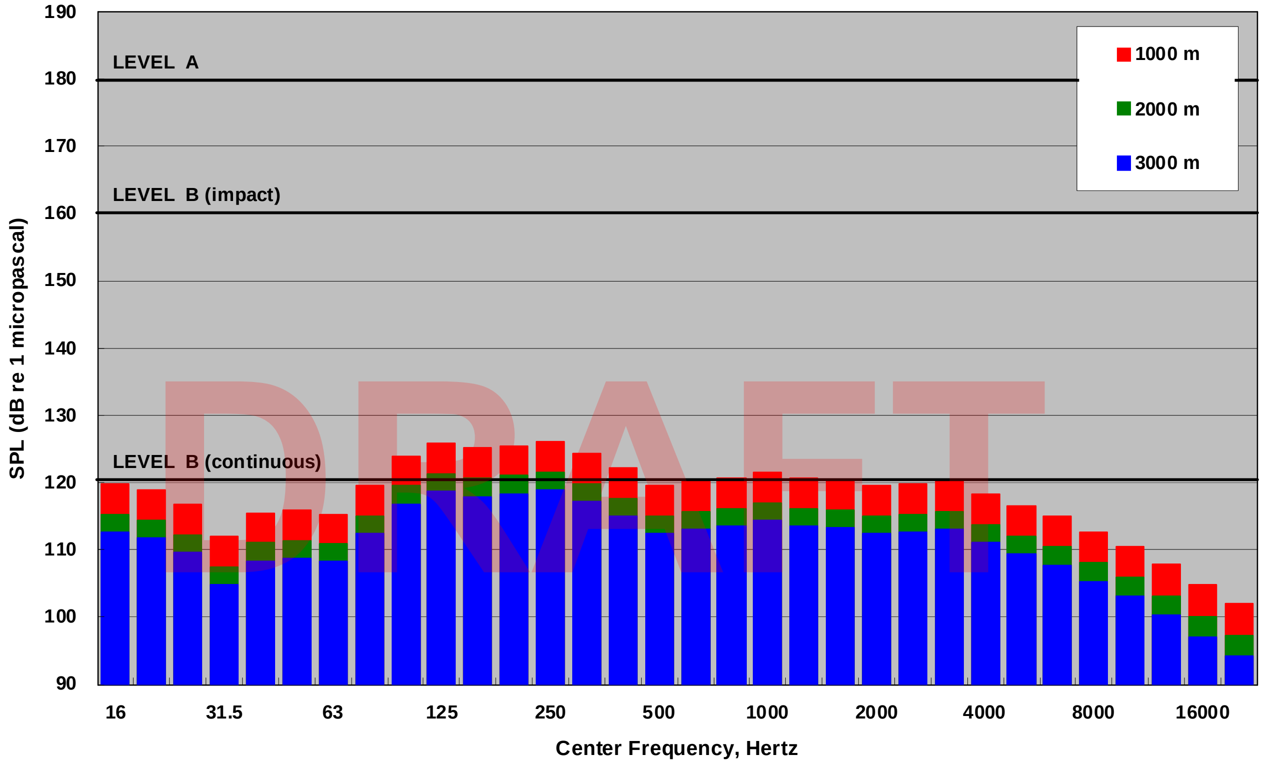


Figure 11. Sound pressure levels radiated from thrusters operated at 100% load

4. Conclusions

In the Marine Mammal Protection Act (MMPA), two levels of underwater noise harassment have been defined: Level A harassment with the potential to injure a marine mammal in the wild, and Level B harassment with the potential to disturb a marine mammal in the wild by causing disruption to behavioral patterns such as migration, breeding, feeding, and sheltering. The current thresholds are 180 dB for Level A harassment, and 160 dB (impulse) and 120 dB (continuous) for Level B harassment.

According to the results of the underwater noise measurements, it is noted that no circumstances do exceed the 180 dB Level A harassment criteria. For the stern thrusters operated at 100% load, it is expected that sound pressure levels at a distance over 3 kilometers from the subject vessel do not exceed the MMPA Level B harassment threshold of 120 dB for continuous noise.

Appendix A. Underwater Noise of Ship

Noise is generated during all phases of oil and gas production, noise sources may be continuous or impulsive and can be described as being transient or permanent. Most noise sources associated with oil and gas production can broadly classified as noise originating from (1) machinery, (2) propulsors (cavitation), (3) hydrodynamic excitation of structures (turbulent flow) or (4) impulsive sound sources (air guns / pile drivers). Underwater machinery noise is the result of mechanical vibration that is coupled to the sea via, for example, a ship hull, oil platform legs or through the ground.

Within the machinery noise class, a distinction between propulsion machinery (diesel engines, thrusters, main motors and reduction gears) and auxiliary machinery (generators, pumps and air-conditioning equipment) can be made. Secondly, propeller or thruster noise is distinguished from machinery noise in that it is the result of propulsor action and originates on the surface of the propulsor. As the propulsor rotates through the water, regions of low or negative pressure are created at its tips, if and when these negative pressures become sufficiently strong, bubbles (cavities) begin to form. These bubbles are short lived and collapse against the surface of the propeller. A sharp pulse of sound is produced as the bubble collapses and this process, "cavitation", is responsible for the loud "hiss" often associated with ships. Causes of propulsor noise are cavitation and propulsor-induced vibration. Finally, hydrodynamic noise is distinguished from cavitation noise in that it does not originate at the propeller but is caused by the flow of water past a physical structure such as the hull of a vessel. Causes of hydrodynamic noise are vortex-induced vibration, resonant excitation of appendages and breaking wave.

The intensity of a sound is defined as the acoustical power per unit area in the direction of propagation. Intensity is proportional to the square of the acoustic pressure which is defined as the sound force per unit area, and is usually measured in μPa. Ideally, acousticians would be able to measure intensity directly but practically it is easier to measure and detect changes in pressure and then convert these to intensities. It is for the reason that decibel (dB) were introduced, and the terms Sound Pressure Level (SPL) which is the sound power measured at the receiver is defined as

$$\mathrm{SPL} = 20\log\left(\frac{\mathrm{P}}{\mathrm{P_{ref}}}\right) \qquad dB \ \ re \ \ 1\mu Pa$$

Transient sounds are usually described by the peak level (the maximum amplitude measured in dB) and continuous sounds and long duration transient sounds are conventionally described by the mean square pressure.

Appendix B. Propagation of Underwater Noise

When describing the propagation of underwater noise, it is useful to apply a simplistic model to this process. These models are based on the sonar equation. The basic parameter of this model are;

1) source : the noise source. Parameter of interest = sourcel level (SL)
2) Path : the water column. Parameter of interest include transmission loss (TL), and ambient noise level (NL)
3) Receiver : e.g. whale, hydrophone etc. Parameter of interest include signal to noise ratio (SNR), receivered sound pressure level (SPL) and detection threshold (DT)

A simple model of sound propagation is SPL = SL – TL. Transmission loss is the decrease in intensity of a sound as it propagates through a medium, and is the result of spreading, absorption, scattering, reflection and refraction.

Appendix C. Transmission Loss

In traveling through the sea, an underwater sound signal becomes delayed, distorted, and weakened. Transmission loss expresses the magnitude of one of the many phenomena associated with sound propagation in the sea. Transmission loss may be considered to be the sum of a loss due to a spreading and a loss due to attenuation.

Spreading loss is a geometrical effect representing the regular weakening of a sound signal as it spreads outward from the source. For the most simple propagation condition, the power generated by the source is radiated equally in all direction so as to be equally distributed over the surface of a sphere surrounding the source. In this spherical spreading, the transmission loss increase as the square of the range. In other words, sound pressure level decreases by 6dB if distance is doubled. Actually, free-field conditions seldom exist in the sea, except at very short ranges, because of refraction, scattering, and the presence of the ocean boundaries. When the medium has plane-parallel upper and lower bounds, the spreading is no longer spherical because sound cannot cross the bounding planes. This spreading is said to be cylindrical.

Type	Transmission loss	Propagation in
No spreading	0	Tube
Cylindrical	10 Log *r*	Between parallel planes
Spherical	20 Log *r*	Free field

Absorption is a form of loss that obeys a different law of variation with range than the loss due to spreading. In seawater, the absorption of sound is caused by viscosity and ionic relaxation of the magnesium sulfate ($MgSO_4$). The ionic relaxation mechanism, together with viscosity, should yield a frequency dependence of the absorption coefficient of the form

$$\alpha = A\frac{S f_T f^2}{f_T^2 + f^2} + B\frac{f^2}{f_T}$$

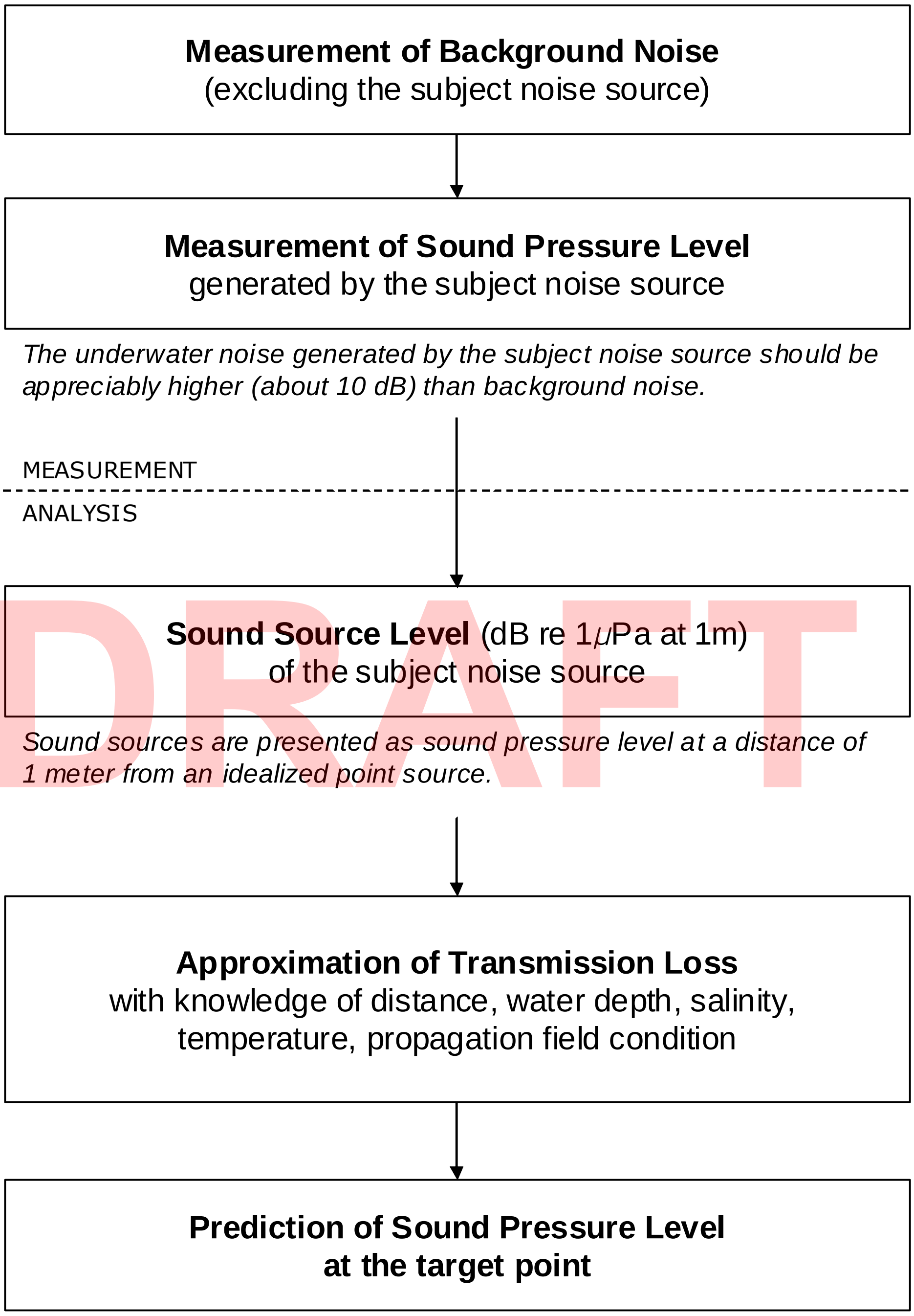
in which S is the salinity in parts per thousand (ppt); A and B are constants found to be equal to $1.86\mathrm{X}10^{-2}$ and $2.68\mathrm{X}10^{-2}$, respectively; f is the frequency in kilohertz; and f_T is the temperature-dependent relaxation frequency given by

$$f_T = 21.9\times 10^{6-1.520/(T+273)} \qquad kHz$$

where T is the temperature in degrees Celsius.

** Source : Principle of Underwater Sound, Robert J. Urick*

Appendix D. Procedure of Measurement and Analysis



The underwater noise generated by the subject noise source should be appreciably higher (about 10 dB) than background noise.

Sound sources are presented as sound pressure level at a distance of 1 meter from an idealized point source.

Appendix E. Marine Mammal Protection Act (MMPA)

Overview

The Marine Mammal Protection Act of 1972 was most recently reauthorized in 1994. In passing the MMPA in 1972, Congress found that:

- certain species and population stocks of marine mammals are, or may be, in danger of extinction or depletion as a result of man's activities;
- such species and population stocks should not be permitted to diminish beyond the point at which they cease to be a significant functioning element in the ecosystem of which they are a part, and, consistent with this major objective, they should not be permitted to diminish below their optimum sustainable population level;
- measures should be taken immediately to replenish any species or population stock which has diminished below its optimum sustainable level;
- there is inadequate knowledge of the ecology and population dynamics of such marine mammals and of the factors which bear upon their ability to reproduce themselves successfully; and
- marine mammals have proven themselves to be resources of great international significance, aesthetic and recreational as well as economic.

The MMPA established a moratorium, with certain exceptions, on the taking of marine mammals in U.S. waters and by U.S. citizens on the high seas, and on the importing of marine mammals and marine mammal products into the United States.

Harassment

Under the 1994 amendments, the Congress statutorily defined and divided the term "harassment" to mean any act of pursuit, torment, or annoyance which --

1. Level A Harassment has the potential to injure a marine mammal or marine mammal stock in the wild; or
2. Level B Harassment has the potential to disturb a marine mammal or marine mammal stock in the wild by causing disruption or behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering.

Example of Noise Exposure Criteria for Gray Whales

	Criterion	Remarks
Level A	180 dB_{rms} re 1μPa	
Level B	160 dB_{rms} re 1μPa 120 dB_{rms} re 1μPa	for impulse for continuous

Federal Register: January 11, 2005 (Volume 70, Number 7)

Appendix C.3

Neptune LNG Deep Water Port: Assessment of Underwater Noise from LNG Carrier Weathervaning on the Mooring

(JASCO Applied Sciences, November 2009)

and

Assessment of the Effects of Underwater Noise from Thrusters to be Used on the Neptune LNG Project, 2nd Supplementary Biological Effects Report

(LGL Limited, 3 December 2009)

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NEPTUNE LNG DEEP WATER PORT: ASSESSMENT OF UNDERWATER NOISE FROM LNG CARRIER WEATHERVANING ON THE MOORING

Isabelle Gaboury and Scott Carr
Version 2.1, 13 November 2009

Delivered to:
ecology and environment, inc.
368 Pleasant View Drive, Lancaster, New York 14086

Revision History

Revision	Date	Person	Reason
1.0	2009-10-02	IG	Initial Release
2.0	2009-10-05	IG	Minor formatting fixes
3.0	2009-11-13	IG	Revisions in response to comments from Doug Jones

Table of Contents

1. INTRODUCTION

Neptune, a liquefied natural gas (LNG) offshore deepwater port (DWP), is currently being built approximately 16 km (10 mi) off the coast of Gloucester, Massachusetts. The port will consist of a buoy system where LNG vessels will moor and discharge natural gas, which will then be transported via a sub-sea pipeline to an existing onshore pipeline system.

In 2005 and 2006, JASCO Research, now doing business as JASCO Applied Sciences, carried out an acoustical modeling study to predict the sound fields likely to be generated by construction, operation, and decommissioning activities associated with the Neptune project (Laurinolli *et al.* 2005; Carr *et al.* 2006). As part of this study, sound fields were estimated for LNG carrier approach, mooring, and position-keeping at two buoy locations, based on modeled LNG carrier source levels. More recently, at-sea measurements have been made for an LNG carrier similar to those expected to operate at the Neptune DWP (Samsung, 2009). In this follow-up report, we present updated model results for LNG carrier thruster use during weathervaning at the Neptune buoys, based on the measured carrier source levels. Modeling methodology, including a description of the scenarios modeled and source characterization, is presented in Section 2. Model parameters are summarized in Section 3. Finally, the results of the modeling study are presented in Section 4.

2. METHODOLOGY

2.1 Modeling Scenario

Modeling was carried out for an LNG Shuttle and Regasification Vessel (SRV) maintaining its position (weathervaning) at the north and south buoy positions described in Laurinolli *et al.* (2005) and shown in Figure 1 below. Because water column properties vary seasonally, model runs were carried out for spring, summer, fall, and winter (see section 3).

In the original weathervaning scenario (Scenario 1 of Carr *et al.* 2006), measured SRV source levels (SLs) were not available, and so source levels were modeled based on available propeller specifications, assuming simultaneous operation of two stern thrusters at 100% power. In the model scenarios described here, source levels were based on field measurements made on an SRV similar to those expected to operate at the Neptune DWP; these are discussed further in Section 2.2 below.

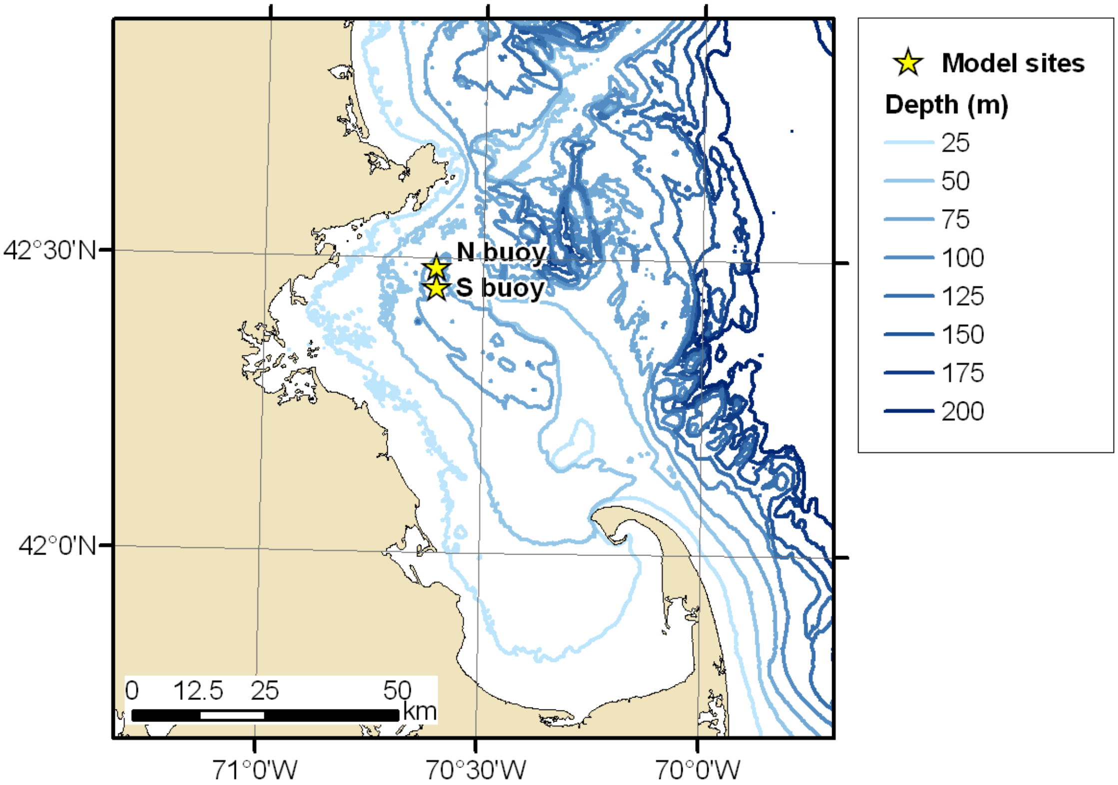

Figure 1: Buoy locations used for modeling of SRV approach and docking. Bathymetry contours are derived from the NGDC US Coastal Relief Model (NOAA Satellite and Information Service 2005).

2.2 Source Characterization

Measurements of underwater noise were made during sea trials of an HN1688 LNG SRV in June, 2009 (Samsung, 2009). The HN1688 has an overall length of 280 m and a capacity of 145,000 m^3, and is equipped with two 2,000 kW bow thrusters and two 1,200 kW stern thrusters (Samsung, 2009). Measurements were taken at close range (approximately 60 m from the SRV's stern thrusters) while both stern thrusters were operated at 100% rpm and 100% pitch, without propulsion power. The draught of the vessel was 9.60 m during the measurements. Received levels at the measurement vessel were back-propagated assuming simple spreading and absorption losses (a reasonable approach for the short range involved) to yield the source level at an idealized point source submerged at a depth of 7 m (Samsung, 2009). The resulting third-octave band source levels are shown in Table 1 and Figure 2 below.

The draught of the HN1688 during these field measurements was shallower than the vessel's design draught of 11.4 m. As a result, the 7 m source depth assumed by Samsung (2009), while appropriate for back-propagation of the measured levels, is less than the depth of the thrusters under typical operating conditions. For the water depths at the DWP buoys, an increased source depth is likely to be associated with slightly longer-range propagation of noise from the thrusters, as destructive interference with the surface-reflected signal will be less. As a result, a source depth of 9.6 m was used for the model runs in this study; this source depth corresponds roughly to the 12.4 m summer draught of the HN1688 (Samsung, 2009).

Comparing Table 1 with Table 1 of Carr *et al.* (2006), we see that the measured broadband source level is 2.2 dB lower (over a frequency range of 16 to 2000 Hz) than the modeled source level that was previously used. The measured third-octave band source levels are lower than the modeled values for frequencies up to 100 Hz, but greater for higher frequencies.

Table 1: Third-octave band source levels for the HN1688 LNG SRV, from Samsung (2009). Source levels are tabulated only for the frequency range modeled.

Frequency (Hz)	Source level (dB re 1 μPa @ 1 m)
16	164.8
20	164
25	161.7
31.5	156.9
40	160.6
50	160.9
63	160.4
80	164.6
100	169
125	170.8
160	170.1
200	170.5
250	171
315	169.3
400	167.2
500	164.6
630	165.2
800	165.7
1000	166.4
1250	165.6
1600	165.4
2000	164.6
Broadband	**180.2**

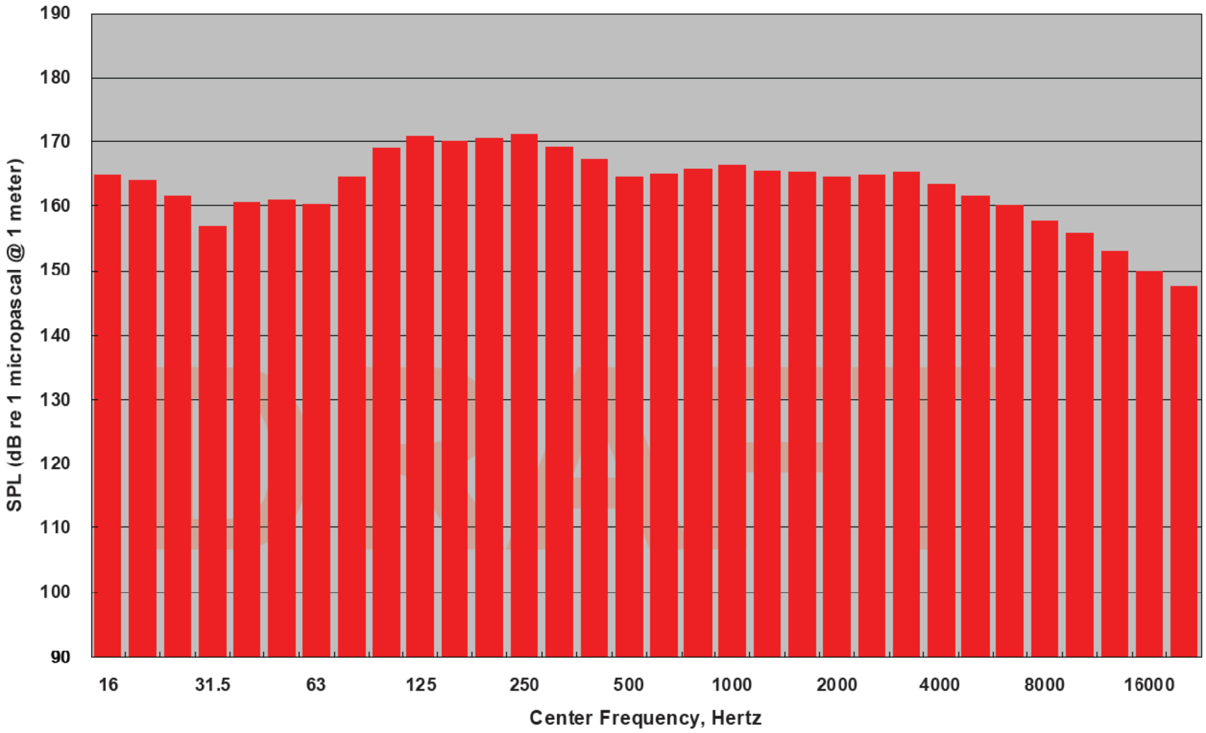

Figure 2: HN1688 SRV source levels for stern thrusters at 100% load. Figure taken from Samsung (2009).

Operation of the thrusters at 100% pitch (i.e., 100% power) is a worst case scenario in terms of underwater sound levels, as cavitation is greatest under these circumstances. Typically, thrusters are operated for only seconds at a time, and not at continuous full loading. While thrusters may be energized for a period of time when they are likely to be needed (e.g., during docking/undocking or position-keeping), during most of this time they rotate at constant RPM with the blades set at zero pitch. When the thruster propellers idle in this mode, there is very little cavitation, and so sound levels are significantly reduced. Although measurements for the current thrusters (Samsung, 2009) are only available for operation at 100% power, an example of the effect of propeller pitch on underwater source levels is provided by measurements made by JASCO in the vicinity of an offshore tug operating at various power levels (Austin *et al.*, 2005). For main propulsion on but idling (propeller power at 0%), broadband source levels were 8 dB higher when thrusters were at 100% power than when they were at 0% power (182 dB re 1 µPa @ 1 m vs. 174 dB re 1 µPa @ 1 m; Austin *et al.*, 2005). While the actual source levels for a given set of thrusters will depend on their specifications, underwater source levels during operation at 0% power are expected to be much lower than those during operation at 100% power for any controllable-pitch, fixed-RPM thruster such as the ones described in this study.

3. MARINE OPERATIONS NOISE MODEL PARAMETERS

Except where stated otherwise, the model parameters used in this study are identical to those outlined by Laurinolli *et al.* (2005) for the dynamic positioning scenarios. These are summarized below:

- Source and receiver locations (see also Figure 1 in Section 2.1):
  - North buoy: 42° 29’ 05.85” N, 70° 36’ 20.82” W
  - South buoy: 42° 27’ 05.93” N, 70° 36’ 22.52” W
  - Source depth: 9.6 m
  - Receiver depths: 1 m; 2 m; 5 m; then 5 m intervals to 50 m; then 10 m intervals to 100 m; 200 m; local bottom depth
- Frequency range: A frequency range of 16 Hz to 2 kHz was used, based on the source levels shown in Table 1 and Figure 2. The highest frequencies measured by Samsung (2009) were excluded for computational efficiency, as almost all the energy content of the vessel is at frequencies less than 2 kHz (there is less than 0.5 dB difference between the broadband source level computed over a frequency range of 16 Hz to 20 kHz and that computed over a range of 16 Hz to 2 kHz).
- Bathymetry: Bathymetry data were obtained from the NGDC US Coastal Relief Model (NOAA Satellite and Information Service 2005); the horizontal resolution of this data set is 3 arc-seconds. Contours generated from this data set are shown in Figure 1 of Section 2.1.
- Geoacoustic properties: The bottom was assumed to consist of 35 m of sand-silt-clay overlying sedimentary rocks (Laurinolli *et al.* 2008). The geoacoustic profile used for sound propagation modeling is summarized in Table 2 below.
- Sound speed profiles: Sound speed profiles were computed from historical temperature and salinity data obtained from the Marine Environmental Data Service (MEDS) for winter (Jan.-Mar.), spring (Apr.-Jun.), summer (Jul.-Sep.), and fall (Oct.-Dec.) using the formulae presented by Mackenzie (1981). As plotted in Laurinolli *et al.* (2005) and summarized in Table 3 below, the sound speed profile for winter is upward-propagating (hence minimizing bottom loss), and so most likely to be favorable to long-range sound propagation. The sound speed profiles are downward-propagating for the remaining three seasons (except for very near-surface features not relevant for the source depths under consideration here), most noticeably in the summer, and so are expected to be associated with greater loss of sound into the sea floor.

Table 2: Geoacoustic profile (mbsf = meters below sea floor)

Depth (mbsf)	Description	Density (g/cm^3)	P-wave		S-wave	
			Velocity (m/s)	Attenuation (dB/λ)	Velocity (m/s)	Attenuation (dB/λ)
0–35	sand-silt-clay	1.596	1579	0.17	310	5.4
>35	sedimentary rock	2.4	3500	0.17		

Table 3: Sound speeds (m/s) used as model input parameter

Season	Depth					
	1m	50m	100m	150m	200m	250m
winter	1465.3	1468.3	1471.0	1474.1	1477.3	1481.5
spring	1479.7	1468.6	1469.9	1473.7	1478.7	1480.4
summer	1509.6	1479.0	1473.8	1476.3	1479.9	1481.2
fall	1494.6	1485.8	1477.3	1477.6	1479.9	1484.0

4. MODEL RESULTS

The Marine Operations Noise Model (MONM) propagation model was run as described in Laurinolli *et al.* (2005). An example of the received sound field, for an SRV at the south buoy in winter, is shown in Figure 3 below. For each x,y point in Figure 3, the received level shown is the maximum over all modeled depths, down to the local sea floor depth.

Radii to threshold values of 100 to 150 dB re 1 μPa are shown in Table 4 below for the two buoy locations and four seasonal sound speed profiles. For each scenario and threshold level, Table 4 lists the 95th percentile radius, again based on maximum predicted levels over all receiver depths. Given a regularly gridded spatial distribution of modeled received levels, this defines the radius of a circle that encompasses 95% of the grid points whose value is equal to or greater than the threshold value. This definition is meaningful in terms of impact because, regardless of the geometrical shape of the noise footprint for a given threshold level, it always provides a range beyond which no more than 5% of a uniformly distributed population would be exposed to sound at or above that level. In the case of a horizontally isotropic sound field and a single receiver depth, the value of this metric is slightly smaller than the average range to the contour, one of the two metrics tabulated by Carr *et al.* (2006) (the second, area inside the contour, is discussed below). For a more irregularly shaped sound field, the 95th percentile radius is larger (i.e., more precautionary).

As expected from the sound speed profiles (Section 3), predicted radii are greatest in the winter, and smallest in the summer (Table 4). The 120 dB re 1 µPa contour (corresponding to the NMFS level B harassment criterion for continuous noise) occurs at a range of 5.8-6 km in the winter, and only 4.3-4.6 km in the summer. As noted by Samsung (2009), received levels are well below the NMFS level A harassment criterion of 180 dB re 1 µPa in all cases. Radii are not significantly different between the two buoy sites.

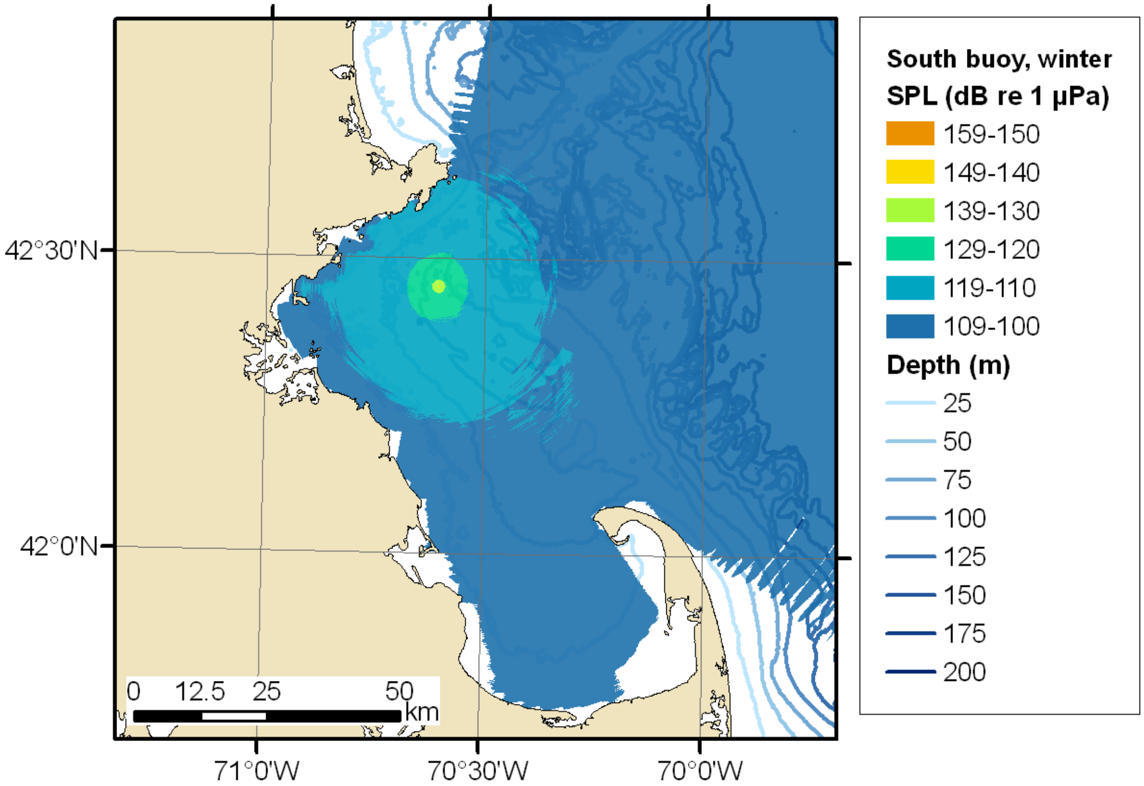

Figure 3: Estimated received levels for SRV dynamic positioning at the south buoy in winter

Table 4: Estimated 95th percentile radii for SRV dynamic positioning at the north and south mooring buoys. Model radial step size is 50 m; maximum modeled range is 75 km.

Location	**Season**	**95th percentile radius (km)**					
		150 dB re 1 µPa	**140 dB re 1 µPa**	**130 dB re 1 µPa**	**120 dB re 1 µPa**	**110 dB re 1 µPa**	**100 dB re 1 µPa**
North buoy	Winter	< 0.05	0.2	1.2	5.8	24.8	> 75
	Spring	< 0.05	0.2	1.2	5.0	13.1	29.5
	Summer	< 0.05	0.3	1.2	4.3	10.4	18.5
	Fall	< 0.05	0.2	1.2	4.7	12.1	25.3
South buoy	Winter	< 0.05	0.2	1.2	6.0	24.8	> 75
	Spring	< 0.05	0.2	1.2	5.4	14.3	28.9
	Summer	< 0.05	0.3	1.2	4.6	10.9	19.3
	Fall	< 0.05	0.2	1.2	5.0	12.8	25.9

For comparison with the model results presented by Carr *et al.* (2006), Table 5 lists the area inside the 120 dB re 1 µPa contour for both sets of source levels at the south buoy in winter. This location and season represent the worst-case scenario, i.e. the one which yields the largest ensonified areas. As can be seen from Table 5, the area inside the 120 dB re 1 µPa contour is greater for the measured SLs than for the modeled SLs for the near-surface and 50 m receiver depths. For receivers on the sea floor, the areas are not significantly different. As discussed in Section 2.2, while the measured broadband SL (Samsung, 2009) is lower than the modeled broadband SL (Carr *et al.*, 2006), the measured third-octave band levels are actually higher for frequencies greater than 100 Hz. This difference is amplified by the higher transmission losses that occur at very low frequencies, particularly for a shallow receiver (Richardson *et al.*, 1995). As a consequence, the area ensonified to a level greater than 120 dB re 1 µPa is larger for the measured thruster SLs for all but a near-bottom receiver.

Table 5: Area inside the 120 dB re 1 µPa contour for the South buoy in winter, for modeled (Carr *et al.*, 2006) and measured (Samsung, 2009) thruster source levels

Receiver depth	**Area inside the 120 dB re 1 µPa contour (km^2)**	
	Modeled thruster SLs	**Measured thruster SLs**
1 m	2.9	8.0
50 m	42.8	66.4
Bottom	48.2	47.8

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ASSESSMENT OF THE EFFECTS OF UNDERWATER NOISE FROM THRUSTERS TO BE USED ON THE NEPTUNE LNG PROJECT

2nd Supplementary Biological Effects Report

By

LGL
LIMITED
environmental research associates

For

Ecology and Environment, Inc.
368 Pleasant View Drive
Lancaster, NY
14086

LGL Report No. 4200-3

3 December 2009

ASSESSMENT OF THE EFFECTS OF UNDERWATER NOISE FROM THRUSTERS TO BE USED ON THE NEPTUNE LNG PROJECT

2nd Supplementary Biological Effects Report

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Introduction

In October 2005, LGL Limited and JASCO Research Ltd. submitted a report entitled "*Assessment of the effects of underwater noise from the proposed Neptune LNG Project*" to Ecology and Environment, Inc. A supplementary acoustic report (Carr et al. 2006) and a biological report (Davis 2006) were issued in 2006. Since then, measurements of the underwater noise emanating from the thrusters of one of the Project's newly constructed Shuttle and Regasification Vessel (SRV) have been made (Samsung 2009) and these measurements form the basis for new transmission loss modeling by JASCO Applied Sciences (Gaboury and Carr 2009). The following report evaluates the potential effects of this ship noise on marine animals in the Neptune LNG project area. The thrusters will be used when the carrier is maneuvering to dock and undock at the Deep Water Port buoys and to maintain position at the buoys in periods of rough weather. In addition, the present report assesses the potential effects of maintenance/repair activities that might be undertaken during the life of the Neptune project. This situation was not addressed in the original report (LGL and JASCO 2005).

Assessment of Noise Effects for Thrusters on the SRV

There are two situations where ship's thrusters may be used. They will be used to dynamically position the vessel at the DWP when it arrives and leaves. Thrusters may also be used under certain conditions during strong winds to maintain the heading of the vessel into the wind when competing tides operate to push the vessel broadside to the wind. The two situations are discussed here.

Dynamic Positioning during Docking and Undocking

In LGL and JASCO Research (2005), the scenario chosen for modeling noise from thrusters on the LNG carriers was based on the use of three thrusters. However, as the design of the project progressed, it was determined that a four thruster scenario was more realistic (Carr et al. 2006). The details of the ship's thrusters are now known with more certainty and actual measurements have been made (Samsung 2009). Sound transmission from the measured thrusters has been modeled by JASCO Applied Sciences (Gaboury and Carr 2009). In addition, more accurate estimates of the amount of usage of the thrusters have been made as the project design has progressed.

When a carrier arrives at the DWP, it is will use its thrusters to position the ship. Similarly, thrusters may be used during the undocking procedure. This may occur at alternate DWP buoys since only one DWP buoy is occupied at a time, with a small overlap at changeover. If it is assumed that the thrusters would be used during 50 cargos per year on average and that the average period of use would be 2 hours during docking and 1 hour during undocking per session (for no more than 20 minutes of intermittent use during each period), then the total period over the course of the year within which the thrusters would be used would be about 150 hours. The effects of noise from the operation of the thrusters while dynamically positioning at the DWP are examined in the following sections. In our supplementary report (Davis 2006), it was assumed that four thrusters (2 fore and 2 aft) would be used when positioning the vessel at the DWP buoy but that the thrusters would operate for about 20 minutes during each of the docking and undocking procedures. In the section below, we modify the period of use as discussed above.

Baleen Whales

Operation of the thrusters will create higher noise levels than the other continuous project noise sources (e.g., regasification equipment noise). The modeled scenario at the two DWP buoys with thrusters operating predicted that there would be an average area ensonified by noise levels of over 120 dB ranging from 6.0 to 115.2 km² (1.8 to 33.6 nm²) and extending out to 1.4 to 6.1 km (0.8 to 3.3 nm) from the source (see Carr et al. 2006). Based on the Department of the Navy's (2005) geospatial analysis model, the average densities of baleen whales in the Neptune area during the year are predicted to be as listed here (see Tables 4 and 5 in Section 1 of LGL and JASCO Research 2005).

North Atlantic right whale	0.01-21.14 per 1000 km²	
Humpback whale	13.85-27.71	"
Fin whale	0.00-16.45	"
Sei whale	0.00-17.27	"
Minke whale	0.00-4.66	"

Assuming that the highest number whales in the range are present all year and that the largest area (115.2 km²) is subject to 120 dB, then about 2 right whales, 3 humpback whales, 2 fin whales, 2 sei whales, and possibly 1 minke whale would be subjected to potentially disturbing levels of noise during each exposure over the course of the year. There are no data on turnover rates, making it impossible to determine the number of different whales that might be exposed to the noise. Given the very small numbers of baleen whales involved, the small amount of exposure (3 hours per cargo for each of 50 cargos per year or 150 hours per year), and the fixed locations of the noise sources, it is not likely that there will be any effects on baleen whale populations or on individual whales from the use of the carrier's thrusters for positioning at the DWP buoys. In fact, the thrusters will be used intermittently for only 33 hours within the 150 hour period (40 minutes per cargo for each of 50 cargos per year or 33 hours per year).

Toothed Whales or Odontocetes

Noise emanating from thruster operations would ensonify an area with noise levels of over 120 dB ranging from 6.0 to 115.2 km² (1.8 to 33.6 nm²) and extending out to 1.4 to 6.1 km (0.8 to 3.3 nm) from the source (Carr et al. 2006). Based on the Department of the Navy's (2005) geospatial analysis model, the average densities of toothed whales in the Neptune area during the year are predicted to be as listed here (see Tables 4 and 5 in Section 1 in LGL and JASCO Research 2005).

Long-finned pilot whale	0.01-271.42 per 1000 km²	
Bottlenose dolphin (fall only)	0.03-278.81	"
Atlantic white-sided dolphin	0.00-265.21	"
Risso's Dolphin (fall only)	0.00-503.06	"
Common Dolphin (fall only)	0.00-464.07	"
Harbor Porpoise	0.00-162.36	"

It should be remembered that dolphin distribution is generally patchy with a few large pods being present rather than an even distribution.

Assuming that the highest number whales in the range are present and that the largest area (115.2 km²) is subject to 120 dB, then about 31 pilot whales, 31 white-sided dolphins, and 19 harbor porpoises would be subjected to potentially disturbing levels of noise during each exposure over the course of the year. During the fall period, an additional 32 bottlenose dolphins, 58 Risso's dolphins, and 53 common dolphins might be exposed during this three-month period. Again, there are no data on turnover rates, making it impossible to determine the number of different whales that might be exposed to the noise. Given the patchy distribution of the toothed whales involved, the small amount of exposure (33.3 hours during a 150 hour period per year), and the fixed locations of the noises sources, it is not likely that there will be any important effects on odontocete populations or on individual whales caused by the proposed use of thrusters to dynamically position the carrier at the DWP buoys.

Pinnipeds or Seals

Noise emanating from the dynamic positioning operation would ensonify an area with noise levels of over 120 dB ranging from 6.0 to 115.2 km² (1.8 to 33.6 nm²) and extending out to 1.4 to 6.1 km (0.8 to 3.3 nm) from the source (Carr et al. 2006). According to the Department of the Navy's (2005) geospatial analysis model, the only seal that regularly occurs in the Neptune area is the harbor seal in winter (see Tables 4 and 5 in Section 1 of LGL and JASCO Research 2005). Using the assumptions developed for whales, it can be calculated that about 8 harbor seals would be exposed to noise levels above 120 dB during winter. Given the infrequency of the use of the thrusters (8.3 hours over a 37.5 hour period during winter) and the observed ability of harbor seals to habituate to human activities including noise, it is unlikely that there will be any deleterious effects on the harbor seal population or on individual seals from the positioning operations of the LNG carriers.

Sea Turtles

Two species of sea turtle occur in the Neptune area and Massachusetts Bay in summer (see LGL and JASCO 2005). The leatherback turtle was not recorded on systematic surveys in the Neptune area but was found in densities of 0-3.46 per 1000 km² in the Massachusetts Bay area. The loggerhead turtle was recorded at densities of 0.00-47.27 per 1000 km² in the Neptune area (U.S. Navy 2005).

The effects of underwater noise on sea turtles are not well studied. There are no safety criteria for sea turtles similar to those used by NMFS for marine mammals. A criterion of 130 dB for continuous sounds was calculated in LGL and JASCO (2005). Based on the modeled results in Carr et al. (2006), the estimated 130 dB ensonified zone was of 1 to 17 km² extending out to 0.5 to 2.4 km. The high end of the density estimate for loggerhead turtles in the Neptune area during summer was 47.27 per 1000 km². Assuming a maximum area (17 km²) ensonified by received levels above 130 dB and assuming that the maximum density of turtles are present and evenly distributed, then an average of 1 loggerhead turtle would be present in the area ensonified by potentially disturbing noise levels or one turtle every five dockings/undockings. It is possible that single leatherback and Kemp's Ridley Turtles could be exposed in summer. It is concluded, based on the small area ensonified, the short period of exposure, and the small number of turtles that might be disturbed, that the effects of noise would be negligible on turtle populations and on individual turtles.

Weathervaning (Maintaining Position on the Mooring)

If the thrusters need to be used to maintain position at the DWP in some circumstances, then it is assumed that the two stern thrusters would operate at 100% load. It should be noted that in circumstances when it is necessary to operate the thrusters, the ambient noise will likely already be high as a result of the wind and associated wave noise. It is not known how often the two stern thrusters will be operated while the vessel is regasifying at the DWP. For the purposes of this analysis it is assumed that the thrusters will operate for 200 hours per year to maintain position on the mooring. It is further assumed that the thrusters will be used evenly over the year with about 50 hours per quarter. The effects of noise from the operation of the stern thrusters while moored to the DWP are examined in the following sections. The noise from the thrusters will be intermittent during the periods that they are used.

Baleen Whales

Operation of the thrusters will create higher noise levels than the other continuous project noise sources. The revised modeled scenario at the two DWP buoys with two stern thrusters operating predicted that there would be an average area ensonified by noise levels of over 120 dB ranging from 58.1 to 113.1 km^2 (16.9 to 33.0 nm^2) and extending out to 4.3 to 6.0 km (2.3 to 3.2 nm) from the source (see Gaboury and Carr 2009). Based on the Department of the Navy's (2005) geospatial analysis model, the average densities of baleen whales in the Neptune area during the year are predicted to be as listed here (see Tables 4 and 5 in Section 1 of LGL and JASCO Research 2005).

North Atlantic right whale	0.01-21.14	per 1000 km^2
Humpback whale	13.85-27.71	"
Fin whale	0.00-16.45	"
Sei whale	0.00-17.27	"
Minke whale	0.00-4.66	"

Assuming that the highest number whales in the range are present all year and that the largest area (113.1 km^2) is subject to 120 dB, then about 2 right whales, 3 humpback whales, 2 fin whales, 2 sei whales, and less than 1 minke whale would be subjected to potentially disturbing levels of noise during each exposure over the course of the year. There are no data on turnover rates, making it impossible to determine the number of different whales that might be exposed to the noise. Given the very small numbers of baleen whales involved, the relatively small amount of exposure, and the fixed locations of the noises sources, it is not likely that there will be any important effects on baleen whale populations or on individual whales from the use of the carrier's thrusters at the DWP buoys.

Toothed Whales or Odontocetes

Noise emanating from thruster operations would ensonify an area with noise levels of over 120 dB ranging from 58.1 to 113.1 km^2 (16.9 to 33.0 nm^2) and extending out to 4.3 to 6.0 km (2.3 to 3.2 nm) from the source (see Gaboury and Carr 2009). Based on the Department of the Navy's (2005) geospatial analysis model, the average densities of toothed whales in the Neptune area during the year are predicted to be as listed here (see Tables 4 and 5 in Section 1 in LGL and JASCO Research 2005).

Long-finned pilot whale	0.01-271.42	per 1000 km^2
Bottlenose dolphin (fall only)	0.03-278.81	"
Atlantic white-sided dolphin	0.00-265.21	"
Risso's Dolphin (fall only)	0.00-503.06	"
Common Dolphin (fall only)	0.00-464.07	"
Harbor Porpoise	0.00-162.36	"

It should be remembered that dolphin distribution is generally patchy with a few large pods being present rather than an even distribution.

Assuming that the highest number whales in the range are present and that the largest area (113.1 km^2) is subject to 120 dB, then about 30 pilot whales, 30 white-sided dolphins, and 18 harbor porpoises would be subjected to potentially disturbing levels of noise during each exposure over the course of the year. During the fall period, an additional 32 bottlenose dolphins, 57 Risso's dolphins, and 52 common dolphins might be exposed during this three-month period. Again, there are no data on turnover rates, making it impossible to determine the number of different whales that might be exposed to the noise. Given the patchy distribution of toothed whales involved, the relatively small but unknown amount of exposure, and the fixed locations of the noises sources, it is not likely that there will be any important effects on odontocete populations or on individual whales caused by the proposed use of thrusters to maintain the carrier at the DWP buoys.

Pinnipeds or Seals

Noise emanating from the maneuvering operation would ensonify an area with noise levels of over 120 dB ranging from 58.1 to 113.1 km^2 (16.9 to 33.0 nm^2) and extending out from 4.3 to 6.0 km (2.3 to 3.2 nm) from the source (Gaboury and Carr 2009). According to the Department of the Navy's (2005) geospatial analysis model, the only seal that regularly occurs in the Neptune area is the harbor seal in winter with average densities of 0.0 to 65.84 per 1000 km^2 (LGL and JASCO Research 2005). Using the assumptions developed for whales, it can be calculated that about 7 harbor seals would be exposed to noise levels above 120 dB during each event during the winter. Given the infrequency of the use of the thrusters (50 hours) and the observed ability of harbor seals to habituate to human activities including noise, it is unlikely that there will be any deleterious effects on the harbor seal population or on individual seals from the maneuvering operations of the LNG carriers.

Sea Turtles

Two species of sea turtle occur in the Neptune area and Massachusetts Bay in summer (see LGL and JASCO 2005). The leatherback turtle was not recorded on systematic surveys in the Neptune area but was found in densities of 0-3.46 per 1000 km² in the Massachusetts Bay area. The loggerhead turtle was recorded at densities of 0.00-47.27 per 1000 km² in the Neptune area (U.S. Navy 2005).

The effects of underwater noise on sea turtles are not well studied. There are no safety criteria for sea turtles similar to those used by NMFS for marine mammals. A criterion of 130 dB for continuous sounds was calculated in LGL and JASCO (2005). Based on the modeled results in JASCO 2006, we estimated a 130 dB ensonified zone of 4.5 km² extending out to 1.2 km. The high end of the density estimate for loggerhead turtles in the Neptune area during summer was 47.27 per 1000 km². Assuming a maximum area (4.5 km²) ensonified by received levels above 130 dB and assuming that the maximum density of turtles are present and evenly distributed, then on average less than one (0.21) loggerhead turtle would be present in the area ensonified by potentially disturbing noise levels. It is concluded, based on the relatively small area ensonified, and the small number of turtles that might be disturbed, that the effects of noise would be negligible on turtle populations and on individual turtles.

Assessment of Noise Effects from Maintenance/Repair Activities

During the life of the project, it may be necessary for maintenance and repair activities to be undertaken. To provide a worst case scenario, it is assumed that the noise generated by these activities would be similar to that generated during the offshore construction of the facilities. Sound levels associated with the vessels used during construction of the pipeline routes were presented in Section 3 of LGL and JASCO (2005). In that report, construction of the Northern Pipeline Route was expected to produce received noise levels of 120 dB that would extend out from 6.5 to 7.6 km and encompass areas ranging from 120 to 152 km². The maintenance/repair activities are estimated to last for 28 days (672 hours) and could occur at any season.

Baleen Whales

Based on the Department of the Navy's geospatial analysis model, the average densities of baleen whales in the Neptune area during the year are predicted to be as listed here.

North Atlantic right whale	0.01-21.14 per 1000 km²	
Humpback whale	13.85-27.71	"
Fin whale	0.00-16.45	"
Sei whale	0.00-17.27	"
Minke whale	0.00-4.66	"

Assuming that the highest number whales in the range are present and that the largest area (152 km²) is subject to 120 dB, then about 3 right whales, 4 humpback whales, 3 fin whales, 3 sei whales, and 1 minke whale would be subjected to potentially disturbing levels of noise during parts of the one month repair period. There would likely be some turnover of individuals during the one month period; thus, more individuals would be affected but for shorter periods assuming that the average density remains the same. There are no quantitative data on turnover rates. Given the small numbers of baleen whales involved and the slowly moving nature of a pipeline repair operation, it is not likely that there would be any important effects on baleen whale populations or on individual whales.

Toothed Whales or Odontocetes

Based on the Department of the Navy's (2005) geospatial analysis model, the average densities of toothed whales in the Neptune area during the year are predicted to be as listed here (see Tables 4 and 5 in Section 1 in LGL and JASCO Research 2005).

Long-finned pilot whale	0.01-271.42	per 1000 km²
Bottlenose dolphin (fall only)	0.03-278.81	"
Atlantic white-sided dolphin	0.00-265.21	"
Risso's Dolphin (fall only)	0.00-503.06	"
Common Dolphin (fall only)	0.00-464.07	"
Harbor Porpoise	0.00-162.36	"

It should be remembered that dolphin distribution is generally patchy with a few large pods being present rather than an even distribution.

Assuming that the highest number whales in the range are present and that the largest area (152 km²) is subject to 120 dB, then about 41 pilot whales, 40 white-sided dolphins, and 25 harbor porpoises would be subjected to potentially disturbing levels of noise during each exposure over the course of the year. If the repairs occur during the fall period, an additional 42 bottlenose dolphins, 76 Risso's dolphins, and 70 common dolphins might be exposed during the approximately one-month period. Again, there are no data on turnover rates, making it impossible to determine the number of different whales that might be exposed to the noise. Given the patchy distribution of toothed whales involved, the relatively small but unknown amount of exposure, and the fixed locations of the noises sources, it is not likely that there will be any important effects on odontocete populations or on individual whales caused by the proposed use of thrusters to maintain the carrier at the DWP buoys.

Pinnipeds or Seals

According to the Department of the Navy's (2005) geospatial analysis model, the only seal that regularly occurs in the Neptune area is the harbor seal in winter with average densities of 0.0 to 65.84 per 1000 km² (LGL and JASCO Research 2005). Using the assumptions developed for whales, it can be calculated that about 10 harbor seals would be exposed to noise levels above 120 dB if the repairs were conducted during the winter. Given the observed ability of harbor seals to habituate to human activities including noise, it is unlikely that there will be any deleterious effects on the harbor seal population or on individual seals even if the repairs are conducted during winter.

Sea Turtles

Two species of sea turtle occur in the Neptune area and Massachusetts Bay in summer (see LGL and JASCO 2005). The leatherback turtle was not recorded on systematic surveys in the Neptune area but was found in densities of 0-3.46 per 1000 km² in the Massachusetts Bay area. The loggerhead turtle was recorded at densities of 0.00-47.27 per 1000 km² in the Neptune area (U.S. Navy 2005).

The effects of underwater noise on sea turtles are not well studied. There are no safety criteria for sea turtles similar to those used by NMFS for marine mammals. A criterion of 130 dB for continuous sounds was calculated in LGL and JASCO (2005). The estimated 130 dB ensonified zone was 27 to 32 km² extending out to 3.2 km. The high end of the density estimate for loggerhead turtles in the Neptune area during summer was 47.27 per 1000 km². Assuming a maximum area (32 km²) ensonified by received levels above 130 dB and assuming that the maximum density of turtles are present and evenly distributed, then on average 1-2 loggerhead turtles would be present in the area ensonified by potentially disturbing noise levels. It is concluded, based on the relatively small area ensonified, and the small number of turtles that might be disturbed, that the effects of noise would be negligible on turtle populations and on individual turtles.

Approach to Estimating "Takes"

In the above analyses, the numbers of animals that would be exposed to received sound levels of 120 dB (or 130 dB for sea turtles) have been estimated, as the basis for determining "takes" as defined under the MMPA. In the analyses, a number of very conservative assumptions have been used. These include

- The maximum density for each species recorded during the year has been used even though the species might be completely absent at some times of the year.
- It has been assumed that the animals have been at the water depth with the maximum received sound levels.
- The sizes of the ensonified areas have been determined using the largest radius for the season with the greatest sound transmission. Therefore, the largest ensonified area has been used even though that maximum size would be applicable for only one of the four seasons.
- In addition, the 120 dB criterion itself is ultra-conservative since it was derived in areas of minimal background shipping noise with possibly naive animals. The animals in the Neptune study area are already exposed to consistently high levels of shipping noise in this busy area.

The reason for taking this conservative approach is that we have no quantitative information on the turnover rates for the animals in the area. Each animal that is exposed to received levels of 120 dB or more is considered to be a "take" under the MMPA. By using the worst case assumptions about numbers of marine mammals and sizes of the areas affected, we are attempting to counter the non-conservative assumption that there is little or no turnover among the animals.

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Appendix D

Neptune Deepwater Port Marine Mammal Detection, Monitoring, and Response Plan for the Operations Phase (January 2010)

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Neptune Deepwater Port

Marine Mammal Detection, Monitoring, and Response Plan for the Operations Phase

January 2010

Neptune LNG LLC
One Liberty Square, 10th Floor
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Acronyms and Abbreviations

AB	auto-detection buoy
AIS	Automatic Identification System
ARU	Autonomous Recording Unit
ATBA	Area to be Avoided
BO	Biological Opinion
BRP	(Cornell University) Bioacoustics Research Program
CFR	Code of Federal Regulations
dB	decibel(s)
DMA	Dynamic Management Area
DP	dynamic positioning
DWP License	Deepwater Port License issued by the Maritime Administration
DWP	deepwater port
ESA	Endangered Species Act
GT	gross ton(s)
IMO	International Maritime Organization
ITS	Incidental Take Statement
LNG	liquefied natural gas
LOA	Letter of Authorization
LT	Local Time
MARAD	U.S. Maritime Administration
MMDMRP	Marine Mammal Detection, Monitoring, and Response Plan
MMPA	Marine Mammal Protection Act
MMOs	marine mammal observers
MSRA	Mandatory Ship Reporting Area
MSRS	Mandatory Ship Reporting System
NARW	North Atlantic right whale
NAVTEX	navigational telex
Neptune	*Neptune* liquefied natural gas deepwater port; also *Neptune* DWP
Neptune LNG	Neptune LNG LLC

NERO	(National Marine Fisheries Service) Northeast Regional Office
NMFS	National Marine Fisheries Service
NMSA	National Marine Sanctuary Act
NOAA	National Oceanic and Atmospheric Administration
ONMS	(National Oceanic and Atmospheric Administration) Office of National Marine Sanctuaries
Operational MMDMRP	*Marine Mammal Detection, Monitoring, and Response Plan for the Operations Phase*
PAM	Passive Acoustic Monitoring (Program)
PMMP	Prevention, Monitoring, and Mitigation Plan
port, the	the *Neptune* liquefied natural gas deepwater port
SAS	Sighting Advisory System
SBNMS	Stellwagen Bank National Marine Sanctuary
Secretary, the	Secretary of Commerce
SMA	Seasonal Management Area
SRV	shuttle and regasification vessel
TSS	Traffic Separation Scheme
USCG	U.S. Coast Guard
VHF	very high frequency
WHOI	Woods Hole Oceanographic Institution
ZOI	Zone of Influence

1 Introduction

This *Marine Mammal Detection, Monitoring, and Response Plan for the Operations Phase* (Operational MMDMRP) (also referred to hereinafter as the plan) provides detailed information on the avoidance and mitigation of potential impacts to marine mammals and sea turtles resulting from operational activities conducted by Neptune LNG LLC (Neptune LNG) at its *Neptune* liquefied natural gas (LNG) deepwater port (DPW) (referred to herein as the port; also *Neptune* DWP) in Massachusetts Bay. During port operations, marine mammals and sea turtles may be affected as a result of vessel strikes or by underwater sound generated through the use of equipment or during vessel movement. The monitoring plan and mitigation techniques described in this document were directed by the National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) as the terms and conditions within the Biological Opinion (BO) issued pursuant to the Endangered Species Act (ESA) and have been imposed in license conditions by the U.S. Maritime Administration (MARAD) and the U.S. Coast Guard (USCG). This plan also incorporates recommendations made by the Stellwagen Bank National Marine Sanctuary (SBNMS) that were accepted by USCG and MARAD. It should be noted, however, that this Operational MMDMRP may be subsequently modified based on final regulations and subsequent Letters of Authorization (LOAs), anticipated to be issued pursuant to Section 101(a)(5)(A) of the Marine Mammal Protection Act (MMPA) for *Neptune* DWP operations. The issuance of the final regulations is anticipated in June 2011.

1.1 Neptune DWP Description and Operations

On March 23, 2007, Neptune LNG received a license from MARAD (the DWP License) to own, construct, and operate *Neptune,* a DWP approximately 22 miles northeast of Boston, Massachusetts. The purpose of the *Neptune* DWP is for the importing of LNG into the New England region. At the port, LNG will be regasified and transported via submerged unloading buoys connecting to an underwater pipeline lateral that, in turn, connects to the existing Algonquin HubLine^{SM}. The *Neptune* DWP has an expected operating life of approximately 20 years.

Construction of *Neptune* began in July 2008. Upon completion of construction, *Neptune* will be capable of mooring up to two LNG shuttle and regasification vessels (SRVs), each with a capacity of approximately 140,000 cubic meters, at its submerged unloading buoy system. The two separate submerged unloading buoys will allow natural gas to be delivered in a continuous flow, without interruption. There will be a brief overlap between arriving and departing SRVs.

The SRVs calling at *Neptune* will approach and depart the port using the International Maritime Organization (IMO)-approved Boston Traffic Separation Scheme (TSS). When transiting the TSS to and from *Neptune*, the SRVs will be operated in accordance with the seasonal regulations governing vessel speeds that were issued by the NMFS on October 10, 2008, for the purpose of reducing the threat of ship collisions with North Atlantic right whales (NARWs). When there are active Dynamic Management Areas (DMAs)[1] (regardless of location or season), active acoustic detections of NARWs, or both, in the vicinity of the transiting SRV in the TSS or at *Neptune*, the vessels will slow their speeds to 10 knots or less.

The SRV will leave the TSS, pick up a pilot inside the precautionary area and make its final approach to the port at speeds of 10 knots or less. Vessel speed will gradually be reduced to less than

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[1] Dynamic Management Area (DMA): Temporary ship strike management areas established by the National Marine Fisheries Service to protect aggregations of right whales that have been sighted outside of Seasonal Management Areas. The National Marine Fisheries Service requests that vessels transit through DMAs at 10 knots or less or route around them.

1 knot within 500 meters of the *Neptune* unloading buoy. When an SRV arrives at the port, it will retrieve one of the two permanently anchored submerged unloading buoys. It will make final connection to the buoy through a series of engine and bow thruster actions.

Neptune will use both bow and stern thrusters when approaching the unloading buoy and when docking the buoy inside the Submerged Turret Loading (STL) compartment, as well as when releasing the buoy after the regasifying process is finished. The thrusters will be energized for up to two hours during the docking process and up to one hour during the undocking/release process. When energized, the thrusters will rotate at a constant RPM with the blades set at zero pitch. There will be little cavitation when the thruster propellers idle in this mode. The sound levels in this operating mode are expected to be approximately 8 decibels (dB) less than at 100 percent load, based on measured data from other vessels.

When the thrusters are engaged, the pitch of the blades will be adjusted in short bursts for the amount of thrust needed. These short bursts will cause cavitation and elevated sound levels. The maximum sound level with two thrusters operating at 100 percent load will be 180 dB re 1 μPa @ 1m. This is not the normal operating mode, but a worst-case scenario. Typically, thrusters are operated for only seconds at a time and not at continuous full loading. These thrusters will be engaged for no more than 20 minutes, in total, when docking at the buoy. The same applies for the undocking scenario.

1.2 Regulatory Requirements for Marine Mammal Detection, Monitoring, and Mitigation and Relationship to this Plan

The requirements of the ESA and the MMPA mandate that *Neptune* minimize the “take” of listed and protected species during port operations. The BO issued by NMFS on January 12, 2007, under the requirements of Section 7 of the ESA states that *Neptune* DWP operations may affect, but are not likely to adversely affect, three listed species of whales (sei whale, blue whale, sperm whale) and four species of sea turtles (loggerhead sea turtle, leatherback sea turtle, Kemp ridley’s sea turtle, green sea turtle) known to be present in the vicinity of the port. The BO also states that *Neptune* operations may adversely affect, but are not likely to jeopardize the continued existence of three species of listed whales (NARW, humpback, and fin). The terms and conditions of the BO are designed to mitigate the potential for adverse effects to federally listed species.

Additionally, other marine mammals not listed as endangered or threatened, but protected under the MMPA, may be present in the area and may potentially be harassed by operational activities at *Neptune,* including the use of underwater sources of sound such as the thrusters. Any operational activity that may result in harassment of a species (i.e., a take of these species), as defined by the MMPA, must be minimized and mitigated. The MMPA directs the Secretary of Commerce (Secretary) to allow a requested incidental taking of small numbers of protected marine mammals during periods of not more than five consecutive years each if the Secretary finds that the total taking will have a negligible impact on the affected species or stocks and not have an unmitigable adverse impact on the availability of the species or stock(s) for subsistence use. A key part of this process is the publication of regulations (i.e., a Rule) setting forth the permissible methods of taking and other means of effecting the least practicable adverse impact, as well as requirements pertaining to the monitoring and reporting of such taking. However, the Final Rule adopted by NMFS does not in itself authorize the taking of marine mammals. Based on the parameters identified in the Final Rule, the NMFS will annually (over a five-year period) authorize incidental take through the issuance of LOAs (50 Code of Federal Regulations [CFR] 216.106). An application for an LOA was submitted to the NMFS in March 2007 and a Notice of Receipt of the Application was published in the *Federal Register* on February 19, 2008. Since construction continued in 2009, a second IHA and ITS to cover the remaining construction period and port commissioning were issued in June 2009 and became effective July 1, 2009. A third IHA/ITS will be sought to cover the commissioning of the second SRV and limited port operations, to become effective July 1, 2010. The final rule and LOA to cover full port operations are projected to be issued in June 2011, to become effective July 1, 2011.

This Operational MMDMRP has been developed to support implementation of the mitigation and monitoring measures pertaining to marine animals identified in the BO and anticipated in the Final Rule and subsequent first annual LOA. This Operational MMDMRP applies specifically to *Neptune* and SRV vessels calling at the port, support vessels, and other vessels used in the port maintenance and repair activities. It is a component of the Prevention, Monitoring, and Mitigation Plan (PMMP) prepared for the port in accordance with Condition 12 of Annex A to *Neptune*'s DWP License. The PMMP is comprised of all federal, state, and local environmental permits, certificates, licenses, and approved monitoring and mitigation plans obtained by Neptune LNG to support the collective preconstruction, construction, post-construction, operation, maintenance and repair, and decommissioning of the *Neptune* DWP and pipeline lateral.

The intent of the information presented in this Operational MMDMRP is to serve as a guide to help *Neptune* personnel better understand the day-to-day procedural requirements for marine mammal protection as identified in the:

- DWP License;
- ESA BO;
- MMPA IHA/ITS expected to become effective on July 1, 2010;
- MMPA LOA when issued in June 2011 (anticipated effective date of July 1, 2011); and
- National Marine Sanctuary Act (NMSA) Section 304 (d) Recommendations.

This Operational MMDMRP does not supersede any of the conditions of the DWP License or the NOAA authorizations listed above. Even so, it is of paramount importance to recognize that the safety of a vessel, its crew, and cargo must be maintained at all times during port operations. The procedures outlined within the context of this Operational MMDMRP must be adhered to at all times except under extraordinary circumstances when the safety of the vessel, crew, or cargo is in doubt. As defined in the DWP License issued on March 23, 2007, and the BO Incidental Take Statement (ITS) (as amended on June 6, 2008), extraordinary circumstances are defined as instances when the vessel's Master:

- Determines that compliance is not possible "taking into account safety and weather conditions" (BO, Section 2.4, Operational Mitigation Measures);
- Determines that "hydrographic, meteorological, or traffic conditions dictate prudent deviation from these procedures to maintain the safety or maneuverability of the vessel" (BO, Section 2.4, Operational Mitigation Measures); and
- Must "respond to safety concerns or for safety reasons or exigent circumstances in existence at the time of such approach or departure" from *Neptune* (DWP License, Annex A, Section 12(b)(ii)(c)(i)).

In all cases where the vessel Master cannot execute the mitigation and monitoring requirements in this Operational MMDMRP due to the above-mentioned extraordinary conditions, each such deviation shall be documented in the log book of the vessel and reported at the conclusion of the regasification activities of the SRV to the NMFS Northeast Regional Office (NMFS/NERO) Ship Strike Coordinator and the NOAA staff at SBNMS.

2 Reporting SRV Activities within the MSRA to USCG

Since the *Neptune* area is within the Mandatory Ship Reporting Area (MSRA), all SRVs transiting to and from *Neptune* shall report their activities to the mandatory reporting section of the USCG to remain apprised of NARW movements within the area. All vessels entering and exiting the MSRA shall report their activities to WHALESNORTH. Vessel operators shall contact the USCG by standard procedures promulgated through the Notice to Mariner system.

3 Passive Acoustic Detection Network and Right Whale Notification Protocol

Neptune LNG will deploy and maintain a passive acoustic detection network along a portion of the TSS and in the vicinity of *Neptune*. This network will consisting of autonomous recording units (ARUs) and near-real-time auto-detection buoys (ABs). To develop, implement, collect, and analyze the acoustic data obtained from deployment of the ARUs and ABs, as well as to prepare reports and maintain the passive acoustic detection network, Neptune LNG has engaged the Cornell University Bioacoustic Research Program (BRP) in Ithaca, New York, and the Woods Hole Oceanographic Institution (WHOI) in Woods Hole, Massachusetts.

3.1 Components of the Passive Acoustic Detection Network

During June 2008, an array of 19 passive seafloor ARUs was deployed by BRP for *Neptune*. The layout of the array centered on the terminal site and was used to monitor the noise environment in Massachusetts Bay in the vicinity of *Neptune* during construction of the port and associated pipeline lateral. The ARUs are depicted on Figure 1. The ARUs were not designed to provide real-time or near-real-time information about vocalizing whales. Rather archival noise data collected from the ARU array were used for the purpose of understanding the seasonal occurrences and overall distributions of whales (primarily NARWs) within approximately 10 nautical miles of the *Neptune* DWP. The data were also used to measure and document the noise “budget” of Massachusetts Bay. Neptune LNG will maintain these ARUs in the same configuration for a period of five years during full operation of *Neptune* in order to monitor the actual acoustic output of port operations and to alert NOAA to any unanticipated adverse effects of port operations, such as large scale abandonment by marine mammals of the area. To further assist in evaluations of the *Neptune*’s acoustic output, source levels associated with dynamic positioning (DP) of SRVs at the buoys will be estimated using empirical measurements collected from the passive detection network.

In addition to the ARUs, Neptune LNG has deployed 10 ABs (Figure 2) within the Separation Zone of the TSS for the operational life of *Neptune*. The purpose of the AB array is to detect the presence of vocalizing NARWs. Each AB has an average detection range of 5 nautical miles of the AB, although detection ranges will vary based on ambient underwater conditions. The AB system will be the primary detection mechanism that alerts the SRV Master to the occurrence of NARWs in the TSS and triggers heightened SRV awareness.

The configurations of the ARU array and AB network presented in this plan (Figure 3) were based upon the configurations developed and recommended by NOAA personnel.

Figure 1. Autonomous Recording Units (ARUs)

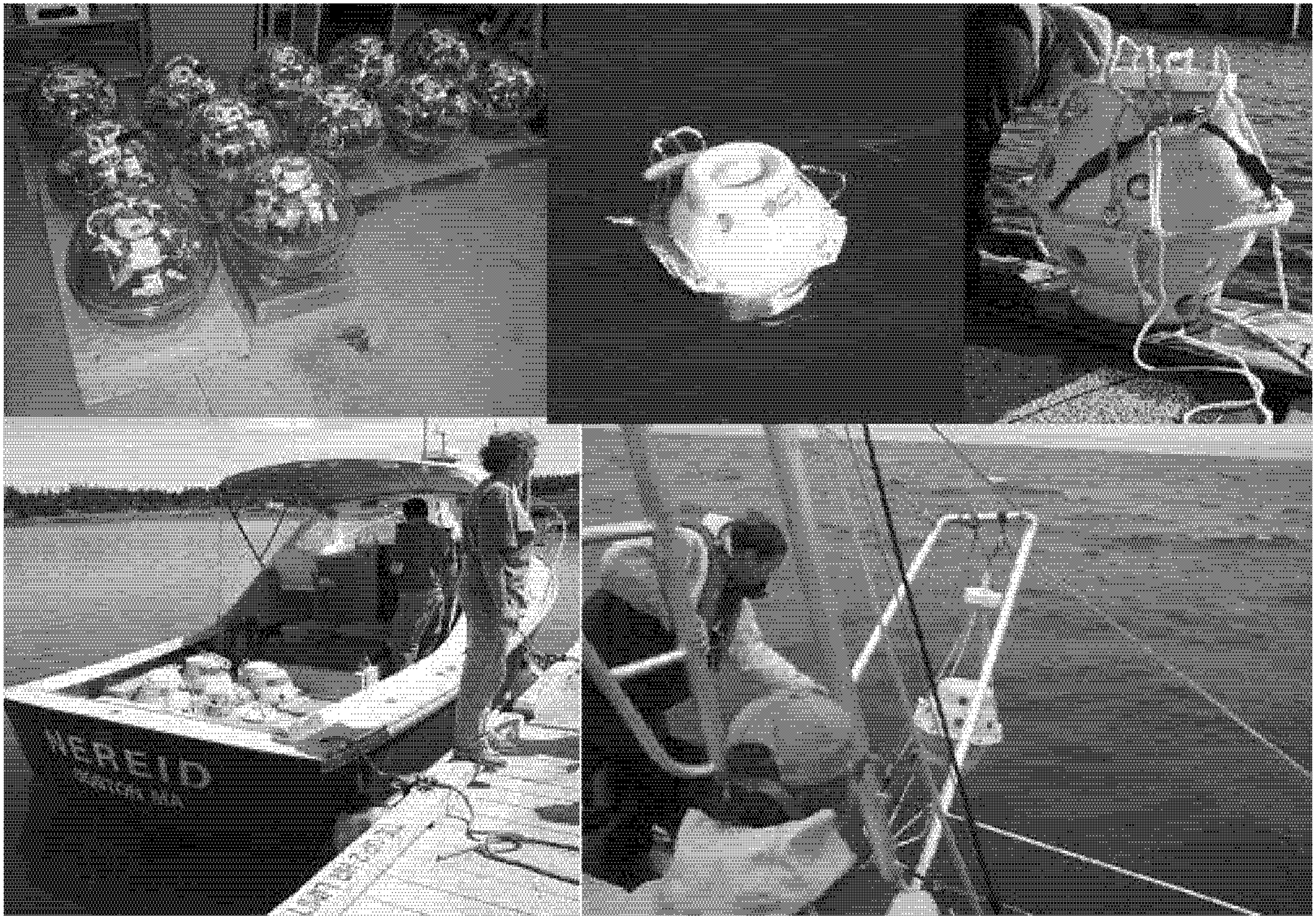
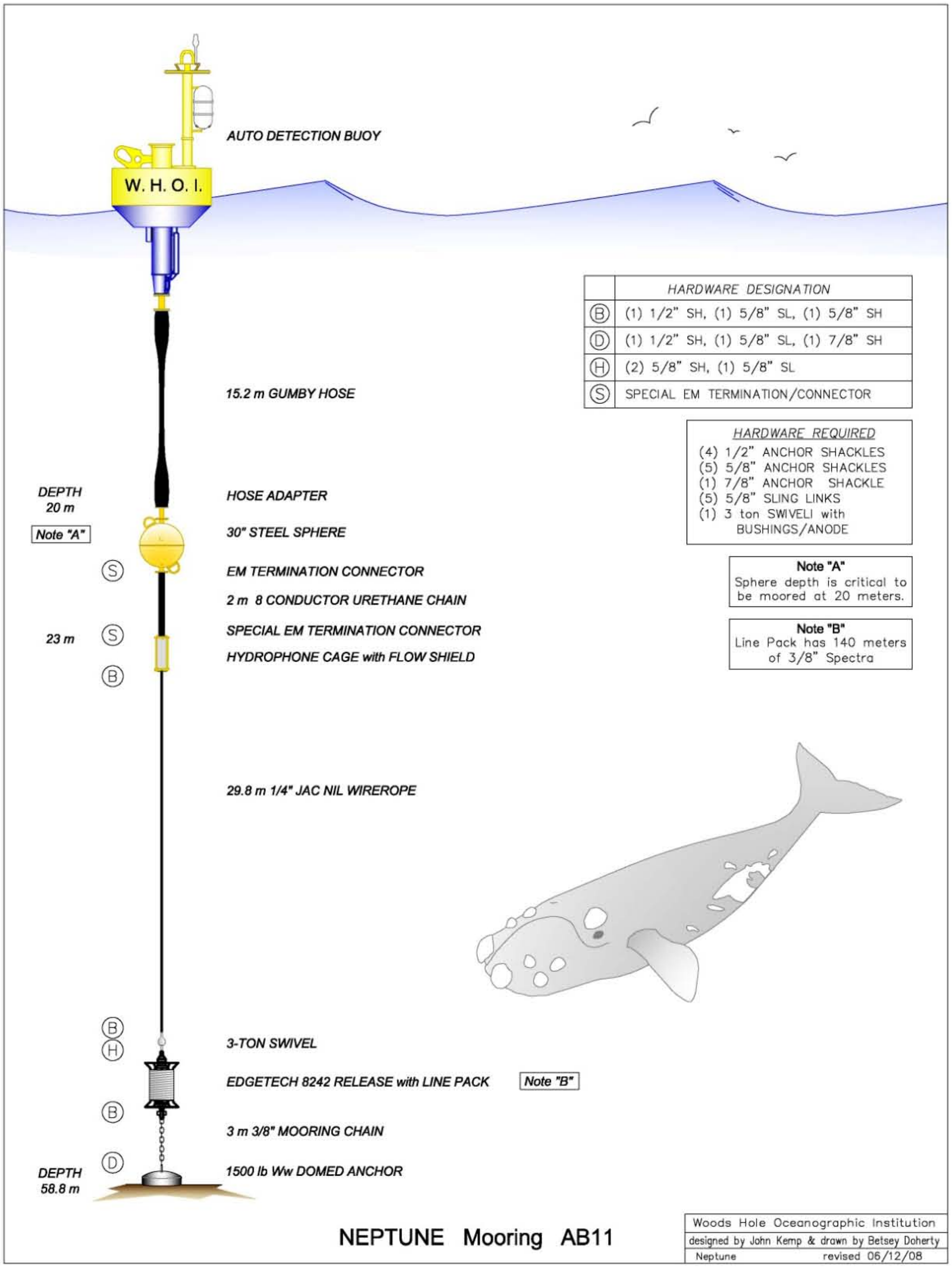


Figure 2. Auto-Detection Buoy (AB) Schematic and Picture of AB Operating Off the Coast of New England



Source: Woods Hole Oceanographic Institution 2007.

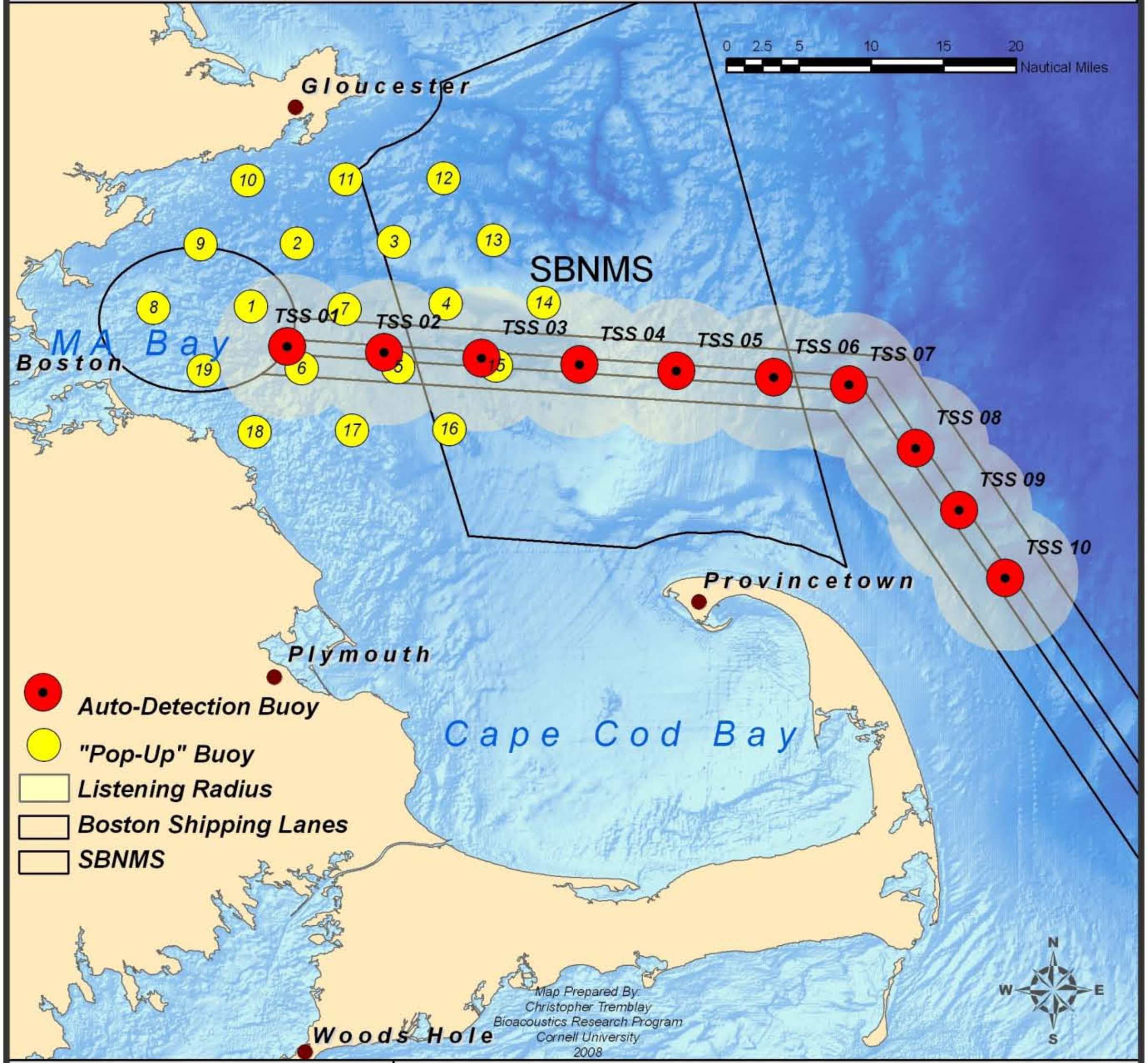
Figure 3. Acoustic Buoy Locations

Neptune LLC.

Cornell University / Woods Hole Oceanographic Institution

Massachusetts Bay, Boston Shipping Lanes

NA Right Whale Auto-Detection Buoy / "Pop-Up" Buoy Operations



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2008

TSS/Boston Shipping Lane AB:

TSS 01:	42 20.832 N	070 40.682 W
TSS 02:	42 20.423 N	070 33.991 W
TSS 03:	42 19.995 N	070 27.270 W
TSS 04:	42 19.572 N	070 20.507 W
TSS 05:	42 19.133 N	070 13.802 W
TSS 06:	42 18.687 N	070 07.082 W
TSS 07:	42 18.173 N	070 01.004 W
TSS 08:	42 13.778 N	069 57.272 W
TSS 09:	42 09.518 N	069 54.292 W
TSS 10:	42 04.840 N	069 51.109 W

MA Bay "Pop-Up" Buoy Locations:

NEP 1:	42 23.382 N	70 43.252 W
NEP 2:	42 27.942 N	70 39.996 W
NEP 3:	42 28.024 N	70 33.288 W
NEP 4:	42 23.767 N	70 29.755 W
NEP 5:	42 19.399 N	70 33.057 W
NEP 6:	42 19.302 N	70 39.774 W
NEP 7:	42 23.398 N	70 36.752 W
NEP 8:	42 23.473 N	70 50.007 W
NEP 9:	42 27.858 N	70 46.756 W
NEP 10:	42 32.241 N	70 43.497 W
NEP 11:	42 32.339 N	70 36.734 W
NEP 12:	42 32.431 N	70 29.971 W
NEP 13:	42 28.143 N	70 26.489 W
NEP 14:	42 23.852 N	70 23.015 W
NEP 15:	42 19.479 N	70 26.291 W
NEP 16:	42 15.104 N	70 29.559 W
NEP 17:	42 15.013 N	70 36.292 W
NEP 18:	42 14.915 N	70 43.024 W
NEP 19:	42 19.195 N	70 46.511 W

3.2 Detecting Right Whale Vocalizations on the TSS and Postings/Notifications

Each AB deployed in the TSS will continuously screen the low-frequency acoustic environment (less than 1,000 Hertz) for right whale contact calls occurring within an approximately 5-nautical mile radius from each buoy (the ABs' detection range) and rank detections on a scale from 1 to 10. Each AB shall transmit all detection data for detections of rank greater than or equal to 6 (≥6) via Iridium satellite link to the BRP server website every 20 minutes. This 20-minute transmission schedule was determined by consideration of a combination of factors including the tendency of NARW calls to occur in clusters (leading to a sampling logic of listening for other calls rather than transmitting immediately upon detection of a possible call) and the amount of battery power required to complete a satellite transmission.

Two protocols will be followed in evaluating AB data and posting the evaluation results (i.e., posting refers to the protocol by which confirmed detections are communicated to an SRV):

- Under a normal monitoring condition (no SRV at the port, no SRV in the TSS, no SRV expected to enter the TSS within 24 hours), BRP staff with expertise in NARW call identification will evaluate all available AB data and post detection results every 12 hours.
- Under a monitoring-alert condition (when the *Neptune* Port Director has received the USCG-required 96-hour notification of an arriving vessel from the SRV Master and notified the BRP staff that an SRV is within 24 hours of entering the TSS, is in the TSS, or is in the *Neptune* area), full-time BRP staff with expertise in NARW calls will evaluate all available AB data and post detection results every 30 minutes.

Once a confirmed detection of an NARW call is made, BRP shall immediately initiate a process to alert the Master of any SRVs operating in the area. This process starts the 24-hour period in which the acoustic detection remains "active." Additional communications between BRP and the SRV Master regarding new confirmed detections (as often as every 30 minutes or every 12 hours under different monitoring conditions) shall either restart the 24-hour clock at an AB that has received multiple confirmed calls or start additional 'clocks' associated with coincident detections at additional buoys. The notification to the Master of an SRV shall include:

- **Time of detection.** Designated in Local Time (LT);
- **Detection AB.** Designated by AB-ID# and latitude/longitude coordinates;
- **Active detection time period.** Indicate start and end times for 24-hour-mandated response; and
- **Special instructions.** Any pertinent information in order to ensure the efficiency with which whale detection information is transmitted to SRV Masters.

Additional notification methods may be developed in cooperation between NOAA, USCG, BRP, and Neptune LNG. Presently, the default notification mechanism is that BRP shall make telephone calls to the Master of any SRV operating in the area. Information detailing the detection shall also be faxed to the *Neptune* Health, Safety, and Environmental (HSE) Manager. In addition, two alternative notification mechanisms – Navigational Telex (NAVTEX) Reporting and Automatic

Identification System (AIS) Reporting – are being developed and their use will be reevaluated by Neptune LNG when they are operational.

3.3 Passive Acoustic Detection and Notification Protocol for Maintenance and Unplanned Repair of Port Components

The components of the *Neptune* port and pipeline are designed to operate with minimal maintenance and/or replacement of parts/equipment. Periodic inspections will be made (as described below) and any maintenance and/or repairs needed will be scheduled in advance during the May 1 to November 30 seasonal window, whenever possible. Neptune LNG envisions only minor maintenance events that are short duration (seven working days or less) and require smaller, local diver support vessels less than 300 gross tons.

In the rare event a major repair is necessary requiring large construction-type derrick barges, similar protocols to those employed during the construction phase of the project will be followed. If the repair cannot be scheduled during the optimal seasonal window between May 1 and November 30 to remedy an immediate emergency situation or as needed to restore gas flow to end-users, then additional mitigation measures will be followed to protect the NARWs and other protected marine mammals and sea turtles, as described below.

Neptune LNG will perform a major inspection of the pipeline every seven to 10 years by running an intelligent pig through the pipeline. This activity requires several large vessels at either end of the pipeline to launch and receive the pig. Major inspections such as this will be scheduled in advance during the May 1 to November 30 seasonal window. If major repairs are required, Neptune LNG will employ the following mitigation protocols, depending upon the season in which they are completed:

3.3.1 Port and Pipeline Major Repair Measures (May 1 to November 30)

Visual Monitoring Program

During maintenance- and repair-related activities, Neptune LNG shall employ two qualified marine mammal observers (MMOs) on each vessel that has a DP system. All MMOs must receive NOAA-approved marine mammal observer training and be approved in advance by NOAA after a review of their resume. Qualifications for these MMOs shall include direct field experience on a marine mammal observation vessel and/or aerial surveys in the Atlantic Ocean/Gulf of Mexico.

The MMOs (one primary and one secondary) are responsible for visually locating marine mammals at the ocean's surface and, to the extent possible, identifying the species. The primary MMO shall act as the identification specialist and the secondary MMO will serve as data recorder and will assist with identification. Both MMOs shall have responsibility for monitoring for the presence of marine mammals.

The MMOs shall monitor the area where maintenance and repair work is conducted beginning at daybreak using 25x power binoculars and/or hand-held binoculars. Night-vision devices must be provided as standard equipment for monitoring during low-light hours and at night. The MMOs shall scan the ocean surface by eye for a minimum of 40 minutes every hour. All sightings must be recorded on marine mammal field sighting logs.

Passive Acoustic Monitoring (PAM) Program

In addition to visual monitoring, Neptune LNG shall work with NOAA (NMFS and SBNMS to install a passive acoustic system (similar to the surface acoustic buoys used during construction) to detect and provide early warnings for potential occurrence of right whales in the vicinity of any major repair area. The number of passive acoustic detection buoys installed around the activity site will be commensurate with the type and spatial extent of maintenance/repair work required, but must be sufficient to detect vocalizing right whales within the 120-dB impact zone.

Neptune LNG shall provide empirically measured source level data for all sources of noise associated with LNG port maintenance and repair activities. Measurements should be carefully coordinated with noise-producing activities and should be collected from the PAM network. Results will be provided to NOAA within the next annual IHA/LOA report.

Distance and Noise Level for Cut-Off

During maintenance or repair activities, the following procedures shall be followed upon detection of a marine mammal within 0.5 mile (0.8 kilometer) of the repair/maintenance vessels:

- If any marine mammals are visually detected within 0.5 mile (0.8 kilometer) of the repair vessel(s), the vessel(s) superintendent or on-deck supervisor must be notified immediately. The vessel's crew shall be put on a heightened state of alert. The marine mammal must be monitored constantly to determine if it is moving toward the repair area.
- Repair vessel(s) must cease any movement and/or cease all activities that emit noises with source level of 139 dB re 1 µPa or higher when a right whale is sighted within or approaching at 500 yards (457 meters) from the construction vessel.
- Repair vessel(s) must cease any movement and/or cease all activities that emit noises with source levels of 139 dB re 1 µPa or higher when a marine mammal other than a right whale is sighted within or approaching at 100 yards (91 meters) from the repair vessel.
- Any vessels transiting the repair area, such as pipe haul barge tugs, must also maintain these separation distances.
- Repair activities must not resume before the marine mammal is positively reconfirmed outside the established zones (either 500 yards [457 meters] or 100 yards [91 meters] range, depending upon the species).
- Neptune LNG must ensure that vessel captains understand that noise generated from thrusters during DP is the most likely source of a "take" to marine mammals; therefore, DP vessel captains shall focus on reducing thruster power to the maximum extent practicable, taking into account diver safety. Likewise, vessel captains shall shut down thrusters whenever they are not needed.

Vessel Strike Avoidance

- While underway, all repair vessels must remain 500 yards (457 meters) away from right whales and 100 yards (91 meters) away from all other whales to the extent physically feasible, given navigational constraints as required by NOAA.

- All repair vessels greater than or equal to 300 gross tons must maintain a speed of 10 knots or less. Vessels of less than 300 gross tons carrying supplies or crew between the shore and the repair site shall contact the Mandatory Ship Reporting System (MSRS), the USCG, or the MMO's at the repair site before leaving shore for reports of recent right whale sightings or active DMAs and, consistent with navigation safety, restrict speeds to 10 knots or less within 5 miles (8 kilometers) of any sighting location and within any existing DMA.

- Vessels transiting through the Cape Cod Canal and Cape Cod Bay between January 1 and May 15 must reduce speed to 10 knots or less, follow the recommended routes charted by NOAA to reduce interactions between right whales and shipping traffic, and avoid identified aggregations of right whales in the eastern portion of Cape Cod Bay.

3.3.2 Additional Port and Pipeline Major Repair Measures (December 1 to April 30)

If unplanned/emergency repair activities cannot be conducted between the May 1 and November 30 optimal window, the following additional mitigation measures shall be implemented:

- If on-board MMOs do not have at least 0.5-mile visibility, they shall call for a shutdown. If dive operations are in progress, then they shall be halted and brought on board until visibility is adequate to see a 0.5-mile range. At the time of shutdown, the use of thrusters must be minimized. If there are potential safety problems due to the shutdown, the captain will decide what operations can safely be shut down and will document such activities.

- Prior to leaving the dock to begin transit, the barge will contact one of the MMOs on watch to receive an update of sightings within the visual observation area. If the MMO has observed an NARW within 30 minutes of the transit start, the vessel will hold for 30 minutes and again get a clearance to leave from the MMOs on board. MMOs will assess whale activity and visual observation ability at the time of the transit request to clear the barge for release.

- A half-day training course will be provided by the current MMO provider to designated crew members assigned to the transit barges and other support vessels. These designated crew members will be required to keep watch on the bridge and immediately notify the navigator of any whale sightings. All watch crew will sign into a bridge log book upon start and end of watch. Transit route, destination, sea conditions, and any protected species sightings/mitigation actions during watch will be recorded in the log book. Any whale sightings within 1,000 meters of the vessel will result in a high alert and slow speed of 4 knots or less. A sighting within 750 meters will result in idle speed and/or ceasing all movement.

- The material barges and tugs used for repair work shall transit from the operations dock to the work sites during daylight hours when possible provided the safety of the vessels is not compromised. Should transit at night be required, the maximum speed of the tug will be 5 knots.

- Consistent with navigation safety, all repair vessels must maintain a speed of 10 knots or less during daylight hours. All vessels will operate at 5 knots or less at all times within 5 kilometers of the repair area.

- Vessels transiting through the Cape Cod Canal and Cape Cod Bay between January 1 and May 15 must reduce speed to 10 knots or less, follow the recommended routes charted by NOAA to reduce interactions between right whales and shipping traffic, and avoid identified aggregations of right whales in the eastern portion of Cape Cod Bay.

3.3.3 Reporting

For any repair work associated with the pipeline lateral or other port components, Neptune LNG shall notify the following as soon as practicable after it is determined that repair work must be conducted.

- **NOAA -** Neptune LNG shall keep NOAA apprised of repair work plans as details (the time, location, and nature of the repair) become available:
  - **NMFS Headquarters, Office of Protected Resources -** Candace Nachman, 301-713-2289, Candace.Nachman@noaa.gov,
  - **NMFS Northeast Regional Office -** Kristen Koyama, 978-282-8481, kristen.koyama@noaa.gov, and
  - **SBNMS -** Leila Hatch, 781-545-8026, leila.hatch@noaa.gov;
- **USCG Deepwater Ports -** Roddy Bachman, 202-372-1451, Roddy.C.Bachman@uscg.mil; and
- **USEPA -** Phil Colarusso (for water-related issues), 617-918-1506, colarusso.phil@epa.gov and Brendan McCahill (for air-related issues) 617-918-1652, mccahill.brendan@epa.gov. Additionally, notification for all repairs and maintenance will be provided to Elizabeth Higgins, 617-918-1051, Higgins.Elizabeth@epa.gov.

During maintenance and repair of the pipeline lateral or other port components, weekly status reports must be provided to NOAA using standardized reporting forms. The weekly reports should include data collected for each distinct marine mammal species observed in the project area in the Massachusetts Bay during the period of port repair activities. The weekly reports shall include:

- The location, time, and nature of the pipeline lateral repair activities;
- Whether the DP system was operated and, if so, the number of thrusters used and the time and duration of DP operation;
- Marine mammals observed in the area (number, species, age group, and initial behavior);
- The distance of observed marine mammals from the repair activities;
- Whether there were changes in marine mammal behaviors during the observation;
- Whether any mitigation measures (power-down, shutdown, etc.) were implemented;
- Weather condition (sea state, wind speed, wind direction, ambient temperature, precipitation, and percent cloud cover, etc.);

- Condition of the marine mammal/sea turtle observation (visibility and glare); and
- Details of passive acoustic detections and any action taken in response to those detections.

4 Plan for Reduction in Vessel-Whale Strikes by SRVs

All NOAA consultations relevant to marine mammal species cited the importance of reducing the potential for vessel-whale strikes by SRVs during the port's operational phase. Therefore, all operations conducted at *Neptune* will adhere to the requirements of this plan in order to reduce the potential for vessel-whale strikes by SRVs, and other vessels (65 feet or greater in overall length) used for repair/maintenance activities. Key elements of this plan are identified below.

4.1 Speed Restrictions in Seasonal Management Areas

On October 10, 2008, NOAA published its Final Rule in the *Federal Register* (73 FR 60173) that implements speed restrictions to reduce the threat of ship collisions with NARWs along the U.S. Atlantic seaboard. The Final Rule imposes speed restrictions of no more than 10 knots on all vessels 65 feet or greater in overall length entering or departing a port or place subject to the jurisdiction of the United States. The following specific restrictions apply to the operations of SRVs calling upon *Neptune* by transiting through defined Seasonal Management Areas (SMAs) in the northeast U.S. (north of Rhode Island):

- **Off Race Point SMA.** SRVs shall reduce their maximum authorized transit speed while in the TSS from 14 knots or less to 10 knots year round in all waters bounded by straight lines connecting the following points in the order stated below unless extraordinary circumstances, as previously defined in Section 1.2, dictate the need for an alternate speed:

42°30′ N	70°30′ W
41°40′ N	69°57′ W
42°30′ N	69°45′ W
42°12′ N	70°15′ W
41°40′ N	69°45′ W
42°12′ N	70°30′ W
42°04.8′ N	70°10′ W
42°30′ N	70°30′ W

- **Great South Channel SMA.** SRVs shall reduce their maximum authorized transit speed while in the TSS from 14 knots or less to 10 knots or less unless extraordinary circumstances, as defined in Section 1.2, dictate the need for an alternate speed between April 1 and July 31 in all waters bounded by straight lines connecting the following points in the order stated below:

42°30′ N	69° 45′ W
41°40′ N	69°45′ W
42°30′ N	67°27′ W
42°30′ N	69°45′ W
42°09′ N	67°08.4′ W
41°00′ N	69°05′ W

- **Cape Cod Bay SMA.** SRVs are not expected to transit Cape Cod Bay; however, in the event that transit through Cape Cod Bay is required, SRVs shall reduce transit speed from 12 knots or less to 10 knots or less (unless extraordinary circumstances as defined in Section 1.2. dictate the need for an alternate speed) from January 1 to May 15 in all waters in Cape Cod Bay, extending to all shorelines of Cape Cod Bay, with a northern boundary of 42°12’ N latitude.

4.2 Heightened Awareness Mode of Operation within the TSS and at Neptune

Neptune LNG must acoustically and visually monitor for the presence of whales (particularly the NARW) while transiting within the designated Boston TSS, while maneuvering within the confines of the *Neptune* DWP, and while SRVs are actively engaging in the use of thrusters. While engaging in any of these activities, the SRV crew will be placed on “heightened awareness,” the protocol for which is summarized below.

Other vessels greater than 65 feet used for repair/maintenance will follow the same heightened awareness protocols as the SRVs described below.

4.2.1 Vessel Operations and Monitoring Protocol within the TSS

In approaching and departing from *Neptune*, SRVs shall use the Boston TSS starting and ending at the entrance to the Great South Channel (subject to extraordinary circumstances as defined in Section 1.2). Upon entering the TSS, the SRV shall go into a “heightened awareness” mode of operation, which is as follows:

HEIGHTENED AWARENESS PROTOCOL

1. Twenty-four (24) hours prior to entering and navigating the modified TSS, particularly before entering the Great South Channel SMA and SBNMS, which are areas where North Atlantic right whales are known to occur, the SRV Master and navigation watch will:
    - Consult NAVTEX, NOAA Weather Radio, the NOAA Right Whale Sighting Advisory System (SAS) or other means to obtain current right whale sighting information, including any active Dynamic Management Areas (DMAs);
    - Receive up-to-date information on acoustic detections of North Atlantic right whales from the passive network of ABs prior to and during transit through the northern leg of the TSS where such buoys are installed; and
    - Post a lookout who has successfully completed the required Marine Mammal and Sea Turtle Training Program to visually monitor for the presence of marine mammals and/or sea turtles. The lookout will concentrate his/her observation efforts within the 2-mile radius Zone of Influence (ZOI) from the maneuvering SRV.
2. The vessel lookout assigned to visually monitor for the presence of marine mammals and/or sea turtles will be equipped with the following:
    - Recent NAVTEX, NOAA Weather Radio, SAS and/or acoustic monitoring buoy detection data;

- Binoculars to support observations;
- Marine mammal training materials (see Attachment 1); and
- Sighting log (see Attachment 2 and reporting requirements below).

3. If a right whale alert is broadcast over the Mandatory Ship Reporting System (MSRS), NOAA Weather Radio, or SAS, the lookout will concentrate visual monitoring efforts in the vicinity of the detection.
4. When notified of an active DMA on the MSRS or SAS, the SRV Master and navigation watch shall respond by concentrating monitoring efforts within the DMA and reducing speed to 10 knots or less or routing around the DMA.
5. Should an active acoustic detection[2] be confirmed as described in Section 3 of this Plan, the SRV Master and navigation watch shall respond by concentrating monitoring efforts towards the area of most recent detection and reducing speed to 10 knots or less within an area 5 nautical miles in radius centered on the detecting auto AB.
6. If the lookout (or any other member of the crew) visually detects a marine mammal within the 2-mile radius ZOI of a maneuvering SRV, he/she will take the following actions:
    - Immediately notify the Officer-of-the-Watch; and
    - Record the sighting in the sighting log (see Attachment 2).
7. If the Officer-of-the-Watch is notified by any crewmember of a marine mammal sighting, he/she will relay the sighting information to the SRV Master immediately so the SRV will be slowed to 10 knots or less and monitoring efforts can be concentrated towards the area of most recent sighting activity. In any case, in accordance with NOAA Regulation 50 CFR 224.103 (c), all vessels associated with *Neptune* activities shall not approach closer than 500 yards (457 meters) to a North Atlantic right whale.
8. Once the SRV is moored at the port and regasification activities have begun, the vessel is no longer considered to be in heightened awareness status. However, when regasification activities conclude and the SRV prepares to depart from the *Neptune* DWP, the crew will once again assume the responsibilities as defined in this Operational MMDMRP.

4.2.2 Vessel Operations and Monitoring Protocol Arriving or Departing *Neptune*

In the event that a whale is visually observed within 1,094 yards (1 kilometer) of *Neptune* or a confirmed acoustic detection is reported on either of the two ABs closest to the port (westernmost in the TSS array), departing SRVs shall delay their departure from the port, unless extraordinary circumstances, as defined in Section 1.2, require that departure is not delayed. The departure delay shall continue until either the observed whale has been visually (during daylight hours) confirmed as more than 1,094 yards (1 kilometer) from *Neptune* or 30 minutes have passed without another

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[2] Active acoustic detections are defined as confirmed North Atlantic right whale vocalizations detected by a TSS AB within 24 hours of each scheduled data review period (e.g., every 30 minutes or every 12 hours, as detailed in Section 2.2). Multiple confirmed acoustic detections at a single AB will extend the duration of minimum mandated SRV response to 24 hours from the last confirmed detection (within the reception area of the detecting AB). Confirmed acoustic detections at multiple ABs within the same 24-hour time period will extend the area of minimum mandated SRV response to encompass the reception areas of all detecting ABs.

confirmed detection either acoustically within the acoustic detection range of the two ABs closest to the port or visually within 1 kilometer from *Neptune*.

SRVs that are approaching or departing from the port and are within the Area to be Avoided (ATBA) surrounding *Neptune* shall remain at least 1,094 yards (1 kilometer) away from any visually detected NARWs and at least 100 yards (91.4 meters) away from all other visually detected whales unless extraordinary circumstances, as defined in Section 1.2, require that the vessel stay its course. The ATBA is defined in the *Neptune* Operations Manual and in 33 CFR 150.940. It is the largest area of the port marked on nautical charts and it is enforceable by the USCG in accordance with the 150.900 regulations. The Vessel Master shall designate at least one lookout to be exclusively and continuously monitoring for the presence of marine mammals at all times while the SRV is approaching or departing *Neptune*.

Neptune LNG will ensure that other vessels providing support to *Neptune* operations during regasification activities that are approaching or departing from the port and are within the ATBA shall be operated so as to remain at least 1,094 yards (1 kilometer) away from any visually detected NARWs and at least 100 yards from all other visually detected whales. To further ensure that marine mammals will not be adversely affected by the operation of the *Neptune* DWP, the DWP License, the BO, and NMSA Section 304 (d) Recommendations have also established specific speed restrictions that SRVs and support vessels must comply with when calling at *Neptune*. Measures include:

- Under normal operating conditions the SRVs and all support vessels servicing the *Neptune* deepwater port will comply with speed restrictions, routing measures, and marine mammal and sea turtle standoff distances in this Operational MMDMRP as defined by the stricter of those included in the DWP License (March 26, 2007); the BO and ITS (as amended on July 1, 2009), and NMSA Section 304 (d) Recommendations; the applicable parts of 50 CFR Parts 222, 223, and 224; and any other regulations or permit requirements that apply.
- SRVs and support vessels will travel at 10 knots maximum speed when transiting to/from the Precautionary Area or to/from *Neptune*. Speed will be reduced to less than 1 knot once inside the *Neptune* Safety/Security Zone.
- It is anticipated that the support vessel will be present while an SRV is moored at *Neptune*, unless providing logistical support services (e.g., crew change-out, supply deliveries, vessel stores). In the event of a safety or security emergency, the SRV and/or the support vessel may travel at speeds greater than 10 knots to respond to the incident. As defined below, a safety or security emergency includes, but is not limited to, rendering assistance to nearby craft (boat or airplane) in distress, providing firefighting or lifesaving measures, and responding to security breaches, acts of terrorism, or piracy.

As stated in the Federal Maritime Security Coordinator's letter, dated December 11, 2006, the support vessel is responsible for first-responder duties. The support vessel's presence at the deepwater port serves the purpose of additional detection and assessment capabilities, visual deterrence, extended means of challenging/ warning approaching vessels, and immediate additional response capabilities for firefighting, rescue, and fending off disabled vessels. As first responder, these capabilities provide information to government response assets and act as an important layer of protection.

Emergency situations as determined by the Vessel Master and/or in coordination with the USCG or other agencies in authority may require rare instances of exceeding speed restrictions and/or variation in vessel course, and/or coming in closer proximity to protected and endangered species than noted in this subsection. Emergency situations involve the risk to life, property and the environment and failure to respond appropriately could potentially worsen the consequences. Such emergency situations include, but would not be limited to, maintaining vessel maneuverability, avoiding severe weather conditions, collision/grounding avoidance, vessel safety and security, and rendering assistance to (i.e., first response) to vessels and aircraft in distress, search and rescue, medical emergencies, fire/explosion, port security/piracy threats, and spill prevention/response to the port itself or other vessels in the area. These actions would normally be coordinated with the USCG.

As an example, the *Neptune* support vessel(s) have defined roles and responsibilities in mitigating port security risks and response in coordination with the USCG per the USCG Federal Maritime Security Coordinator Assessment and Recommendations: *Neptune* Deepwater Port Facility Proposal, dated December 11, 2006, and incorporated into the Port Security Plan of the Operations Manual. In such response to emergency situations, the SRV and support vessels will, if possible, maintain an even higher level of vigilance en route to avoid vessel strikes or other potential adverse impacts to marine mammals or sea turtles.

In all cases where the vessel cannot execute the mitigation and monitoring requirements in this Operational MMDMRP due to responding to an emergency, each such deviation shall be documented in the log book of the vessel and, depending on investigation, legal and security restrictions, reported at the conclusion of the emergency situation to the NMFS Northeast Regional Office (NMFS/NERO) Ship Strike Coordinator and the NOAA staff at SBNMS.

4.2.3 Visual Monitoring Protocol for Marine Mammals and Reporting Requirements

While an SRV is navigating within the designated TSS, three people have lookout duties on or near the bridge of the ship including the SRV Master, the Officer-of-the-Watch, and the Helmsman on watch. In addition to standard watch procedures, while the SRV is within the ATBA and/or while actively engaging in the use of thrusters an additional lookout shall be designated to exclusively and continuously monitor for marine mammals. Once the SRV is moored and regasification activities have begun, the vessel is no longer considered in "heightened awareness" status. However, when regasification activities conclude and the SRV prepares to depart from *Neptune*, the Master shall once again ensure that the responsibilities as defined in this Operational MMDMRP are carried out.

All sightings of marine mammals by the designated lookout, individuals posted to navigational lookout duties, and/or any other crew member while the SRV is within the TSS, in transit to the ATBA, within the ATBA, and/or when actively engaging in the use of thrusters shall be immediately reported to the Officer-of-the-Watch who shall then alert the Master.

Visual sightings made by lookouts from the SRVs will be recorded using a standard sighting log form. The lookout responsible for visual monitoring during any given watch period must keep a log of all marine mammal sightings. At the end of each monitoring watch, the lookout will provide the log entries to the Officer-of-the-Watch. The Officer-of-the-Watch will be responsible for providing the sighting log entries to the *Neptune* HSE Manager. A sample sighting log sheet is included as Attachment 2. The basic reporting requirements include the following:

- Date;
- Time monitoring watch commenced/Time monitoring watch was suspended;
- Name of lookout;
- Vessel name;
- Lookout position;

- Weather and sea-state conditions;
- Time of sighting;
- Type of species sighted (categories will include: species [if known], unknown large whale, unknown small whale, unknown dolphin/porpoise, unknown seal, unknown sea turtle), as well as a comment area for unusual or obvious behaviors;
- Number of individuals sighted (record will include: exact number [if known], 5+, 10+, 50+, 100+);
- Approximate location (latitude and longitude) at the time of the sighting;
- General direction and distance of sighting from the vessel (distance should be recorded as: within 50 yards, within 100 yards, within 500 yards, within 0.5 mile; within 1 mile, within 2 miles, greater than 2 miles);
- Activity of the vessels at the time of sighting; and
- Action taken by the observer.

The visual monitoring data collected will be entered into a database and a summary of monthly sighting activity will be provided in the monitoring reports prepared by the BRP and as required by NMFS pursuant to the anticipated LOA monitoring reports. The Master or Officer-of-the-Watch shall ensure the required reporting procedures are followed and the designated marine mammal lookout records all pertinent information relevant to the sighting.

All individuals onboard the SRVs responsible for the navigation duties and any other personnel that could be assigned to monitor for marine mammals during port operations shall receive training on marine mammal sighting/reporting and vessel strike avoidance measures. Neptune LNG has developed materials for marine mammal and sea turtle observers aboard the SRV (see Attachment 1).

4.2.4 Visual Monitoring Protocol for Marine Mammals and Reporting Requirements for Routine Maintenance and Unplanned Repairs

Visual monitoring and reporting protocols for major repairs to either the port facilities or pipeline are described in Section 3.3 of this MMDMRP.

For minor repairs and maintenance activities, the following protocols will be followed:

- All vessel crew members will be trained in marine mammal and sea turtle identification and avoidance procedures;
- Repair vessels will notify designated NOAA personnel when and where the repair/maintenance work is to take place along with a tentative schedule and description of the work;
- Vessel crews will record/document any marine mammal/sea turtle sightings during the work period; and
- At the conclusion of the repair/maintenance work, a report will be delivered to designated NOAA personnel describing any marine mammal/sea turtle sightings, the type of work taking place when the sighting occurred, total accumulated “takes” attributed to these activities and any avoidance actions taken during the repair/maintenance work.

5 Injured/Dead Protected Species Reporting

During all phases of *Neptune*'s operation, including routine maintenance and unplanned repairs, sightings of any injured or dead protected species (sea turtles and marine mammals) shall be reported immediately, regardless of whether the injury or death was caused by port activities. Sightings of injured or dead whales and sea turtles not associated with *Neptune* activities can be reported to the USCG on VHF Channel 16 or to the NMFS Stranding and Entanglement Hotline: (978) 281-9351. If the injury or death was caused by a *Neptune* DWP vessel or *Neptune*-related equipment or material/activity (e.g., SRV, Support Vessel, or construction vessel, entanglement, buoy, etc.), Neptune LNG shall notify NOAA/Office of National Marine Sanctuaries (ONMS)/SBNMS and NMFS Office of Protected Resources and Northeast Regional Office. The reports to NOAA shall include the following information:

- Time, date and location (latitude/longitude) of the incident;
- Name and type of the vessel involved or other equipment/material that caused the injury or death;
- Vessel's speed during the incident, if applicable;
- Description of the incident;
- Water depth;
- Environmental conditions (e.g., wind speed and direction, sea state, cloud cover and visibility);
- Species identification or description of the animal, if possible; and
- Fate of the animal.

6 Maintaining the Passive Acoustic Detection Network

6.1 Maintaining the ARU and AB Systems

ARUs and AB units shall be refurbished and repaired as necessary, and the schedule for such repairs shall be carefully orchestrated so as not to impact auto-detection coverage in the TSS. For example, units will be swapped out during periods when no *Neptune* DWP vessels are in the area or expected to enter the area. Neptune LNG shall be required to maintain the TSS AB system for the life of the project. ARUs will be maintained/refurbished/repaired as necessary for a period of 5 years of operation (from commissioning). BRP shall provide regular reports to MARAD, USCG, and NOAA (both NMFS and ONMS), including information on the functioning and performance of this system.

6.2 Speed Restrictions Applicable to Vessels Maintaining the Acoustic Detection Network

Vessels associated with maintaining the acoustic seafloor array of ARUs and the AB network operating as part of the mitigation/monitoring protocols under this Operational MMDMRP shall adhere to the following speed restrictions and marine mammal monitoring requirements.

- Vessels greater than 300 gross tons (GT) shall not exceed 10 knots. Vessels less than 300 GT shall not exceed 15 knots at any time, but shall adhere to speeds of 10 knots or less in the SMAs defined in Section 4.1 of this Plan.
- All vessels associated with *Neptune* activities shall not approach closer than 500 yards (457 meters) to an NARW, in accordance with 50 CFR 224.103 (c).
- All vessels shall post lookouts during operations to help avoid collisions with marine mammals. Individuals posted as lookouts shall receive training in marine mammal observation.
- All vessels shall obtain the latest right whale sighting or Dynamic Management Area information via NAVTEX, MSRS, SAS, NOAA Weather Radio, or other available means prior to operations to determine if right whales are present in the operational area.

7 MARAD, USCG, and NOAA Reporting Requirements

During the first five years of operations, Neptune LNG will provide regular reports to MARAD, USCG, and NOAA (both NMFS and ONMS) regarding the progress and status of the port's operational marine mammal detection and monitoring requirements.

- For the first six months of *Neptune* operation, BRP shall provide a monthly AB Report that includes detailed information on the functioning and performance of the AB system, as well as reports of whale detections, presence of SRVs, and SRV responses to notification. After this initial six-month period, the AB Report shall be submitted quarterly (every three months) beginning after the ninth month of operation.
- On a quarterly basis from the start of operations, BRP will also provide a Passive Acoustic Monitoring Report to MARAD, USCG, and NOAA (both NMFS and ONMS). This report will include information regarding the noise environment of the adjacent area of Massachusetts Bay, the noises attributable to the operation of *Neptune* (including any empirical source level measurements conducted), and, as feasible, the movement of vocalizing whales in the detection area based on empirical data collected by the ARUs. A summary of the sighting information collected by the SRV lookouts will be included with this report. BRP also has access to both the SAS and MSRS data for any given reporting period and will use this data in combination with the visual sighting information collected by the SRV and repair/maintenance vessels lookouts (see the next paragraph and Section 3.1) to assist in their estimation of the presence of whales during the operation of the port.
- On a monthly basis, Neptune LNG will submit a monthly ITS/LOA Report to the designated representatives at MARAD, USCG, and NOAA (both NMFS and ONMS). The format for this report will be similar to that used during the construction period to meet reporting requirements under the construction-related Incidental Harassment Authorization (IHA) issued in 2008 and the second IHA issued in 2009.
- On a yearly basis, Neptune LNG will submit an annual ITS/LOA Report to NOAA (both NMFS and ONMS). A draft annual report is due at the time of

request for LOA renewal. The report shall include data collected for each distinct marine mammal species observed in the project area during operational activities. Descriptions of marine mammal behavior, overall numbers of individuals observed, frequency of observation, and any behavioral changes and the context of the changes relative to operational activities shall also be included in the report. Empirical source level measurements for operations and/or repair/maintenance-associated noise sources will also be included. Neptune LNG will submit a final annual report within 30 days of receiving comments from NOAA. If no comments are received from NOAA, the draft report will be considered the final report.

- At the end of each five-year monitoring period, BRP shall prepare an Operational MMDMRP Summarization Report and provide it to Neptune LNG and to designated representatives of the MARAD, USCG, and NOAA (both NMFS and ONMS).

Each of these reporting requirements is summarized in Table 1. Neptune LNG will provide a monthly LOA/ITS Report to the following individuals that includes copies of the sighting logs, a summary for the species sited for the month, and an estimate of take on a monthly basis:

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NOAA NMFS Northeast Regional Office (NERO)
Ship Strike Coordinator
One Blackburn Drive
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Candace Nachman
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Yvette M. Fields
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(202) 366-0926

Mark A. Prescott
Chief, Deepwater Ports Standards
Commandant CG-5225
US Coast Guard
2100 2nd St. SW Stop 7126
Washington, DC 20593-7126
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202-372-1440

Table 1
Marine Mammal Detection and Monitoring Reporting Requirements

Report Title	Scheduled delivery to NOAA	Summary of Contents
Incidental Take Statement/Letter of Authorization/ (ITS/LOA) Monthly Report	Monthly throughout operations	Tabulation of number of marine mammals visually detected; estimation of take per species/species class; raw sighting logs for month
ITS/LOA Annual Report	Draft and Final	On a yearly basis, Neptune LNG will submit an annual ITS/LOA Report to NOAA (both NMFS and ONMS). A draft annual report is due at the time of request for LOA renewal. The report shall include data collected for each distinct marine mammal species observed in the project area during operational activities. Descriptions of marine mammal behavior, overall numbers of individuals observed, frequency of observation, and any behavioral changes and the context of the changes relative to operational activities shall also be included in the report. Empirical source level measurements for operations and/or repair/maintenance -associated noise sources will also be included. Neptune LNG will submit a final annual report within 30 days of receiving comments from NOAA. If no comments are received from NOAA, the draft report will be considered the final report.
Auto-detection Buoy (AB) Report	Monthly for first six months, then every three months (beginning nine months into operations)	Whale detections by TSS ABs, presence of SRVs, and SRV responses to notification
Passive Acoustic Monitoring Report	Quarterly during operations, in coordination with the recovery schedule of the ARUs.	Functioning and performance of the ARU network, including information on the noise environment in the ARU monitoring area, the presence of vocalizing whales in the ARU monitoring area, numbers of whales occurring in the ARU monitoring area and in the vicinity of port operations (based on the visually and acoustically located animals), and the movements of vocalizing whales based on empirical data collected by the ARUs. This will also include, as feasible, the attribution of specific operational events (as noted in operations logs), with specific sound events (as empirically measured and as recorded on the ARUs).
Operational Marine Mammal Detection, Monitoring, and Response Plan (MMDMRP) Summarization Report	Every five years	Overall review of the performance and effectiveness of the passive acoustic monitoring and mitigation systems within the areas of the ARU and AB networks including documentation, quantification, and measurements of the contributors to ocean ambient noise.

Key:
AB = auto-detection buoy.
ARU = Autonomous recording unit.
NOAA = National Oceanic and Atmospheric Administration.
SRV = Shuttle and regasification vessel.
TSS = Traffic Separation Scheme.

Attachment 1

Marine Mammal and Sea Turtle Training Materials

Marine Mammal Training for *Neptune* Operations

Species to be Reported

Marine Mammals

- Species of marine mammals identified in MMPA permits:
  - North Atlantic right whale
  - Humpback whale
  - Fin whale
  - Minke whale
  - Long-finned Pilot whale
  - Atlantic white-sided dolphin
  - Harbor porpoise
  - Harbor seal

Whales, Dolphins, and Porpoises

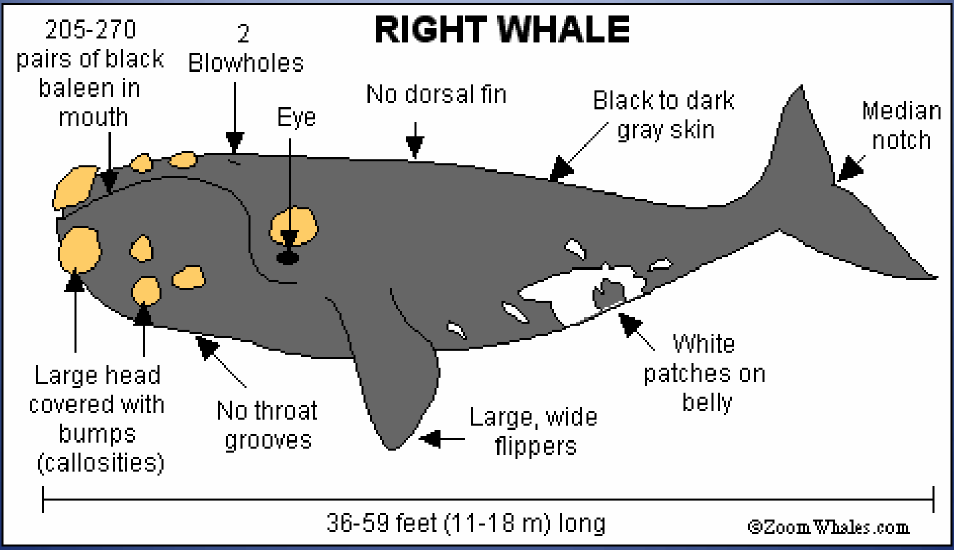
- Body Size/Shape
- Coloration
- Blow Description (if applicable)
- Behavior
- Number in Group
- Direction of Travel

North Atlantic Right Whale

- Critically endangered
- Only 300 to 400 individuals left
- Docile slow moving making them prone to boat/ship strikes
- Low or negative birth to death rate

North Atlantic Right Whale Identification

- Large whale 40 to 60 feet long (13 to 18 meters)
- V-shaped bushy Blow to 16 (5 meters) feet height
- Lack of dorsal fin
- Black broad body
- Callosities on rostrum, lower lips and around eyes
- Fluke is very smooth



North Atlantic Right Whale

Humpback Whale

- Large Whale 11 to 16 meters (36 to 52 Feet)
- Blow broad and bushy to 3 meters (10 ft) height
- Dorsal fin small with broad base, knuckles behind
- Black in color with white on throat and belly
- Fluke broad with irregular trailing edge

Humpback Whale

Fin Whale

- Large Whale 17 to 24 M (56 – 79 Ft)
- Blow - Tall elliptical 5.5 – 6 m (18 – 20ft)
- Dorsal Fin - Tall and falcate with blunt tip
- Dark grey in color with light under side
- Lower right jaw white, Lower left jaw dark
- Rarely show fluke
- Wheel-like role when diving

Fin Whale

Minke Whale

- Smallest baleen whale found in the north Atlantic 9–10 m (29 – 33ft)
- Blow low bushy and rarely seen
- Dorsal fin – prominent and falcate
- Black or dark steel-gray lighter undersides white band on both flippers
- Does not show flukes

Minke Whale

Long-Finned Pilot Whale

- Bulbous head
- Prominent melon
- Sickle-shaped flippers/sharply pointed and long
- Upturned mouthline
- Black or dark gray with lighter markings on throat, shoulder, and belly
- Low and broad-based

Long-Finned Pilot Whale

Atlantic White-Sided Dolphin

- Short, thick two-colored beak
- Coloration:
  - Grey sides
  - Black back, top of beak, flippers, and flukes
  - White belly and bottom of beak
  - Yellow dorsal band
- Dorsal fin sharply pointed with narrow base

Atlantic White-Sided Dolphin

Harbor Porpoise

- Smallest cetacean in U.S. Atlantic
- No beak
- Small bumps on leading edge of dorsal fin
- Dark gray or black on back with lighter sides and belly
- Dark narrow band between mouth and flipper
- Small triangular dorsal fin

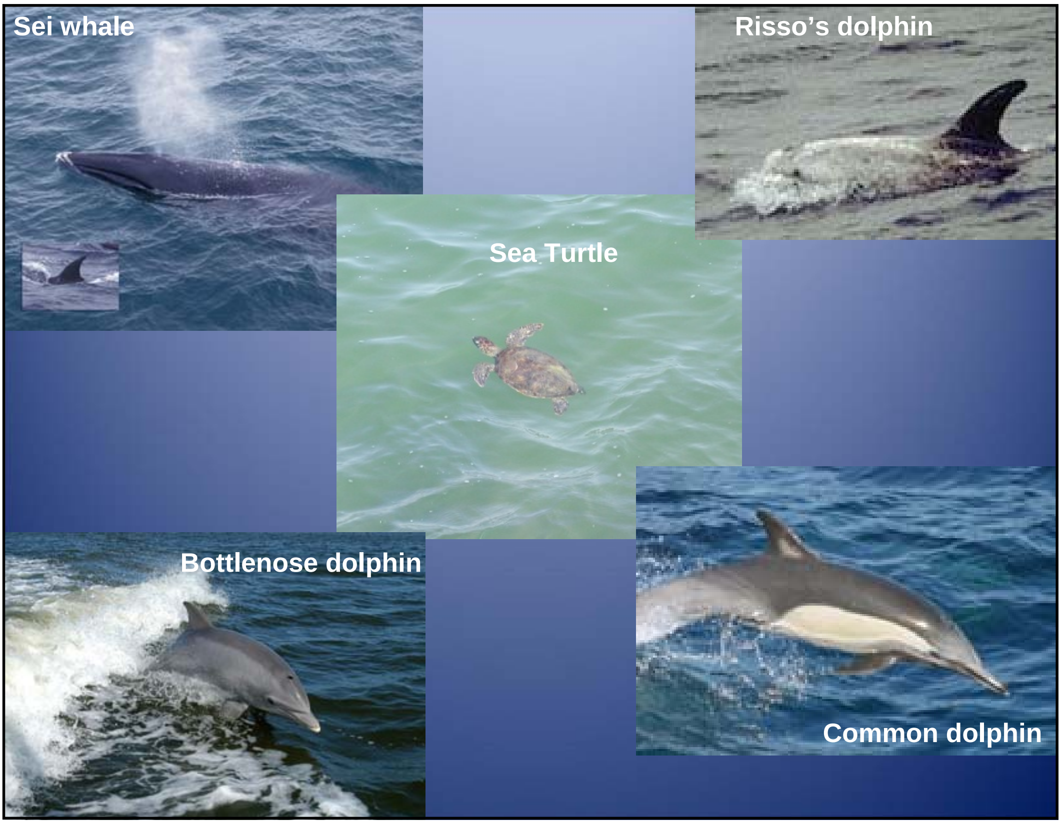
Harbor Porpoise

Harbor Seal

- Head rounded with short, “dog-like” snout
- Nostrils form “V”
- Color variable
  - Silver to reddish tan to nearly black
  - Lighter belly
  - Speckling

Other Marine Species That May Be Encountered

- Other whales or dolphins
  - Sei whale
  - Bottlenose dolphin
  - Common dolphin
  - Risso’s dolphin
  - Striped dolphin
- Sea turtles



Heightened Awareness Protocols for SRVs Operating on the TSS

- Vessels shall not approach closer than 500 yards (457 meters) to a North Atlantic right whale
- Adhere to NOAA ship strike speed restrictions when applicable by season or geographic area
- Prior to entering and navigating the modified TSS, the Master of the vessel obtains current right whale sighting information:
  - NAVTEX
  - NOAA Weather Radio
  - NOAA Right Whale SAS
  - BRP acoustic monitoring buoy data
- Post a trained lookout for visual monitoring
  - Observation efforts concentrated within 2-mile radius of SRV unless sighting data directs otherwise
- Maintain a sightings log and record all sightings
- Reduce speeds to 10 knots or less when marine mammal is sighted within 8 nm radius of visual sighting or 5 nm radius of AB detecting a vocalizing marine mammal

Heightened Awareness Protocol at *Neptune*

- Speed Restrictions:
  - 10 knots maximum speed restriction for SRVs and support vessels transiting to/from the Precautionary Area and/or *Neptune*
  - At 1,640 feet (500 meters) from the *Neptune* buoys, speed will reduced to 1 knot
- Maintain visual monitoring during mooring and log sightings when thrusters are engaged
- SRVs approaching or departing from Neptune or the ATBA shall remain at least 1 km away from any visually detected North Atlantic right whale and at least 100 yards from all other visually detected whales
- Once moored, the SRV is no longer in heighted awareness mode, unless thrusters are engaged

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Heightened Awareness Protocol at *Neptune*

- Departure Delay Requirements
  - At time of SRV departure, if a whale is visually observed within 1 km of *Neptune* or a confirmed acoustic detection is reported on either of the two ABs closest to the Port (westernmost in the TSS array), the departing SRV(s) shall be delayed until:
    - Visual confirmation (during daylight hours) shows that the observed whale is more than 1 km from *Neptune, OR*
    - 30 minutes have passed without another confirmed detection either acoustically within the acoustic detection range of the two ABs closest to the Port, or visually within 1 km from *Neptune*.

Sighting Log Requirements

- Maintain log of marine mammal sightings
  - Date
  - Vessel name
  - Name of lookout
  - Lookout position and time monitoring watch commenced/time monitoring watch suspended
  - Time of sighting
  - Location of Sighting (latitude/longitude)
  - Type of species (whale, dolphin, etc.) and behaviors
  - Number of individuals (exact number or estimate)
  - General direction and distance of sighting from the vessel (within 50 yds, within 100 yds, within 500 yds, etc.
  - Actions taken by vessel

Injured or Dead Protected Species

- Report sightings of injured or dead protected species (sea turtles and marine mammals) immediately, regardless of whether the injury or death was caused by Port activities:
  - USCG on VHF Channel 16
  - NMFS Stranding and Entanglement Hotline: (978) 281-9351.

Attachment 2

Sighting Log

Marine Mammal and Sea Turtle Sighting Log

Date of Sighting:

Vessel Latitude/Longitude:

General Direction of Sighting from the Vessel:	**General Distance of Sighting from Vessel** (within 50 yards, 100 yards, 500 yards; within 0.5 mile, 1 mile, 2 miles, >2 miles, etc)**:**
Time When Sighting Began:	**Time at End of Sighting:**
Name of Watchstander: **(print):**	**(Signature):**
Vessel Name and Flag:	**Vessel Heading** (direction and end location):
Lookout Position on ship:	**Vessel Activity at Time of Sighting:**

Vessel-Generated Noise During Sighting Period (applicable to docking and undocking; indicate if thrusters in use):

Action Taken by Observer:	**Action Taken by Crew/Vessel:**

Weather and Sea Conditions:

Type of Species Sighted (e.g., species [if known]; unknown large whale; unknown small whale; unknown dolphin/porpoise; unknown seal; unknown sea turtle; etc):

Unusual or Obvious Behaviors: (Whales only)	**Blowing** (air coming from top of head)	**Breaching** (leaping out of the water)	**Spy Hopping** (rising head vertically out of water)	**Slapping** (pounding the water surface with a fin or tail)	**Rolling** (rolling upside down at surface of water)	**Swimming**	**Other**

Number of Individuals Sighted (exact number [if known], or 5+, 10+, 50+, 100+, etc.):

Mother and Baby (Calf) Sighting? (Yes or No, if known)

Photos Attached (Yes or No):